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Date: November 13, 2007

I, Christine Lauren Moskalik,

hereby submit this work as part of the requirements for the degree of:

Master of Science

in:

Biological Sciences

It is entitled:

I. Impact of a Genetics Education Workshop on Faculty Participants

II. Investigations of Undergraduate Genetic Literacy

This work and its defense approved by:

Chair: Dr. Carl A. Huether

Dr. Theresa M. Culley

Dr. Melanie F. Myers

I. Impact of a Genetics Education Workshop on Faculty Participants

II. Investigations of Undergraduate Genetic Literacy

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Thesis submitted to the faculty of the University of Cincinnati
in partial fulfillment of the requirements for the degree of

Master of Science
In the
Department of Biological Sciences

Dr. Carl A. Huether, Committee Chair

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ABSTRACT:

This research extends previous studies of undergraduate genetic literacy in two ways: (1) we assessed a 2006 undergraduate genetics education workshop for college faculty teaching genetics using three different measures. Based on participants' feedback from immediate and long-term evaluations, we determined that the workshop was effective at meeting its objectives. However, meaningful conclusions regarding the workshops' impact on course modifications and student learning could not be established due to limited data. (2) At one university, genetic literacy of biology majors was assessed, and compared with that of non-science majors, using two different instruments. The observed trendline was that increased biology experience yields increased genetic literacy; however the level of genetic literacy attained was lower than expected. Assuming the goals of these courses are consistent with our definition of genetic literacy, and how we measured it, the results suggest a need to modify both the content and pedagogy in these courses.

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PART ONE: INTRODUCTION

With the continued increase in the availability of genetic and medical technology, there is also an increasing need for the public to have baseline knowledge of genetics (Griffiths 1993, Terry and Davidson 2000, Lanie, *et al.* 2004, Bates 2005). This understanding is important because it can improve communication on genetic issues, especially those dealing with healthcare and public policy (Kolstø 2001, Haga 2006), as well as genetics education. Furthermore, accurate knowledge of genetics is necessary to appreciate its relevance in everyday life (McInerney 1995, Miller 1998, Gellerman 2004). Understanding genetic information provided by health care professionals, voting responsibly on genetics issues, and differentiating accurate from inaccurate portrayals of genetics in the media are some examples of situations that illustrate the need for a genetically literate society.

In the United States, exposure to genetic information begins during the primary and secondary school years (K-12) with national science education standards dictating which genetics concepts are taught at various grade levels (National Research Council 1996). While efforts have been made to improve genetics education for grades K-12 (National Research Council 1996), medical students and professionals (Childs *et al.* 1982), and the general public (Lanie *et. al.* 2004, Bates 2005), another critical population to consider is undergraduates (Bowling 2007a). Undergraduate biology courses for non-science majors are an ideal opportunity for improving genetics education for

the general public because students in these courses will become our future professionals, teachers, voters, etc.

Jennings (2004) suggests there may be deficits in undergraduate genetics education in that most understanding of genetics (if any) is limited to broad generalizations. According to McInerney (2002), the content of genetics education needs continual improvement and as advances in the field of genetics continue, Booth and Garret (2004) suggest our formal undergraduate education system should reflect such advances in its curricula. Furthermore, Miller (1998) suggests that university education may be the most efficient avenue for improving genetic literacy in the general public. Thus, it is imperative that undergraduate students are adequately exposed to and subsequently learn genetic information. However, little has been done to evaluate genetics knowledge of undergraduate students and there have not been any suggestions for specific improvements that could be made in undergraduate genetics education.

One potential improvement in undergraduate genetics education could be the development of curricula recommendations because there are no current standards for the specific area of genetics for biology majors. The development of such standards was suggested over 15 years ago (Sheeley & Mertens 1990) after extensive survey data were collected (from 135 four-year institutions in 39 states) and compared to similar data collected by Straney and Mertens (1969). These survey data included information about the academic environment, subject matter and laboratory content, preparation by instructional staff, and

teaching approaches employed in presenting genetics content. Only 77% of the respondents indicated that an introductory genetics course was required for biology majors, which was only 2% higher than what was found in 1969. Based on the tremendous growth of knowledge in the field of genetics at the time of their study (even more so today), the results were disappointing (Sheeley & Mertens 1990).

Recommendations have been made more recently on which genetics concepts and content areas should be emphasized in undergraduate non-science majors' courses (Hott *et al.* 2002). There have been curricula recommendations for undergraduate biology majors in specific areas such as introductory biology (Khodar *et al.* 2007), physiology (Silverthorn 2003), and biochemistry and molecular biology (Voet *et al.* 2003). In addition, recommendations have been made regarding genetics curricula for K-12 students (Drew *et al.* 2006). Given these recommendations exist for other biological areas, for genetics education for undergraduate *non-science majors,* and K-12 students, perhaps similar genetics education recommendations should be developed for biology majors. Before such recommendations can be made for biology majors it is important to first determine the level of knowledge these students attain from their genetics courses and to identify any gaps in student learning.

Concept inventories have been developed in other academic areas (i.e. physics and chemistry) which have been highly useful at assessing undergraduate student knowledge and achievement (Hake 1998, Fagen 2003).

More recently, tools to help improve and assess undergraduate biology education have also been developed. Klymkowsky *et al.* (2003) reported on the development of a "Biology Concept Inventory" (BCI) which "accurately measures student comprehension of concepts in introductory, genetics, molecular, cellular, and developmental biology". More recently, a "Biology Concept Framework" (BCF) has been constructed by a team of biology educators at Massachusetts Institute of Technology (MIT) (Khodor *et al.* 2007). Used as a tool to organize any introductory biology curriculum, the BCF is aimed to enhance teaching and learning within the biological sciences for majors and non-majors at MIT, and its use has been offered to interested institutions. As useful and important as the BCF (Khodor *et al.* 2007) and BCI (Klymkowsky *et al.* 2007) are, genetics is only one of several concepts/biological areas addressed by each of these new tools. Both tools are valuable in assessing and/or enhancing students' conceptual understanding of fundamental biological concepts. However, the development of multiple inventories (suggested by Klymkowsky *et al.* 2003) dedicated to a specific biological area (i.e. genetics) would likely be more useful in making specific improvements than would a single inventory addressing several biological areas.

Undergraduate science education has received much recent attention (Udovic 2002, Brenner 2003, Labov 2003, NRC 2003) and not just within the United States. For example, the challenges facing undergraduate STEM (Science, Technology, Engineering, and Mathematics) education were discussed for a dozen different countries on six different continents, including the UK,

Japan, Australia, India, and the United States (Mervis *et al.* 2007). Undergraduate Genetics education does not escape the need for such attention. As suggested by McInerney (2002) evaluating America's current formal schooling practices with regard to undergraduate genetics education is a step in the right direction toward making any improvements (i.e. the development of curricula recommendations for genetics in undergraduate biology majors' courses). But such improvements cannot be made unless there is a clear indication of what needs to be improved and an identification of where deficits in student learning exist. Therefore, evaluation of the current level of genetics knowledge of undergraduates is an important step.

ASSESSING GENETIC LITERACY

Saddler and Zeidler (2004) examined genetic content knowledge, attitude, and informal reasoning of undergraduates in both natural science and non-natural science courses. Among their findings is that (when asked questions about genetics) fewer informal reasoning flaws occurred in individuals with a strong understanding of genetics as compared to individuals with relatively less understanding of genetics. It was concluded that genetic content knowledge may impact students' informal reasoning patterns, which may play a role in how students make decisions about genetics issues (Saddler and Zeidler 2004). If so, this could impact future genetic-related decisions (i.e. health care, moral, political, etc.) that these students may eventually face. Consequently, understanding the level of genetic literacy of undergraduates (both science and

non-science majors) is a necessary first step in improving undergraduate genetics education.

In response to the need for improving undergraduate genetics education, recent studies have investigated undergraduate genetic literacy (Acra 2006, Bowling *et al.* 2007b,c). There currently are few definitions of genetic literacy in the literature, with most definitions based on applicability to medical professionals (McInerney 2002, Andrews *et al.* 2004). For the purposes of this research, genetic literacy is defined more broadly as: "sufficient knowledge and appreciation of genetic principles to allow informed decision making for personal well-being and effective participation in social decisions on genetic issues".

Acra (2006) modified an existing genetics knowledge inventory and assessed genetic literacy in four groups of undergraduate students at the University of Cincinnati which included both biology majors and non-science majors. The original instrument was created by Harvey Bender at Notre Dame to measure undergraduate genetics knowledge but it was not tested for validity or reliability until Acra's (2006) investigation. By collecting pre- and post-course scores on the modified inventory, Acra (2006) detected a significantly higher level of genetic literacy (as measured by the normalized gain [Hake 1998] from pre- to post-course) for honors biology majors compared to other groups (non-honors biology majors, non-science majors and psychology majors [the control group]). When examining increases in genetics knowledge from pre- to post-course, Acra (2006) detected significant increases in genetics

knowledge in two of the groups (honors biology majors and non-science majors), yet increases in the other two groups (biology majors and psychology majors) were not significant. Acra (2006) determined that the modified instrument was not effective at measuring genetic literacy (Cronbach's alpha <0.70); she concluded that further work needs to be done to more adequately assess undergraduate students for genetics knowledge, including the development of a more reliable tool for measuring genetic literacy.

In order to address this need, Bowling *et al.* (2007b) developed a "Genetic Literacy Concept Inventory" (GLCI) that was intended to measure the level of genetic literacy of undergraduates in introductory biology and genetics courses. In Bowling's (2007c) study, 287 students from six undergraduate non-science majors' courses at five different institutions completed the GCLI both pre- and post-course. Relatively small increases in the inventory scores from pre- to post-course were detected despite the development of a very reliable and valid tool with "exceptionally high internal consistency". In addition to the conclusion that the GLCI is a reasonable tool for measuring genetic literacy, Bowling *et al.* (2007c) concluded that students in her study are leaving their introductory courses without an understanding of a number of basic genetics concepts.

THE IMPACT OF COURSE INSTRUCTION

Although these previous studies (Saddler and Zeidler 2004, Acra 2006, Bowling *et al.* 2007) have addressed and discovered relatively low levels of

genetics understanding at the undergraduate level, the student is not solely responsible. There are a number of factors that can impact student learning and retention of science concepts, especially genetics. For example, previous work has considered faculty reports' on course preparation, time spent on teaching specific content areas, and teaching approaches (Sheeley and Mertens 1990) but has not considered the impact of these factors on student learning. The pedagogy used by the instructor and its impact on student learning needs to be given more attention in the movement towards improving undergraduate education as a whole, and genetics in particular.

Bowling *et al.* (2007c) looked specifically at the impact of course content and instructor pedagogy on student learning and detected a small but significant effect of having a reformed course (as measured by RTOP scores) as opposed to the more traditional, lecture based course. The RTOP, or Reformed Teaching Observation Protocol, is a standardized instrument for measuring the degree to which a classroom is 'reformed' (i.e. instruction occurs via constructivist, inquiry-based methods advocated by professional organizations and researchers [MacIssac and Falconer 2002]). The amount of time spent on a given topic was also addressed in the Bowling *et al.* (2007c) study, but surprisingly, did not appear to affect student learning (as measured by the normalized gain of pre- and post-course scores on the GLCI).

One potential reason for pedagogy and/or course content having a limited impact on student learning could involve a lack of teaching resources that are readily available to college faculty. Stephanie Pfirman, a distinguished

undergraduate STEM educator at Barnard College in New York City, said "Many of us realize that there are ways to improve teaching, but it's hard to find that information…I don't know how to find the resources I'm looking for in the educational arena" (Mervis, *et al.* 2007). A good way to encourage professors to improve their teaching of genetics is to offer them regular opportunities from which they can learn new teaching strategies, stay up to date on advances in the field of genetics, network with other professionals, and obtain useful teaching resources. In fact, faculty development has been identified as an important step toward improving undergraduate biology education and, in an effort to implement reform, the establishment of summer workshops for faculty has been suggested (NRC 2003).

To this end, an Undergraduate Genetics Education workshop was held in New Orleans, L.A. at the American Society of Human Genetics (ASHG) annual meeting in October 2006. The one-day workshop consisted of presentations and break-out sessions (Appendix A) and was conducted specifically for college level faculty teaching courses which emphasize concepts in genetics. The primary goal was to expose participating faculty to teaching techniques and genetic content that could improve their teaching effectiveness and promote active learning in their classroom. Although some studies indicate uneven support for active learning (Prince 2004), it is thought that pedagogies which engage students and allow for discussions regarding course material that is relevant to the students' lives can help increase the biological information that is retained by the students (Allen and Tanner 2005, DeHaan 2005, Smith *et al.*

2005, Michael 2006). Based on the constructivist theory for education, which suggests that learning is a "social process of making sense of experience[s] in terms of existing knowledge" (Tobin et al. 1994), applying course content to current events and social issues can be a very effective pedagogy. Therefore, the ASHG workshop was developed to expose participating faculty to interactive and engaging pedagogies as well as content information that could be implemented in their respective classes to enhance student learning. A number of take-home resources and handouts were provided to participants at the 2006 ASHG workshop (Appendix B).

Increased opportunities for professors to obtain teaching resources may lead to improvements in pedagogy and/or course content. If professor pedagogy and appropriateness of course content improves, then the learning of genetics concepts by undergraduate students is also likely to improve. When undergraduate students exhibit improved levels of genetic literacy, we can expect a more genetically literate society to follow.

PROJECT GOALS

The goal of this research was to extend previous studies of undergraduate genetics education in two ways: (1) to assess the effectiveness of the ASHG Undergraduate Genetics Education workshop. This assessment was accomplished using three measures (i) an immediate anonymous survey by participants; (ii) a seven-month follow-up survey of workshop participants' (at the end of the 2006-07 academic year, which allowed them time to implement

workshop material in their classes), and (iii) an assessment of genetics knowledge of undergraduate students enrolled in these classes. (2) To determine the level of genetic literacy of students in courses for biology majors at the University of Cincinnati using the Genetic Literacy Concept Inventory (GLCI) and nine True/False (T/F) questions which also address genetic literacy (Miller, *et al.* 2006). The level of genetic literacy of these students was compared with that of non-biology majors.

The results from these studies are expected to provide insight into a variety of aspects of undergraduate genetics education: how students in courses for both biology and non-biology majors compare in their understanding of genetics; how the GLCI might improve assessment of student learning of genetics; and how an undergraduate genetics education workshop might improve faculty teaching and student learning.

PART TWO: THE WORKSHOP ASSESSMENT

Background:

Given the important role that faculty play in student acquisition of genetics knowledge, the ASHG Undergraduate Genetics Education (UGE) Workshop was an important step toward making improvements in undergraduate genetics education. This study assessed ASHG's inaugural UGE Workshop in New Orleans, L.A. by obtaining participant reports regarding workshop impact and effectiveness immediately following the event, and seven months later. We know of no other reports quantitatively assessing a workshop designed to enhance UGE. Although an annual week-long summer institute on undergraduate biology education for college biology instructors (hosted by the National Academies) was deemed successful based on "lively discussions" with participants (Wood and Gentile 2003), there was no further elaboration nor have there been any additional published reports assessing the annual summer institutes thereafter. The National Human Genome Research Institute has also conducted an annual week-long summer institute on genetics, primarily for faculty from historically black colleges and universities, but again, there have not been any published reports assessing the effectiveness of these annual institutes.

While opportunities like this can be valuable for improving undergraduate biological education, assessment is necessary to determine their effectiveness. Consequently, the objectives of the current study were to: (1) complete a comprehensive workshop assessment, consisting of (i) a pre-

workshop survey to provide baseline data, (ii) an anonymous evaluation to assess the immediate impact of the workshop, and (iii) a seven-month follow-up survey to determine the long-term impact of the workshop and to compare with the pre-workshop survey data. (2) Conduct pre- and post-course measurements of students' genetics knowledge (using the GLCI) from courses taught by faculty who participated in the workshop.

Methods:

Participation

A convenience sample was obtained for the workshop evaluations and student genetic literacy assessment. Workshop participants primarily included college-level faculty who teach a course/s including undergraduate genetics topics. The majority of workshop participants registered for the workshop in advance, but there were also six walk-ins. The participating students included those enrolled in courses taught by a subset of the workshop participants who met certain criteria for the student genetic literacy assessment (Table 2.1).

Pre-workshop data were collected from 38 of 45 total pre-registrants (84%). Prior to the workshop, these 38 pre-registrants were informed about (and recruited to participate in) the seven-month follow-up survey and student genetic literacy assessment via email. Thirty-three of the 38 respondents (87%) reported they had been teaching during the previous academic year, therefore the pre-workshop data regarding course content, comfort level, and pedagogy from these 33 pre-registrants served as the baseline for comparing the pre-workshop data to the seven-month follow-up survey data (hereafter referred to as pre- to post-workshop comparisons).

Regarding the comprehensive workshop assessment (objective 1 above), there was slippage in the number of study participants (Table 2.2). Only 30 (67%) of the original 45 pre-registrants actually attended the workshop and of these, 26 (87%) were among those 33 who had taught the previous year. At the start of the workshop, all participants (n=36: 30 pre-registrants and 6 walk-ins)

were informed that they would be asked to complete an immediate anonymous survey at the end of the workshop but only 26 of the total workshop participants (n=36) remained at the end to do so. Of these 26 who remained at the end of the workshop, 19 (73%) were pre-registrants and agreed to participate in the seven-month follow-up survey and/or student genetic literacy assessment. In an effort to maximize the response rate, these 19 individuals were periodically reminded (approximately once/month after the workshop) about completing the seven-month follow-up survey. Fourteen (74%) individuals completed the seven-month follow-up survey in May 2007; these data were compared to the pre-workshop data from the same 14 individuals to assess the longer-term impact of the workshop (see Seven-Month Follow-up ~ Pre- to Post-Workshop Comparisons below).

Regarding the pre- and post-course measurements of student genetics knowledge (objective 2 above), there were eight workshop participants who met the criteria for this aspect of the study (Table 2.1), but only four did. Students of these four instructors were invited to participate via email during the first week of classes in the spring term of the academic year 2006-2007. This consisted of 318 students in five classes (three introductory biology, one introductory genetics, and one Anatomy and Physiology course).

Table 2.1: Criteria for faculty to participate in the genetic literacy assessment:

1) teaching a course(s) for undergraduate non-science majors
2) having greater than 50% genetics content in the course(s)
3) having a minimum of 20 students enrolled in (each of) the course(s)
4) teaching during the Spring terms of the '06-07 academic year.

Table 2.2: Slippage in Number of Faculty Participants		
	Number	
Pre-registered……..45		
Pre-registered teachers during '05-'06……..….....33		
Pre-registered teachers who attended…….……26		
Pre-registered non-teachers who attended....……4	+ 6 walk-ins	
Total Workshop Participants…….…..36	-10 (left early)	
Completed immediate evaluation.....26		
Participants who signed consent …….19		
Met eligibility criteria for the GLCI assessment…..8		
Faculty who collaborated on GLCI…….....4		
Faculty who completed seven-month follow-up.... 14		

Faculty participants completed the immediate anonymous survey at the end of the workshop (n=26) and used the internet for completing the seven-month follow-up survey via SurveyMonkey (n=14). The study participants, including faculty who attended the workshop and their students, were not coerced in any way. All of the instruments and procedures were reviewed and approved by the Institutional Review Board (IRB) for Behavioral and Social Sciences at the University of Cincinnati (UC). Additional approval was provided by the IRB (or equivalent thereof) at the institutions from which student data were collected.

PRIOR TO THE WORKSHOP:

Pre-workshop data were collected online via SurveyMonkey (Appendix C) in August 2006 from individuals who registered with ASHG to attend the workshop. These data included demographic information about the faculty participants and baseline data about course content, pedagogy, and comfort

level, to compare with post-workshop data from the seven-month follow-up survey.

AT THE WORKSHOP:

The workshop participants who remained at the end of the workshop were asked to complete the immediate anonymous survey (Appendix D). The anonymous survey assessed the overall workshop effectiveness, the immediate impact of the workshop on its participants, and provided feedback on individual components of the workshop. Pre-registrants were given information about this study including informed consent documents (Appendix E). By signing the informed consent, participants agreed to complete the seven-month follow-up survey and/or facilitate the undergraduate student genetic literacy assessment.

AFTER THE WORKSHOP: FACULTY PARTICIPATION

The seven-month follow-up survey (Appendix F) was conducted in May, 2007 and included questions from the pre-workshop survey, in addition to other general questions. This instrument allowed for an evaluation of the long-term impact of the workshop as well as participant reports of changes in pedagogy, course content, and comfort as compared to the pre-workshop data. Participants were instructed to complete the seven-month follow-up survey based on their course with the greatest amount of genetics content.

AFTER THE WORKSHOP: STUDENT PARTICIPATION

Workshop participants who met the criteria outlined in Table 2.1 (above) were invited to participate in the student genetic knowledge (genetic literacy) assessment (objective 2). Measuring student genetic literacy was accomplished using Bowling's (2007a,b) Genetic Literacy Concept Inventory (GLCI) (Appendix G) which has been tested for validity and reliability. This GLCI was implemented online (via SurveyMonkey) twice; at the beginning of the course ("pre-course") and after the course ("post-course"). As incentive, students who completed both the pre- and post-course GLCI online earned extra credit amounting to 1% of their final grade. Informed Consent forms were provided to the students (Appendix H) by their instructor who returned them to the investigators by mail. An email with a link to complete the GLCI via SurveyMonkey was sent to the students during their first week of classes (pre-course) and again towards the end of the term (post-course). Average pre- and post-course scores for participating students in each course were calculated.

Results:

PRE-WORKSHOP SURVEY:

Although 45 individuals pre-registered for the workshop, 38 (84%) completed the pre-workshop survey. Of these, 33 (87%) reported teaching the previous academic year and provided baseline data for the pre- to post-workshop comparisons of course content, pedagogy tools, and comfort in teaching genetics content in their course/s (see below).

IMMEDIATE ANONYMOUS WORKSHOP SURVEY:

Twenty-six workshop participants completed the immediate anonymous workshop survey. To determine whether or not the workshop objectives were met, participants rated each objective (Table 2.3). The average rating for each objective ranged from 3.82 to 4.68 out of a maximum of 5. Additionally, when asked if their expectations for the workshop were met, 81% (n=21) reported either 'yes' (n=11) or 'yes, definitely' (n=10); 15% (n=4) reported 'for the most part', 4% (n=1) reported 'occasionally', and zero reported 'not at all'. When asked how likely they are to implement some aspects of the workshop in future teaching plans, 92% (n=24) reported either 'likely' (n=8) or 'very likely' (n=16); 8% (n=2) reported 'neutral', and zero reported either 'unlikely' or 'very unlikely'. The two individuals who reported a neutral score either were not currently teaching or were already using some of the pedagogies covered at the workshop.

Table 2.3:
Average participant ratings for agreement with whether workshop objectives were met (n=26)

Objective	Participants were expected to:	Average Rating†	Range
1:	have an increased knowledge of a variety of human genetics topics which are relevant to their classes.	4.00	1-5
2:	have a greater understanding of pedagogies to improve active student learning in their class/es.	4.00	2-5
3:	have an appreciation for the value of relating class material to the students' everyday lives and important societal issues.	4.52	3-5
4:	have a greater appreciation for how societal issues such as race and genetics, evolution, stem cell research, etc. can be presented and discussed in their classes.	4.68	3-5
5:	have an awareness of additional resources that will help them accomplish their course objectives.	4.54	2-5
6:	tools or ideas that will clearly improve the teaching of human genetics concepts in their courses.	4.52	4-5
7:	an increased desire to incorporate teaching human genetics in their course/s.	4.35	3-5
8:	a greater comfort level for teaching human genetics concepts.	3.82	1-5

† Ordinal scale used: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree

Regarding the content of the workshop, participants rated the value of each component of the workshop in contributing to course improvements. Average ratings for the sessions ranged from 3.69 to 4.38 (Table 2.4). The presentation on the topic "Genetics of Race" had the highest average rating for value to participants in making improvements in their courses.

Table 2.4:
Average participant rating for the value of each workshop session

Workshop Session	Average Rating†	Range
Presentation **(D) Genetics of Race**	4.38	3-5
Presentation **(I) How the Media Mangle Science**	4.33	2-5
Pedagogical Session #2 **(F) Integrating Social Issues Through Writing**	4.19	3-5
(E) Question/Discussion session 2	4.18	2-5
Pedagogical Session #1 **(C) Getting Students Involved**	4.16	2-5
Presentation **(H) PRS/Genetics in the News**	4.13	2-5
Presentation **(A) Direct-to-Consumer Genetic Testing**	4.08	3-5
Brainstorming/discussion session **(J) Taking it all back: self-reflection/review**	3.96	2-5
(B) Question/Discussion Session 1	3.92	2-5
(G) Small group brainstorming session	3.69	2-5

† Ordinal scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Note: The letters (A-J) represent the chronological order of the workshop sessions

Furthermore, participants reported on what they most gained from the workshop:

> "Different resources available on the internet for genetics, current news, etc."
>
> "Personal Response System"

"Interaction with the teaching community"

"An increased awareness for the importance of race"

"A variety of pedagogy tools to increase engagement, interactive learning, and involvement of students"

The comments above were given by multiple participants and consequently reflect what was gained; however there were several unique comments regarding other participant gains (Appendix I).

Participants were also asked if there was one thing about the workshop that could be improved. Answers consisted of the following:

"More concrete examples of how to integrate specific strategies in our courses"

"Maybe this [workshop] could have been two days instead of one"

"More time for group work; changing group composition"

"More specific ideas for concepts such as mitosis/meiosis, transcription, translation, etc."

"The repetition of speakers; more involvement with geneticists – laboratory of clinical"

When asked if something was missing from the workshop, 39% (n=9) responded with 'yes', 22% (n=5) with 'no' and 39% (n=9) with 'unsure'. For those who reported 'yes' some explanations included:

"Information for genetic labs would be useful"

"A presentation on revisions of course structure"

"A section on course design/set-up"

"More time to interact with each other"

"Involve students from the classes – a professor/student dyad would be helpful"

Fourteen (54%) participants reported they would be interested in participating in a longer/more extensive summer institute in the future, while 7 (27%)

reported they were unsure about attending a future, longer workshop and 5 (19%) reported they would not be interested. Explanations for not being interested included 'expense' and/or 'time' while explanations from those reporting unsure also included 'expense', but "depends on topics to be covered" was also an explanation for unsure.

SEVEN-MONTH FOLLOW-UP EVALUATION

Although baseline data regarding teaching during the previous year were collected from 33 pre-registrants, only 26 attended the workshop. Of these, 19 (73%) agreed to participate in the seven-month follow-up survey but only 14 (74%) did (Table 2.1). Only data from those who completed both the pre-workshop and seven-month follow-up surveys (for the pre-post-workshop comparisons) could be used.

Seven-month follow-up ~ General Questions:

When asked if the workshop enhanced participant comfort level in teaching genetics, 79% reported at least some increase in comfort (Table 2.5).

Table 2.5:
Participant responses to whether the workshop provided them with a greater comfort level for teaching genetics concepts

RESPONSE OPTIONS	%
Entirely -	-
For the most part	29%
Somewhat	43%
Neutral	14%
Not at all	7%
Other (please specify)	7%

When participants were asked if they have implemented aspects of the workshop in their teaching plans for the current academic year, eight individuals (57%) reported "yes" while six (43%) reported "no" and an explanation for their answer was requested. Explanations for "no" included:

> "haven't had a chance yet"
>
> "Plan to implement workshop material during future terms"
>
> "already use some of the pedagogies presented"

While explanations for "yes" included:

> "Incorporated a student genetics project into my course; it was particularly helpful to have seen how a grading rubric was developed to assess student writing"
>
> "Included a section on lay literature on genetics into one of my courses"
>
> "Used the "Genetics and Race" video (2) and discussion questions"
>
> "It added to my general background understanding with relation to genetic testing and current issues. I have also used some of the articles provided in the supplemental handouts."
>
> "I incorporated a little more information regarding race and genetics into one of my lectures, using some of the educational material that was provided for us at the workshop."
>
> "I covered aspects of 'Genetics and Society'."
>
> "Have implemented more ethics discussion (discussion of case studies) and more small group work. Have included more history of genetics in lecture and on tests."

At the time of the seven-month follow-up, greater than 50% of the respondents (n=14) were implementing at least some content from each of the workshop sessions (Table 2.6) and are also using the take-home resources provided at the workshop (Appendix B) in their courses. Textbooks, DVDs,

scientific articles, speaker/presenter handouts and a poster were among the most commonly used resources reported (Appendix J).

Thirteen respondents reported on the relative amount of changes made in their courses as a result of the workshop and of these, 10 individuals reported some changes: seven made changes up to 10%, two made changes up to 20%, and one made up to 30% changes in their courses. The remaining three individuals (23%) haven't made any changes yet but reported plans to do so.

Table 2.6:
Average rating for workshop session material being incorporated into participants' course(s).

Workshop Session	Average Rating†	% participants who implemented content from session (n=14)	Range
Presentation			
Direct-to-Consumer Genetic Testing	1.71	57%	1-3
Pedagogical Session #1			
Getting Students Involved	1.67	64%	1-3
Presentation			
Genetics of Race	2.14	50%	1-4
Pedagogical Session #2			
Integrating Social Issues Through Writing	1.89	64%	1-3
Presentation			
PRS/Genetics in the News	2.38	57%	1-4
Presentation			
How the Media Mangle Science	1.56	64%	1-3

† Ordinal Scale: 0=haven't implemented anything yet; 1=a very little amount; 2=a good amount; 3=almost all information; 4=everything

Seven-Month Follow-up ~ Pre-to Post-Workshop Comparisons:

To determine specific changes made by workshop participants as a result of attending the workshop, pre- and post-workshop comparisons after seven

months were made on the following topics: percentage of course content dedicated to genetics, importance of various genetics concepts in meeting course objectives, comfort level in teaching within six different content areas[1] of genetics, and pedagogy tool usage. The following pre- to post-workshop results are reported for the 14 participants who completed both the pre-workshop and the seven-month follow-up surveys. Results from the 33 pre-registrants who had reported teaching the previous year (via the pre-workshop survey) which provided the baseline data for these pre- to post-workshop comparisons are also included.

Among the 14 who completed the pre-workshop and seven-month follow-up surveys, there was little difference from pre- to post-workshop in the majority of responses regarding amount of genetics content emphasized in workshop participants' individual courses. Both before (n=9) and after (n=8) the workshop, over half of the respondents reported that >60% of their course content was dedicated to genetics. The pre-workshop averages for importance of concepts (in the six content areas) in meeting course objectives which were reported at baseline by all 33 pre-registrants were comparable to the pre-workshop averages for the subset of individuals (n=14) who completed the post-workshop survey. The average ratings for such concepts were slightly higher before the workshop, as compared to after the workshop (Table 2.7). Similar results were seen for comfort level (Table 2.8) in that there were slightly higher averages before the workshop. With regard to average ratings for

[1] Hott, *et al.* (2002) developed a list of six content areas with various sub-concepts that should be emphasized in non-science majors' courses.

pedagogy tool usage (Table 2.9), most category ratings either slightly decreased or stayed approximately the same from pre- to post-workshop, but there were some increases. Interestingly, there was one relatively large decrease from pre- to post-workshop in the category of using "lecture only" as a pedagogy tool (3.43 decreased to 2.00), while there was a slight increase from pre-to post-workshop in the category of "Socratic/interactive" (1.43 to 1.79). Two other pedagogy tool categories, PowerPoint and guest speaker, had average ratings which increased from pre- to post-workshop. Overall the results from the pre-/post-workshop comparisons do not appear to be in line with the results obtained from the some of the seven-month follow-up general questions, which is discussed below.

Table 2.7:
Average ratings† for the importance of various genetic content areas and their sub-concepts in meeting course objectives

I. Content Area a. Sub-concept	Total Baseline (n=33)	Baseline subset (n=14)	Seven-month follow-up (n=14)
I. The nature of the Genetic Material	**3.63**	**3.61**	**3.47**
a. DNA Structure	3.58	3.64	3.50
b. DNA Function	3.67	3.57	3.43
II. Transmission	**3.49**	**3.55**	**3.22**
a. Mitosis	3.33	3.64	3.50
b. Meiosis	3.42	3.71	3.29
c. Mendelian Genetics	3.76	3.64	3.14
d. Human Disease Inheritance	3.45	3.21	2.93
III. Gene Expression	**3.17**	**3.12**	**2.90**
a. Translation	3.45	3.36	3.36
b. Transcription	3.42	3.36	3.29
c. Gene-Environment Interaction	2.64	2.21	1.86
IV. Gene Regulation	**2.76**	**2.40**	**2.24**
a. Protein Products & Function	2.94	2.71	2.50
b. Turning Genes On and Off	2.79	2.43	2.21
c. Errors in Gene Regulation	2.55	2.07	2.00
V. Evolution	**2.48**	**2.60**	**1.98**
a. Genetic Variation	3.06	2.93	2.50
b. Natural Selection	2.52	3.00	2.21
c. Darwinian Evolution	2.33	2.93	2.07
d. Conserved DNA sequences	1.97	1.50	1.21
e. Population Genetics	2.52	2.64	1.93
VI. Genetics & Society	**2.49**	**2.44**	**2.02**
a. Human Genome	3.09	2.79	2.14
b. Genetic Technology	2.91	2.93	2.74
c. Genetics in the Media	2.58	2.64	1.71
d. Genetics & Society	1.88	1.71	1.86
e. Genetic Misconceptions	2.00	2.14	1.64

†Scale: 0= not taught, 1= somewhat important, 2 = neutral, 3 = important, 4 = v. important

Table 2.8:
Average ratings† for comfort level at baseline and from pre- to post-workshop

I. Content Area	Baseline (n=33)	Baseline subset (n=14)	Seven-month follow-up (n=14)
I. The nature of the Genetic Material	2.73	3.00	2.71
II. Transmission	2.75	3.00	2.50
III. Gene Expression	2.55	2.86	2.43
IV. Gene Regulation	2.34	2.14	2.36
V. Evolution	1.82	2.14	2.14
VI. Genetics and Society	1.93	2.21	2.14

†Scale: 0=not at all, 1=somewhat, 2=comfortable, 3=quite comfortable

Table 2.9:
Average ratings† for pedagogy tool usage at baseline and from pre- to post-workshop

Pedagogy Tools	Baseline (n=33)	Baseline subset (n=14)	Seven-month follow-up (n=14)
PowerPoint	3.08	**2.93**	**3.29**
In-class handout	2.58	2.50	1.89
Blackboard/equivalent	2.55	2.93	2.64
Personal Response System (PRS)	0.42	0.29	0.07
Overhead projector	1.62	1.79	1.14
Chalkboard/Whiteboard	2.79	2.64	2.57
Class discussion	2.62	2.36	2.21
Hands-On	1.98	2.07	1.29
Interactive/Socratic	1.74	**1.43**	**1.79**
Video	1.17	1.21	1.07
Internet	1.48	1.43	1.00
Role Play	0.52	0.21	0.21
Small Group Discussion	1.45	1.07	0.29
Guest speaker	0.42	**0.29**	**0.93**
Lecture only	2.46	**3.43**	**2.00**

†Scale: 0=not used, 1=use some of the time, 2=use about half of the time, 3=use most of the time, 4=use all of the time

For the undergraduate genetic literacy assessment, there were two participating institutions with a total of five courses [three introductory biology courses, one introductory genetics course, and one anatomy and physiology (A&P) course] taught by four different faculty participants (one faculty participant taught a general biology course and the A&P course). Of the total number of students invited to participate at the beginning of the spring term of 2007 (n=318), only 65 (20%) attempted to complete the GLCI pre-course. Of these, 14 (22%) completed only demographic questions, decreasing the pre-course GLCI student sample size to 51 (16%). Of these 51 students, only 16 completed the post-course GLCI.

Course outcome data regarding the number of students in each course who earned a letter grade (other than those which indicate an "incomplete" or "withdrawal", etc.) were also collected (Table 2.10). Overall, only 67% (n=213) of the initial total students enrolled (n=318) in each of the five courses actually earned a letter grade in the course. Furthermore, only 39% (n=125) of those who earned a letter grade earned a C or higher. Despite the low sample size of 16, some increase from pre- to post-course was seen for the two courses in which students completed both the pre- and post-course GLCI. Course 2 (n=10) had higher pre- and post-course averages than course 1 (n=6).

Table 2.10:
Course outcome regarding number of students grades earned, and participating students from each course

Instructor	Course†	Max Enrollment	# Students Enrolled	# earned grade (%)	# C or better (%)	# Pre-course GLCI	# Post-course GLCI
A	A&P	60	60	43 (71.7%)	21 (48.8%)	11	6
A	IB	40	38	28 (73.7%)	11 (39.3%)	5	0
B	IB	120	120	67 (55.8%)	51 (76.1%)	12	0
C	IB	80	77	53 (68.8%)	23 (43.4%)	13	0
D	G&S	30	23	22 (95.7%)	19 (86.4%)	10	10
TOTALS		**330**	**318**	**213 (67.0%)**	**125 (39.3%)**	**51**	**16**

†A&P=Anatomy and Physiology; IB=Introductory Biology; G&S=Genetics and Society

Discussion:

In this study, results from the immediate, anonymous workshop evaluation provide support for a successful workshop: there were high average ratings for the workshop having met its objectives; workshop expectations were met for nearly all participants (81%); the ratings for workshop content were relatively high; the likelihood of implementing aspects of the workshop into courses was also high (92% of participants said they were either "likely" or "very likely" to do so); and there was a moderate level of interest in attending future workshops. If "time" and "expense" were not a factor, perhaps the interest in future, longer summer workshops would have been greater. Substantial funding of future faculty workshops could help alleviate these inhibiting factors (i.e. time and expense). The immediate evaluation provided valuable insight into how future workshops might be improved. For example, since participants indicated preference for other (specific) topics to be presented and also indicted an interest in more time to interact with each other, perhaps future workshops could benefit from incorporating such suggestions. The lowest averages for workshop content seemed to be for the discussion/group brainstorming sessions which immediately followed a presentation or pedagogical session. However, when participants were asked if something from the workshop could be improved, a number of responses included more time for group discussions. Perhaps longer workshops (i.e. 2-7 days) would allow for specific sessions with more time for group discussions, etc.

Further support for a successful workshop was evident from the seven-month follow-up survey, as many positive responses were received. However, these positive results need to be tempered by the reality that only 14 of the original 45 pre-registrants are reporting them, and that only 10 (71%) of these respondents indicated changes in their courses. However, positive responses were received from the seven-month follow-up. Seventy-nine percent of the 14 participants who completed the seven-month follow-up survey reported at least some increase in comfort level for teaching genetics. In addition, 57% reported they have implemented something from the workshop into their courses and those who haven't reported plans to do so in the future. Half of the respondents reported up to 10% changes, while another few reported changes of up to 20% and 30%. Additionally, preparation of lesson plans using workshop material was reported by 10 (77%) of the respondents. Workshop material currently being implemented includes information from the presentations and pedagogical sessions, as well as use of the various take-home resources provided at the workshop. For example, some participants reported use of information/handouts from the "Race and Genetics" presentation, while some indicated that seeing how to develop a grading rubric was helpful (from a pedagogical session), and others reported use of the textbooks and DVDs. At least half of the respondents reported some use of each resource (Appendix J).

The pre- to post-comparisons of comfort, course content, and pedagogy were less supportive of the positive results above. An inconsistent finding from

the seven-month follow-up is that 79% of the respondents to the general follow-up question addressing comfort reported at least some increase in comfort level for teaching genetics. However, the only increase from pre- to post-workshop for the average ratings for comfort was within one of six content areas, Gene Regulation (2.14 – 2.36). Since the workshop material did not emphasize gene regulation, this result is surprising. It might be explained by gene regulation having a low pre-workshop rating compared to the other five content areas; these other five categories had little room for improvement (compared to gene regulation) from pre- to post-workshop (i.e. in two of these five content areas, the average rating was the maximum possible rating of three). The lower average ratings for comfort level (from pre- to post-workshop) for the remaining five content areas seen at the seven-month follow-up could possibly be explained by participants gaining enlightenment for what really should be emphasized in undergraduate courses or an identification of individual deficits in any given content area.

Regarding course content, the ratings for the importance of the sub-concepts in meeting course objectives was lower for the great majority of the concepts after the workshop than prior to it (except VI.d, Genetics and Society – Table 2.7), although initially they were relatively high. Although results from other surveys in this workshop assessment have indicated success, the results regarding course content and comfort level imply that the workshop did not have a positive effect. A reason for the disparity could be that the respondents better understood what was meant by 'sub-concept' after the workshop,

skewing the pre- to post-workshop comparisons. The results are surprising in that we would not have expected any change because most of these topics were not covered at the workshop. A similar trend was observed for the average ratings for use of pedagogy tools; the majority of tools had a lower average rating after the workshop than before, but the respondents' understanding of 'pedagogy tool' after the workshop also may have been different than before the workshop. Some of the decreases were substantial, such as use of PRS and small group discussion. Decreases in these categories are unusual since they were emphasized at the workshop. Based on the participant responses both pre-workshop and post-workshop (i.e. at the seven-month follow-up), only one individual actually used PRS prior to the workshop (rated 4/4) and that individual reported a much lower rating of PRS usage (1/4) at the time of the seven-month follow-up. Another participant reported (from the seven-month follow-up survey) that they did not use PRS due to "cost and reliability". There were few notable differences in the pedagogy tool ratings from pre- to post-workshop however; the ratings for use of PowerPoint, guest speaker, and Socratic/interactive techniques all increased and were emphasized during the workshop.

For the genetic literacy assessment of students, one obvious contributor to the low number of respondents was the decline in total course enrollment (~33%, Table 2.10). Additionally, over 40% of the students did not earn a passing grade of C or higher among all the courses surveyed, suggesting student motivation was low and may have affected their participation. Thus,

offering extra credit for participation in this study did not seem enough to encourage more students to participate, in contrast with previous studies where extra credit was an adequate incentive (Acra 2006, Bowling 2007a). The low sample size in our study does not allow meaningful conclusions regarding workshop impact on subsequent student learning, but there was a tendency for average scores on the GLCI to increase for the 16 students who completed the GLCI both pre-course and post-course.

Workshop assessments have been conducted in other disciplines in a similar fashion. For example, a teaching workshop for improving Emergency Department (ED) instruction (Bandiera, *et al.* 2005) and a continuing medical education workshop for improving how physicians break bad news to their patients (Ladouceur, *et al.* 2003) have been evaluated by questionnaires immediately and several months following the event. Bandiera, *et al.* (2005) concluded that the half-day faculty development workshop (limited to 15 participants) was successful based on high participant ratings of the program (n=15) and reports from a four-month follow-up (n=10). At the time of the immediate evaluation, all participants (n=15) reported intent to attend additional similar workshops and indicated they would recommend the workshop to peers. At the time of the follow-up all respondents (n=10) had implemented new teaching strategies and eight said they were more comfortable teaching the emphasized topics. Ladouceur *et al.* (2003) concluded that the 90-minute workshop was successful based on participant reports immediately following the workshop (n=539) and from the six-month follow-up

(n=205). From the immediate evaluation, they determined that participant expectations were met, comprehension of the material occurred, acquisition of new techniques and higher confidence was reported, and implementation of suggested strategies was a possibility. At the time of the six-month follow-up, the great majority of respondents (95%) had retained at least one out of three key concepts presented and many (62%) indicated that the workshop helped them in breaking bad news to patients subsequently (Ladouceur *et al.* 2003).

A major result of the current study was the substantial slippage in faculty participation from pre-registration to having students complete the GLCI. One-third of the pre-registrants did not attend the workshop; 10 workshop participants left before the workshop was completed (leaving 26 at the end to complete the anonymous survey); 14 of the 19 who agreed to participate at the end of the workshop completed the seven-month follow-up survey, and only four of these 14 facilitated the student genetic literacy assessment. This suggests some changes should be considered for future workshops and for subsequent assessments of them (namely, for retaining participants which would allow for more accurate assessments of their impact). Because the workshop was free of charge, pre-registrants may not have felt a sense of commitment to attend. A small fee at the time of registration may therefore improve attendance. Furthermore, since all of the take-home resources were distributed at the beginning of the day, participants may have been encouraged to stay until the end by delaying the distribution of resource materials. Future workshops would also be well advised to be more selective in

accepting faculty participants; particularly those who are definitely teaching courses with a strong genetics component, and who are likely to follow through with implementation after the workshop.

LIMITATIONS

The lack of faculty continuity in this study was not only one of the study's results, but also one of its limitations. Also, the very low number of student participants did not allow for meaningful pre- and post-course GLCI comparisons. Furthermore, there could have been a response bias on the immediate anonymous survey due to the absence of several (28%) participants. Also, the length of the surveys may have contributed to some of the unusual findings; since the surveys were relatively lengthy, perhaps the respondents rushed through the questions which could have impacted their responses. Lastly, this study is limited to participants' reported perceptions regarding impact of the workshop on subsequent teaching activities; without verification that faculty actually modified their courses in the way they indicated at the time of the seven-month follow-up, these data are only as good as other self-reported data. According to Ladouceur *et al.* (2003), participants may overestimate the actual impact of a workshop on their professional activities by up to 30%, and this should be considered for drawing conclusions from future workshop evaluations.

CONCLUSIONS

While faculty workshops are an excellent step toward making improvements in undergraduate education, critically evaluating the impact and effectiveness of them is essential. The fact that the workshop participants felt the goals of this workshop were met is a positive first step in assessing the ASHG workshop in this study. The importance of providing good resources to participants was also underscored as a useful component of this workshop and should be emphasized for the planning of future workshops. The need to retain faculty interest and involvement from the beginning to the end of the evaluation process was also found to be critical. In attempting to provide a comprehensive assessment of this first annual ASHG UGE Workshop, we have demonstrated the many components that are necessary, as well as a number of unanticipated pitfalls. Furthermore, being the first attempt at determining a workshops' impact on student learning (and using the GLCI to collect genetic literacy data on a national level) there are a number of improvements that could increase student participation. For example, recruiting faculty with higher levels of enrollment in their courses and finding a way for faculty and students to be more committed to the research as collaborators may be useful for future studies.

Improvements have been documented to be necessary in undergraduate genetics education (Jennings, 2004, McInerney 2002,), and an important avenue toward making such improvements is faculty development (NRC 2003). It is important to have faculty development activities, but it is equally

important to assess their efficacy. Perhaps faculty development activities, such as workshops, will lead to increased comfort and an enhanced knowledge base in the field, as well as improved pedagogy. With advances in these areas, students are likely to benefit by acquiring an adequate level of genetic knowledge. Our results should encourage future opportunities for similar workshops, as well as subsequent comprehensive evaluations of them.

PART THREE: UDERGRADUATE GENETIC LITERACY – GLCI

Background:

Recent studies have addressed genetic literacy in undergraduate students (Saddler and Zeidler 2004, Acra 2006, Bowling, *et al.* 2007c). With Bowing's (2007) development of the Genetic Literacy Concept Inventory (GLCI) it is now possible to determine the level of genetic literacy of non-science majors (NSM) as well as students in introductory biology and genetics courses. While undergraduate NSMs should be expected to graduate with an adequate level of genetic literacy, these students are still scoring low (<50%) on the GLCI after completing some courses dedicated to genetics concepts (Bowling *et. al* 2007c).

If non-majors are expected to complete a genetics course with improved genetic literacy, then biology majors should be held to at least the same (and possibly higher) standards as measured by the GLCI. A minimum score on the GLCI representing a "genetically literate" individual has not yet been established, however it has been informally suggested that a score of ≥70% should reflect an adequate level of genetic literacy for at least NSMs (Huether, personal communication). Making initial comparisons of undergraduate scores on the GLCI between NSMs and science majors will aid in the establishment of a minimum score by determining whether differences exist between the two groups, and what score might be appropriate as a minimum for science majors.

The objectives of this study were as follows: (1) to determine the level of genetic literacy of students in introductory and sophomore level courses for

biology majors, which include other science majors in the Life Sciences (physical therapy, medicine, medical technology, dentistry, etc.); (2) to compare the level of genetic literacy in these biology students to that of NSMs, with one goal of helping to propose a minimal level of genetic literacy.

Methods:

Participation

Undergraduate students in two courses for biology majors participated toward the end of the 2006-2007 academic year by completing Bowling's (2007) GLCI, which consists of 31 multiple choice items (each with five answer options), and nine true/false questions (from Millers *et al.* [2006] investigation--see part Four). All study procedures were reviewed and approved by the University of Cincinnati (UC) Social and Behavioral Sciences Institutional Review Board (IRB) prior to the onset of data collection.

The two biology courses were the third quarter of course sequences for either freshmen (Introductory Biology) or sophomores (Ecology) and each course consisted of a mixture of students of different class standings. However, the majority of students in the Introductory Biology course were freshman and sophomores while the majority of students in the Ecology course were juniors and seniors (Table 3.2). There were 361 students distributed among five sections of the introductory course: two daytime (B1 and B2), one evening (BH9), and two honors sections (BH1 and BH2). There were 117 students in the Ecology course, which had only one section. The sophomore level ecology course has the following pre-requisites: complete the introductory biology sequence (with students earning a C or better in each course in the sequence) and a sophomore genetics course.

Students completed the survey questions around the 8th week of the ten-week spring quarter. As incentive to participate, the investigators offered

students a one-of-a-kind discount coupon donated from a local college bookstore (DuBois Bookstore in Cincinnati, O.H.). Participation was completely voluntary and did not impact course grades. GLCI data from these courses were compared to post-course NSM GLCI data collected by Bowling (2007a), which were obtained during the winter quarter of 2007 from students enrolled in an introductory biology course for undergraduate NSMs.

Data Collection

The online course management system (Blackboard 6) was used for data collection and also for subsequent distribution of the incentive coupons for those participating. Student names were not linked to any individual response to the GLCI items, so every response was anonymous. Incomplete student responses (approximately 3%) were eliminated from the final dataset.

Data Analysis

Data were analyzed using the JMP Start Statistical Software package 5.1 (SAS Institute). Since the GLCI data from the five sections of Introductory Biology violated assumptions of normality, the Kruskall-Wallis test was performed in order to determine if there were differences in the average GLCI scores among students in each of these five introductory biology sections. Some of the sections had normal distributions (Table 3.1) but the small sample size for each section was the major violation of normality and thus, was our primary reason for using the Kruskall-Wallis test.

Table 3.1: Results of Shapiro-Wilks W test for goodness of fit for a normal distribution of GLCI scores for each section of Introductory Biology.

Introductory Biology Section	n	W	p-value
B1	42	0.9668	0.258
B2	48	0.9471	0.031
B3	17	0.9730	0.868
BH1	9	0.9379	0.563
BH2	9	0.7316	0.003

The Kruskal-Wallis test revealed no significant differences (x^2=7.78, df=4, p=0.100) among the five sections of Introductory Biology (Figure 3.1). Given homogeneity, data from these five individual sections were combined, so the students from each of the two courses represented two groups: Introductory Biology (IB) and Ecology/Sophomore Biology (SB). The average GLCI scores from IB and SB were compared to each other, and to the average post-course GLCI scores for the NSM group from Bowling's (2007a) study. Additionally, all three courses' average scores were compared to an average score of 20%, which would be the expected outcome obtained from random guessing since there were five answer options per GLCI question. The Institutional Research office at the University of Cincinnati provided demographic data to determine how representative the volunteer responder population was compared of the whole course population (Table 3.2).

Results:

The response rate of 35% (125/361) from IB was relatively low compared to the total enrollment in the five sections. The response rate from SB was even lower at only 17% (20/117). However, demographic data for each course as a whole and the subset of respondents indicate the sample is fairly representative for the IB course, but less so for SB (Table 3.2).

Students in the different sections of the IB course scored similarly, although honors section 2 (BH2; n=9) had the highest average GLCI scores (Figure 3.1). After condensing these IB sections into one IB group for analyses, significant differences were detected among the three groups (IB, SB and NSM; Figure 3.2) (X^2=30.88; DF=2; p<<0.01). The students in the IB course scored an average of 56.9%, which is significantly less than the average of 63.8% scored by students in the SB course (X^2=4.64; DF=1; p=0.03). Individual Pairwise comparisons revealed that students in both of these biology courses averaged higher GLCI scores than student in the NSM course (46.5%) (IB vs. NSM: X^2=22.030; DF=1; p<<0.01 and SB vs. NSM: X^2=13.00; DF=1; p<<0.01; Figure 3.2). All three groups' average GLCI scores were higher than what would be obtained from random guessing (20%).

Table 3.2:
Percent demographics for the total number of students in each course and for the subset of student respondents in each courses

	IB	IB Respondents (%)	SB	SB Respondents (%)
College	n=355	n=125 (35%)*	n=118	n=21 (17%)
Allied Health	15.5%	19.8%	6.0%	10.5%
Arts and Sciences	78.3%	73.6%	91.5%	89.5%
Education	2.5%	1.9%	1.7%	--
Other	3.7%	4.7%	0.8%	--
Major				
Biological Sciences	24.8%	17.9%	70.1%	73.7%
Pre-Pharmacy	24.8%	31.1%	4.3%	--
Health Sciences	7.0%	6.6%	--	--
Psychology	5.9%	6.6%	0.9%	--
Exploratory	5.6%	1.9%	1.7%	--
Environmental	2.0%	2.8%	8.5%	10.5%
Other	29.9%	33.1%	14.5%	15.8%
Class Standing				
Freshman	37.2%	44.3%	--	--
Sophomore	29.6%	24.5%	12.0%	5.3%
Junior	15.2%	16.0%	40.2%	57.9%
Senior	18.0%	15.1%	47.9%	36.8%
Gender				
Female	60.0%	67.0%	55.6%	57.0%
Male	40.0%	33.0%	44.4%	43.0%
Ethnicity				
White	74.9%	78.3%	70.1%	73.7%
Black	11.0%	10.4%	6.0%	5.3%
Asian	5.4%	3.8%	13.7%	15.8%
Other	8.7%	7.5%	10.2%	5.3%
Grade				
A	20.8%	25.5%	31.6%	47.4%
B	33.0%	38.5%	31.6 %	21.1%
C	27.9%	26.4%	27.3%	15.8%
D	12.2%	7.5%	6.9%	10.5%
F	6.2%	1.9%	2.6%	--

*Demographics reported for 106/125 respondents

Figure 3.1: Average GLCI scores (max=31) for each section Introductory Biology. *Standard error bars provided.*

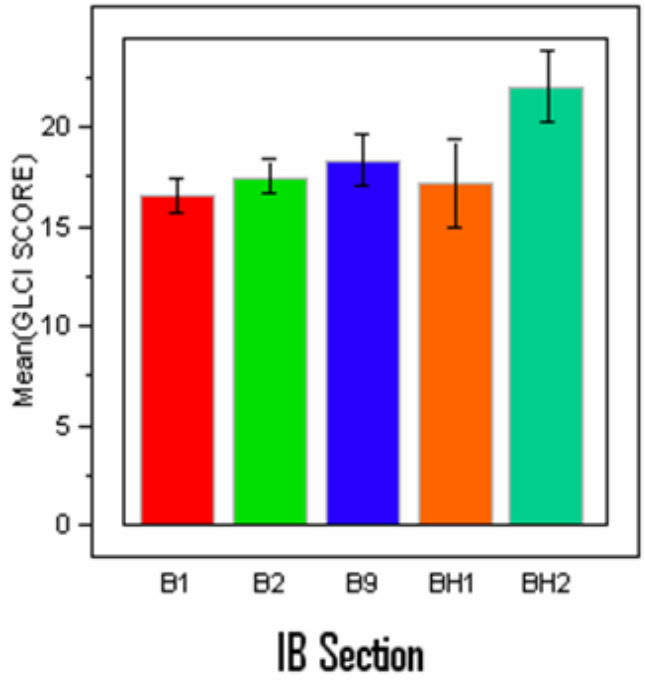
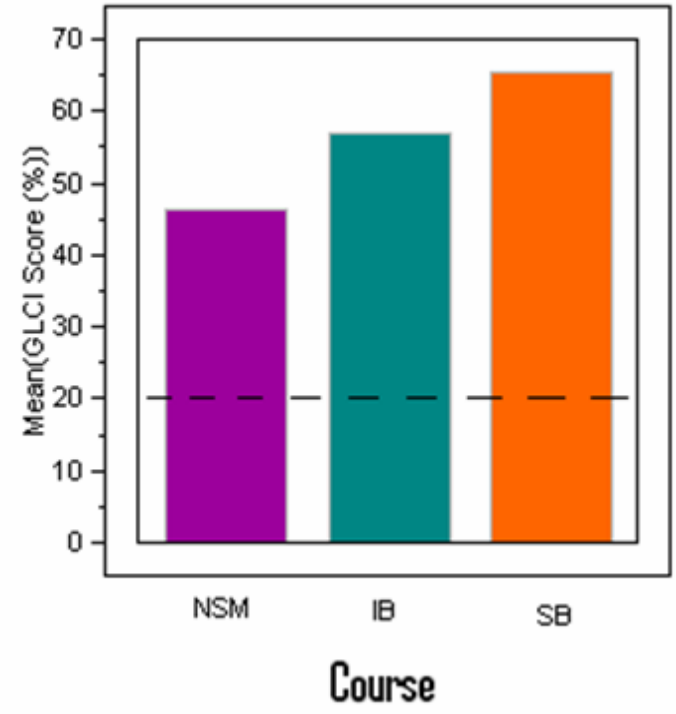


Figure 3.2: Average GLCI scores (%) for each course.



Discussion:

With the recent development of the GLCI (Bowling *et al.* 2007b) we can now assess how improvements in genetic literacy might be achieved, similar to what has already been accomplished in physics and chemistry (Fagen 2003, Hake 1998). The results of this study are nicely consistent with expectations: the average GLCI score of students in the IB course (56.5%) is significantly higher than the NSM average (46.5%), while the SB average (63.8%) is significantly higher than both. These results were expected because biology majors are more likely to have a better grasp of biological concepts (including genetic concepts) than non-science majors due to the increased class work and experiences that occur from majoring in biology. For example, most biology majors' coursework includes co-requisite weekly 3-hour labs which give majors additional practical application of course material in a setting with a higher teacher-student ratio. Furthermore, students in the SB course have previously had an entire course in genetics (with a 3-hour weekly lab), as well as having at least a total of six quarters of biology courses (although most of the students in the SB course were juniors and seniors [Table 2.10] having had 9 and 12 quarters of biology courses, respectively).

LIMITATIONS

The low level of participation in this study is one of the limitations and is probably due to a lackluster incentive (the money saving coupon from the local bookstore). If a more desirable incentive were available, participation might

have been higher. In Bowling's (2007a) study, NSMs were offered extra credit amounting to 1% of their final grade, which is probably why a higher response rate was obtained (83%); offering extra credit in this study was not an option for the investigators because of difficulty in getting permission to do so from all the collaborating instructors. Another possible reason for low participation could have been a lack of student time. Given that the study was implemented toward the end of the quarter which was also the end of the academic year, it is possible students were preoccupied and/or overwhelmed with other responsibilities. Future studies need to consider both of these potential problems in an effort to maximize response rate. An additional limitation is that the results reported from this study reflect only two biology majors' courses at a single institution and we cannot discount the possibility that the results may have been different if additional institutions and courses (and therefore more biology students) were involved. Lastly, given that the individual GLCI responses were anonymous, we were unable to make direct comparisons of genetic literacy to various factors that may contribute to it (such as the grade in the course, number of biology/genetics courses taken, age, class standing, ethnicity, gender, etc.). Knowing if these or other factors contribute to genetic literacy would potentially aid in improving it within the classroom environment.

CONCLUSIONS

An important trend from the this study is that students in a sophomore biology course for majors and pre-professionals in the life sciences have higher GLCI scores than majors in an introductory biology course, who in turn had higher GLCI scores than non-science majors. Despite detecting a higher level of genetic literacy of students in the SB course, an average score of 63.8% may not be sufficient for demonstrating genetic literacy. The informally suggested minimum score of 70% or higher may be adequate (Huether, personal communication) and seems to be supported in this study. If so, none of these groups of students have achieved it. Bowling's (2007a) study provides additional support for the observed trend since she reported that genetics graduate students scored 87% on the GLCI. Given this graduate student GLCI scoring along with the GLCI scores of 63% from the sophomore class, a GLCI score of 70-75% might be viewed as an appropriate range for a minimally genetically literate individual.

Furthermore, an evaluation of the undergraduate genetics curriculum and teaching practices, for both majors' and non-majors' courses, would appear to be in order since the highest level of achievement in this study of undergraduates was 63%. An identification of the factors that impact student acquisition of genetics knowledge may also be necessary and would likely be helpful in efforts to improve undergraduate genetics education. It would be interesting to determine the level of genetic literacy at a future time (i.e. follow-

up four or six months later) for these same students, to determine the relative level of retention of genetics knowledge.

These findings, together with Bowling's (2007a), provide further support that the GLCI is an effective tool for measuring genetic literacy since higher levels are detected in students with more biology experiences. In addition, the GLCI is useful for measuring the effect of courses at different university levels. This study is an important step in assessing student learning of genetics at the undergraduate level and also for suggesting a minimal level of genetic literacy via the GLCI. Further work is needed to support these preliminary findings and to continue the effort toward making improvements in undergraduate genetics education. Specifically, an appropriate minimum score on the GLCI is needed in order to more adequately determine the level of undergraduate genetic literacy that students obtain from their coursework.

PART FOUR: UNDERGRADUATE GENETIC LITERACY – T/F QUESTIONS

Background:

Just as recent studies have identified low levels of genetics knowledge in the general public (Lanie *et al.* 2004, Bates 2005) and also in undergraduate students (Saddler and Zeidler 2004, Acra 2006, Bowling, *et al.* 2007c), Miller *et al.* (2006) considered the impact of genetic literacy (and other variables) on public acceptance of evolution. Miller, *et al.* (2006) reported that people in the United States have limited acceptance of evolution. Using data collected in 2002 as a part of a larger study of public attitudes toward understanding biotechnology, nine independent variables were considered in an effort to predict attitudes toward evolution in 10 countries, including the United States (Miller, *et. al.* 2006). One of the nine variables was genetic literacy, which was measured by scoring participants' answers to a set of 10 true/false genetics questions (Miller, *et al.* 2006).

Our study attempted to determine the level of genetic literacy of undergraduate biology majors and non-science majors (NSM) as measured by 9 of the 10 genetics questions from the Millers, *et al.* (2006) study, but did not consider student attitudes toward evolution. The objectives of this study were (1) to determine the level of genetic literacy of students in a freshman Introductory Biology (IB) course and a sophomore Ecology (SB) courses as measured by nine True/False questions, (2) to compare this level of genetic literacy between these two courses, and also with the level of genetic literacy as

measured by Bowling's' (2007b) GLCI, and (3) to compare this level of genetic literacy in the IB and SB courses to that of non-science majors (NSM).

Methods:

Participation

The participants and methodology for this study were the same as those involved in part three. Students in the five sections of the IB course and the SB course completed 40 questions (toward the end of the 2006-2007 academic year) which intend to measure genetic literacy. These questions included Bowling's 31-item GLCI (discussed in part three) and nine of the 10 True/False (T/F) questions from the Miller *et al.* (2006) study. Responses to the questions for students in the IB course and SB course were compared with that of non-science majors (NSM) in an introductory biology course who answered the same set of questions (Bowling, unpublished data). Of the 10 T/F questions, only nine were used in this study because Bowling's data (2007) included results from nine of the ten T/F questions; this was because one of the questions was controversial (i.e. it was no longer consistent with the findings of recent research regarding the use embryonic stem cells [Liao 2005]); the omitted question states "It is possible to extract stem cells from human embryos without destroying the embryos" (originally listed as False, but now True). Student scores were calculated by providing one point per correct response, for a maximum score of nine.

Data Analysis

Data were analyzed using the JMP Start Statistical Software package 5.1 (SAS Institute). Since these data violate the assumptions of normality due to low sample size, the Kruskall-Wallis test was performed in order to determine if

there were differences in the average T/F scores among students in each of these five introductory biology sections. Two of the five introductory biology (IB) sections had normal distributions, but the small class sizes (and therefore sample sizes) for these sections (n=17, n=9) were our primary reason for performing the Kruskall-Wallis test (Table 4.1).

Table 4.1: Results of Shapiro-Wilks W test for goodness of fit for a normal distribution of T/F scores for each section of introductory biology

Introductory Biology Section	n	W	p-value
B1	42	0.8783	0.0003
B2	48	0.8787	0.0001
B3	17	0.9109	0.1035
BH1	9	0.8541	0.0826
BH2	9	0.6363	0.0003

The average T/F scores for students in the five different sections of the Introductory Biology course, and the other courses were compared (Table 4.2). The Kruskall-Wallis test revealed no significant differences among these five sections of Introductory Biology (X^2= 6.93; DF=4; p=0.139). As such, data from these five sections were condensed into one Introductory Biology group (IB). The mean T/F scores for all three courses (IB, SB and NSM) were subsequently compared and the Kruskall-Wallis test revealed significant differences (X^2=15.91; DF=2; p<<0.01). Pair-wise comparisons revealed that the two groups of biology majors (IB and SB) were not significantly different from one another (X^2=1.50; DF=1; p=0.22). Thus, the students from each of the two courses (IB and SB) were further condensed into one group of biology majors

and life science pre-professionals (identified hereafter as Biology Majors, or [BM]).

The average scores on the T/F questions for the BM group were compared to average post-course T/F scores for the NSMs. Both groups' average scores were compared to a mean score of 50%, which is the expected outcome obtained from random guessing since each question had only two answer options (either 'true' or 'false') (Figure 4.1). The students from each course (NSM Introductory Biology, BM Introductory Biology, and BM Sophomore [Ecology] Biology) were also compared across the nine individual T/F questions (Table 4.3).

Results:

Participants included 125 students from the five sections of the Introductory Biology course (IB group) which averaged 7.42 (82.4%) and 21 students from the sophomore course (SB group) which averaged 7.82 (86.9%) (Table 4.2).

Table 4.2: Average T/F scores for each course

COURSE	**n**	**Average T/F Score (%)**
Sophomore Biology (SB)	21	7.82 (86.9%)
Introductory Biology (IB)		
Section: B1	42	7.19 (79.9%)
B2	48	7.40 (82.2%)
B9	17	7.47 (83.0%)
BH1	9	7.67 (85.2%)
BH2	9	8.22 (91.3%)
IB Overall:	*125*	*7.42 (82.4%)*
NSM	235	6.82 (75.8%)

Introductory biology students in one of the honors sections (BH2) scored higher than all other IB sections and even higher than those in the SB course. Bowling's (2007a) NSM students (n=235) returned an average score of 6.82 (75.8%) which was significantly lower (X^2=37.29; DF=1; p<0.0001) than that of biology majors (BM) who scored 7.48 (Table 4.2). When examining the average scores among the students across the three courses, there was a trendline of increasing genetic literacy; the students in the NSMs course scored the lowest, the students in the IB course scored higher, and the students in the SB course scored the highest (Table 4.2). Both groups had a higher mean score than what would have been obtained from random guessing (Figure 4.1)

Students in the sophomore biology (SB) course scored highest on six out of the nine questions with two questions being universally answered correctly (Table 4.3). Introductory Biology (IB) students (within the BM cohort) scored the highest on question five and seven while the NSMs scored the highest on question six. All three groups scored relatively low for question seven and relatively high for question nine.

Figure 4.1: Average T/F scores (max=9) for each type of student. *Standard Error bars provided.*

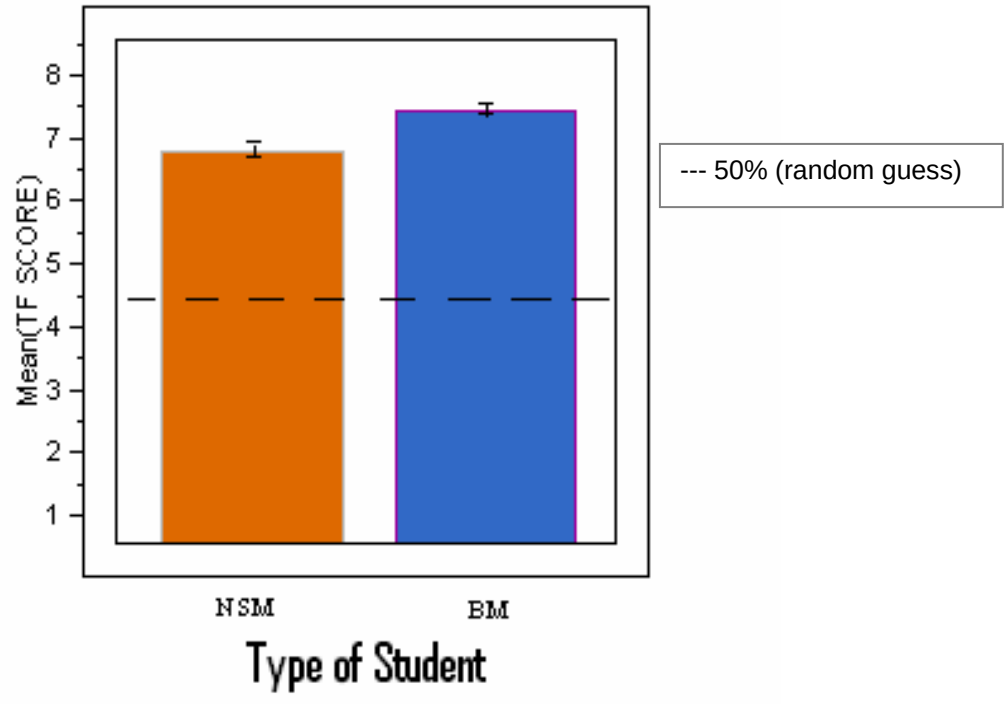


Table 4.3 Number of students from each course answering the True/False questions correctly

	(NSM) Introductory Biology	**(BM) Introductory Biology**	**(BM) Upper Level Biology**
Question (correct answer)	n=235	n=125	n=21
1. Ordinary tomatoes do not have genes, whereas genetically modified tomatoes do. (F)	209 (88.9%)	113 (90.4%)	20 (95.2%)
2. Genetically modified animals are always larger than ordinary animals. (F)	187 (79.6%)	116 (92.8%)	21 (100%)
3. Cloning is a form of reproduction in which offspring result from the union of sperm and egg. (F)	174 (74.0%)	96 (76.8%)	17 (81.0%)
4. Today it is not possible to transfer genes from humans to animals. (F)	132 (56.2%)	93 (74.4%)	16 (76.2%)
5. If someone eats a genetically modified fruit, there is a risk that a person's genes might be modified too. (F)	207 (88.1%)	121 (96.8%)	20 (95.2%)
6. All plants and animals have DNA. (T)	208 (88.5%)	105 (84.0%)	18 (85.7%)
7. Today it is not possible to transfer genes from animals to plants. (F)	103 (43.8%)	72 (57.6%)	11 (52.4%)
8. Humans have somewhat less than half of the DNA in common with chimpanzees. (F)	178 (75.7%)	97 (77.6%)	21 (100%)
9. All humans share exactly the same DNA. (F)	205 (87.2%)	114 (91.2%)	20 (95.2%)
10. It is possible to extract stem cells from human embryos without destroying the embryos. (F)	not included	not included	not included
AVERAGE TOTAL (%) CORRECT:	**75.80%**	**82.40%**	**86.80%**

Discussion:

Determining baseline levels of undergraduate genetics knowledge is necessary for making improvements in genetic literacy. While the development of the GLCI is a valuable step toward accomplishing this, using the true/false questions from the Miller *et al.* (2006) investigation provides additional insight into the level of genetics knowledge obtained by students. The trendline established from this study is similar to that which was seen from the GLCI results (part three) and further supports our expectation that with increased biology education there is increased genetic literacy. However, this observed trendline is not as strong as that elucidated by the GLCI test; the T/F questions have indicated there is no measurable difference within the biology major cohorts (either IB or SB) while this was clearly discernable from the GLCI results (see part three). Potential reasons for the T/F questions not distinguishing among these two levels as well as the GLCI are as follows: the questions are not as sophisticated, there are only nine of them (compared to 31 GLCI items), and the range above random guess is 50 points (rather than 80 points from the GLCI items).

The results from this study nicely illustrate that some concepts are generally and consistently understood by undergraduate students while others are not. For example, all three groups scored well on question nine (All humans share exactly the same DNA. [F]) but none of the groups scored well on question seven (Today it is not possible to transfer genes from animals to plants. [F]).

Interestingly, NSMs scored the highest on question 6 [All plants and animals have DNA. (T)] which might be viewed as addressing a fundamental concept all biology majors should firmly understand. However, this question could be misleading, and an explanation for this result could be that biology majors knew too much. They may have considered retro viruses (which have RNA rather than DNA) when answering this question; if the students concluded that retro viruses are living organisms (and therefore could be classified as either living "plants" or "animals") then in this instance, answering the question as 'false' would not be incorrect.

LIMITATIONS

Having only two options ('true' or 'false') could have forced the strength of each position (Miller *et al.* 2006). In the Miller *et al.* (2006) study, the True/False questions offered five answer choices including 'definitely true', 'probably true', 'probably false', 'definitely false' and 'uncertain' with scoring accomplished by assigning one point for an "absolutely true/false" response, one-half of a point for a "probably true/false" response (depending on correct answer being either 'true' or 'false') and zero for answering incorrectly. Future studies may benefit from adopting this type of scoring policy, since it can delineate more clearly among the ambiguity of a dichotomous response. Dichotomous answer options were used for the T/F questions in this study because Bowling's NSM T/F data was dichotomous and it was being used in comparison.

CONCLUSIONS

A similar trend was seen in this study, as in part three of this research: students in a sophomore biology course for majors and pre-professionals in the life sciences scored higher (although, not significant) than similar students in an introductory biology course when answering questions which address genetic concepts, while NSM students scored the lowest. Results from this study provide useful insight to instructors regarding the instruction of various genetics topics. While the GLCI items may detect the increase of genetic literacy among the different levels of students more accurately, the T/F questions nicely demonstrated which concepts might be more difficult for students to grasp. Attitudes toward evolution were not considered in this investigation, but future studies could easily compare student answers to these questions with their acceptance of evolution.

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Appendix A: The Workshop Agenda

Time	Event
8:00-8:30 am	Continental Breakfast
8:30-8:35 am	Welcome
8:35-8:45 am	Opening Remarks, Introduction of the Course
8:45-9:00 am	Summary of participant demographics
9:00-9:15 am	Introductions by participants
9:15-9:30 am	Agenda Review: Goals of Workshop
9:30-9:50 am	Direct-to-Consumer Genetic Testing
9:50-10:00 am	Questions/Discussion
10:00-10:30 am	Pedagogical Session #1
10:30-10:45	Break
10:45-11:15 am	Genetics of Race
11:15-11:25 am	Questions/Discussion
11:25-Noon	Pedagogical Session #2
Noon-12:30 pm	Lunch
12:30-1:00 pm	Small group brainstorming session
1:00-1:50 pm	Genetics in the News
1:50-2:45 pm	How the Media Mangle Science
2:45-3:00 pm	Break
3:00-3:30 pm	Taking it all back: Time for self-reflection and review on what they learned, how to put it in the context of their own course. What they could adapt, develop, concerns, questions?
3:30-4:00 pm	Evaluation and Seven-month follow-up: What happens next?

Appendix B: List of Resources provided to Workshop Participants

DVD: Evolution
DVD: Race: The Power of an Illusion
DVD: Learning From Patients The Science of Medicine
Nature Collections – Human Genome (scientific articles)
Poster: Human Genome Landscape
Resource Packet: Website (handout)
Resource Packet: Genomics and its Impact on Science and Society (handout)
Resource Packet: Copy of article in Genetics – Teaching resources for Genetics, Haga, S.B. 2006
Resource Packet: Copy of article in Cell Biology Education – Approaches to Cell Biology Teaching, Allen and Tanner 2003
Resource Packet: Copy of article in Journal of Animal Science – Writing Across the Curriculum, Aaron, D.K. 1996
Resource Packet: Race The Power of an Illusion (handout)
Resource Packet: Race, Genetics, and Health Care (DVD/CD-ROM)
Speaker Handouts: Vence Bonahm, Genetics of Race
Speaker Handouts: Ricki Lewis, How the Media Mangle Science
Nature Genetics Volume 38: Number 7, July 2006
Nature Milestones: Gene Expression, December 2005
Textbook: Human Genetics, 7th Ed. By Ricki Lewis
Textbook: Human Heredity, 7th Ed. By M. Cummings

Appendix C: Pre-workshop Data Collection Instrument

1. Please provide the following information:

Name Institution Department

2. Of the courses you plan to teach in 2006-2007, will at least one course contain genetics content?

- o Yes
- o No

3. If yes to question 2, please indicate (up to 2 courses) the name of the course, when during the '06-07 year you plan to teach it.

Course name: When:
Course name: When:

4. Does your institution operate on a quarter or semester system?

- o **Quarter**
- o **Semester**
- o **Other; please specify:**

5. What do you hope to gain from this workshop (i.e. what information would you like receive; what topics would most help you in preparing to teach your course/s after the institute)?

6. In addition to the Genetics Education Workshop, are you planning on registering for and attending the ASHG meeting itself?

- o **Yes**
- o **No; please provide reasons**

7. Would you have attended the ASHG meeting even if the Genetics Education Workshop was not offered?

- o **Yes**
- o **No**

Please provide information regarding courses you have taught during the last academic year that contained genetics/human genetics content (include a course/s that is/are taught on an alternate year schedule).

If you did not teach any course with genetics content, please proceed to question 15.

8. At what level do you currently teach a course/s that have genetics/human genetics content? Please check all that apply.

_Freshman non-science majors
_Freshmen biology majors
_Sophomore biology majors
_Advanced undergraduate biology
_Advanced undergraduate chemistry
_Advanced undergraduate nursing
_Graduate biology
_Graduate nursing
_Other _____

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9. Please list (up to 3) courses you taught during the past academic year that contained genetics/human genetics (including course name, textbook, and when it was taught).

Course Name	**Book** (title, edition, and authors)
1.	
2.	
3.	

10. Regarding the course you have taught which has the <u>most</u> genetics content, about what percent of your total course content includes genetics?

- o <15%
- o 15-30%
- o 30-45%
- o 45-60%
- o >60%

11. About what percent of your total genetics content (from previous question) is specific to HUMAN genetics?

- o <15%
- o 15-30%
- o 30-45%
- o 45-60%
- o >60%

12. Of the concepts listed below, please choose the number that represents the importance of each concept in meeting your course objectives, with "3" being the most important, and "0" indicating you do not teach the concept.

0 = Concept not taught 1 = Minimally Important 2 = Important 3= Very Important

Nature of the Genetic material				
DNA Structure	0	1	2	3
DNA Function	0	1	2	3
Replication	0	1	2	3
Transmission				
Mitosis	0	1	2	3
Meiosis	0	1	2	3
Mendelian Genetics	0	1	2	3
Human Disease Inheritance	0	1	2	3
Gene Expression				
Translation	0	1	2	3
Transcription	0	1	2	3
Gene-Environment interaction	0	1	2	3
Gene Regulation				
Protein products and function	0	1	2	3
Turning genes on/off	0	1	2	3
Errors in gene regulation	0	1	2	3
Evolution				
Genetic Variation	0	1	2	3
Natural Selection	0	1	2	3
Darwinian Evolution	0	1	2	3
Conserved DNA sequences	0	1	2	3
Population Genetics	0	1	2	3
Genetics and Society				
Human Genome	0	1	2	3
Genetic technology	0	1	2	3
Genetics in Society	0	1	2	3
Genetics in the Media	0	1	2	3
Genetic Misconceptions	0	1	2	3

13. How comfortable do you currently feel teaching the following genetics concepts?

0=not at all, 1=somewhat comfortable, 2=comfortable, 3=quite comfortable

I. The Nature of the Genetic Material	0	1	2	3
II. Transmission	0	1	2	3
III. Gene Expression	0	1	2	3
IV. Gene Regulation	0	1	2	3
V. Evolution	0	1	2	3
VI. Genetics and Society	0	1	2	3

14. What teaching tools have you used in your course/s containing genetics content? Please indicate which tools you use by choosing the number that represents your use of each tool: "4" represents you use the tool in essentially all of the courses you have taught.

0=not used, 1=a few classes, 2=about half, 3=most, 4=essentially all.

Teaching Tools:

PowerPoint	0	1	2	3	4
In-class handout	0	1	2	3	4
Blackboard/equivalent	0	1	2	3	4
Personal Response System (PRS)	0	1	2	3	4
Overhead projector	0	1	2	3	4
Chalkboard/Whiteboard	0	1	2	3	4
Class discussion	0	1	2	3	4
Hands-on	0	1	2	3	4
Interactive/Socratic	0	1	2	3	4
Video	0	1	2	3	4
Internet	0	1	2	3	4
Role play	0	1	2	3	4
Small group discussions	0	1	2	3	4
Guest speaker	0	1	2	3	4
Lecture only	0	1	2	3	4

15. Recently there has been a demand for information about how undergraduates are performing in classes that present genetics concepts. Would you be willing to participate in a project that involves assessing your undergraduate students' knowledge of genetics concepts?

- o Yes
- o No
- o Maybe. Please send me more information. My email address is:_____

16. What is your ethnicity?

- o White (non-Hispanic)
- o Black
- o Indian
- o Native American
- o Asian
- o Hispanic
- o Other: (please specify):_____

17. What is your highest degree?

- o Associate's
- o Bachelor's
- o Master's
- o Doctoral
- o Other (please specify):_____

18. Please indicate the discipline in which you are professionally trained.

- o Botany
- o Ecology
- o Evolution
- o Genetics
- o Microbiology
- o Molecular/Cellular Biology
- o Science Education
- o Zoology
- o Nursing
- o Chemistry
- o Biophysics
- o Other _____

19. What is your current title?

- o Tenure-track Assistant Professor
- o Tenure-track Associate Professor
- o Tenured Professor
- o Adjunct professor/instructor
- o Department Head
- o Other (please specify):_____

Thank you for your time.
If you have any questions, please contact Christine Moskalik at moskalcl@email.uc.edu

Appendix D: Immediate anonymous surveyImmediate anonymous survey Survey/Data Collection Instrument

1. Please use the table to indicate how the workshop impacted you as a professor, by placing an "x" in the appropriate box for each statement.

The workshop provided me with:	1 Strongly disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly agree	N/A *please indicate why
tools or ideas that will clearly improve my teaching of human genetics concepts in my courses.						
an increased knowledge of a variety of human genetics topics which are relevant to my classes.						
a greater understanding of pedagogies to improve active student learning in my class/es.						
an appreciation for the value of relating class material to the students' everyday lives and important societal issues.						
a greater appreciation for how societal issues such as race and genetics, evolution, stem cell research, etc. can be presented and discussed in my classes.						
an increased desire to incorporate teaching human genetics in my course/s.						
a greater comfort level for teaching human genetics concepts.						
an awareness of additional resources that will help me accomplish my course objectives.						

2. Name one thing you felt you most gained from the workshop.

_____

3. Name one thing you felt could have been most improved in the workshop.

_____

4. Were your expectations for the workshop met?

- o Yes, definitely
- o Yes
- o For the most part
- o Occasionally
- o Not at all

5. Was there something missing from the workshop? Please provide an explanation for your response.

- o Yes:_____
- o No:_____
- o Unsure at this time:_____

6. Please rate each workshop <u>Presentation</u> and <u>Discussion/Brainstorming Session</u> as to how valuable each was in contributing to improvements you could make in teaching human genetics in your own courses.

The following workshop sessions were useful to me for making improvements in teaching human genetics in my class/es.	1 Strongly disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly agree	N/A *please indicate why
Presentation **Direct-to-Consumer Genetic Testing** Roberta Pagon						
Question/Discussion Session 1						
Pedagogical Session #1 **Getting Students Involved** Adam Hott						
Presentation **Genetics of Race** Vence Bonham						
Question/Discussion session 2						
Pedagogical Session #2 **Integrating Social Issues Through Writing** Adam Hott						
Small group brainstorming session						
Presentation **PRS/Genetics in the News** Carl Huether						
Presentation **How the Media Mangle Science** Ricki Lewis						
Brainstorming/discussion session **Taking it all back: self-reflection/review**						

7. Do you live/work within 50 miles of New Orleans?

- o Yes
- o No

8. How likely are you to implement some aspects of this workshop into your future teaching plans?

- o Very likely
- o Likely
- o Neutral
- o Unlikely
- o Very unlikely

9. If you answered Neutral, Unlikely, or Very Unlikely for question 8, please provide reasons:_____

_____

_____

10. Who is <u>the primary audience</u> for which the information from this workshop may be brought back to?

- o Freshman non-science majors
- o Freshmen biology majors
- o Sophomore biology majors
- o Advanced undergraduate biology
- o Advanced undergraduate chemistry
- o Advanced undergraduate nursing
- o Graduate biology
- o Graduate nursing
- o Other _____

11. Do you currently use one or both of the textbooks (Human Genetics, 7th Ed. By Ricki Lewis, and Human Heredity, 7th Ed. By M. Cummings) **that were given to you at the workshop?**

- o Yes, Lewis.
- o Yes, Cummings.
- o Yes, Both.
- o No.

12. If no to 11, are you planning on using one or both in your future course/s?

- o Yes, definitely
- o Probably
- o No
- o Unsure at this time

13. If a more extensive one-week Institute was offered next summer somewhere in the US, would you be interested in participating?

- o Yes
- o No
- o Unsure at this time

14. If no to question 13, please explain:_____

_____

15. How important would it be for part of or all or your expenses to be paid for attending a more extensive Institute in the future?

- o Very Important
- o Important
- o Somewhat important
- o Not important

16. How important would it be for you to receive a stipend for attending the institute?

- o Very Important
- o Important
- o Somewhat important
- o Not important

Please provide any additional comments/feedback below:_____

_____

_____

_____

Thank you!

Appendix E: Faculty Informed Consent Document

University of Cincinnati
Consent to Participate in a Research Study
McMicken College of Arts and Sciences
Department of Biological Sciences
Christine L. Moskalik, Principle Investigator
(513) 556-2044/moskalcl@email.uc.edu

Title of Study:
Impact of an Undergraduate Genetics Education Workshop on Faculty Participants and Their Students.

Introduction:
Before agreeing to participate in this study, it is important that the following explanation of the proposed procedures be read and understood. It describes the purpose, procedures, and the potential risks and benefits of the study. It also describes the right to withdraw from the study at any time. It is important to understand that no guarantee or assurance can be made as to the results of the study.

Purpose:
The American Society of Human Genetics (ASHG) Annual meeting in October 2006 (New Orleans, LA) will involve a one-day workshop for college level faculty members from various institutions who teach courses involving concepts in genetics. The primary goal of the workshop will be to expose participating faculty to teaching techniques and genetic content that can contribute to improving their effectiveness in teaching genetics.

The purpose of my study is to assess the effectiveness of the Undergraduate Genetics Education Workshop. You will be one of approximately 40 college faculty who participate in this study.

Duration:
Your participation in the study will involve the completion of one approximately 45-minute seven-month follow-up survey during the Spring term, 2007.

Procedures:
You are being asked to provide permission for me to have access to the data collected by ASHG at the time you registered for the workshop (these data are referred to as 'pre-workshop data'). Please do so by checking the appropriate box at the end of this document. The ASHG workshop committee has requested that you electronically provide a copy of your course syllabus. I would like your permission to have access to your syllabus as well. If you did not provide your syllabus to ASHG, please indicate if you are willing to share your syllabus with me by checking the appropriate box at the end of this document. Lastly, your participation will involve the completion of a 45-minute seven-month follow-up survey during the Spring term, 2007.

Exclusion:
You will not be able to participate in this study if any of the following apply to you:

1. You do not teach an undergraduate course/s containing a meaningful amount of genetics content.
2. You will not teach during the 2006-2007 academic year.

For those teaching at least one non-science majors course, there is additional exclusion criteria:

2. You do not agree to the student genetic literacy assessment.
3. You will have less than 20 undergraduates enrolled in your course.

Risks/Discomforts:
There are no foreseeable risks associated with participating in this study.

Benefits:
You will receive no direct benefit from participating in this study, but your participation may help college faculty and undergraduate institutions better understand undergraduate genetic literacy. These results may provide ideas for

enhanced teaching of genetics concepts by faculty, which would in turn lead to increased genetic literacy/enhanced learning of genetics concepts by undergraduate students.

Confidentiality:
Information you provide for this study will only be used for purposes of this research project. Research data obtained in this study will be kept in a locked file cabinet in the investigator's office, and stored on the principle investigator's personal computer in a password-protected database. Only the investigator will have access to your data. At the end of this study, any data on hard copy documents will be destroyed by shredding while electronic data will be destroyed by expunging. The data from the study may be published; however, you will not be identified by name.

Financial costs to the participant:
There are no costs for your participation in this study.

Right to refuse or withdraw:
Your participation is voluntary and you may refuse to participate**.** You may discontinue participation AT ANY TIME, without penalty or loss of benefits to which you are otherwise entitled. The investigator has the right to withdraw you from the study AT ANY TIME. Your withdrawal from the study may be for reasons related solely to you (for example, not following study-related directions from the investigator, etc.) or because the entire study has been terminated.

Offer to answer questions:
If you have any other questions about this study, you may call Christine Moskalik at 513-556-2044 or Dr. Carl Huether at 513-556-2044. If you have any questions about your rights as a research participant, you may call the Chair of the Institutional Review Board – Social and Behavioral Sciences, at 513-558-5784.

LEGAL RIGHTS:
Nothing in this consent form waives any legal right you may have nor does it release the investigator, the institution, or its agents from liability for negligence.

I HAVE READ THE INFORMATION PROVIDED ABOVE. I VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY. I WILL RECEIVE A COPY OF THIS CONSENT FORM FOR MY INFORMATION.

Permission to use information you provided at the time of you workshop registration:
☐ Yes, you have my permission to access the information I provided at the time I registered for the workshop. I understand my answers are confidential and will only be used for the purposes of this research project.

☐ No, please do not use that information.

Permission to use your course syllabus which you have provided electronically to the workshop committee:
☐ Yes, you have my permission to access the syllabus that I provided electronically.

☐ I did not provide my syllabus electronically, but I am happy to share it with you for purposes of this research project.

☐ No, you may not have access to my course syllabus.

_____
Please PRINT Full Name (First, Last)

_____ _____
Participant Signature Date

July 1, 2006

Appendix F: The 7-month Seven-month follow-up Survey/Data Collection Instrument

1. What is your name?

2. What is the name of your institution?

3. Regarding your course that has the most genetics content this academic year, about what percent of your total course content is genetics?

- o <15%
- o 15-30%
- o 30-45%
- o 45-60%
- o >60%

4. About what percent of your total genetics content (from previous question) is specific to HUMAN genetics?

- o <15%
- o 15-30%
- o 30-45%
- o 45-60%
- o >60%

5. Regarding the course from the previous two questions:

- o The course is primarily for non-biology majors
- o The course is primarily for biology majors
- o The course is for an even mix of both majors and non-majors
- o I didn't actually teach a course with lessons that included genetic content this academic year
- o Other (please specify)

6. Of the genetics concepts listed below, please choose the number that represents the importance of each concept in meeting your course objectives, with "4" being the most important, and "0" indicating you do not teach the concept. Choose "NA" only if your teaching plans changed and you did not/will not teach this academic year.

Nature of the Genetic material						
DNA Structure	0	1	2	3	4	NA
DNA Function	0	1	2	3	4	NA
Replication	0	1	2	3	4	NA
Transmission						
Mitosis	0	1	2	3	4	NA
Meiosis	0	1	2	3	4	NA
Mendelian Genetics	0	1	2	3	4	NA
Human Disease Inheritance	0	1	2	3	4	NA
Gene Expression						
Translation	0	1	2	3	4	NA
Transcription	0	1	2	3	4	NA
Gene-Environment interaction	0	1	2	3	4	NA
Gene Regulation						
Protein products and function	0	1	2	3	4	NA
Turning genes on/off	0	1	2	3	4	NA
Errors in gene regulation	0	1	2	3	4	NA
Evolution						
Genetic Variation	0	1	2	3	4	NA
Natural Selection	0	1	2	3	4	NA
Darwinian Evolution	0	1	2	3	4	NA
Conserved DNA sequences	0	1	2	3	4	NA
Population Genetics	0	1	2	3	4	NA
Genetics and Society						
Human Genome	0	1	2	3	4	NA
Genetic technology	0	1	2	3	4	NA
Genetics in Society	0	1	2	3	4	NA
Genetics in the Media	0	1	2	3	4	NA
Genetic Misconceptions	0	1	2	3	4	NA

8. In thinking about teaching the genetics portion of your course(s), to what degree to you use each of the following teaching tools?

Please indicate which tools you use by choosing the number that represents your use of each tool: (0=not used, 1=use some of the time, 2=use about half of the time, 3=use most of the time, 4=use all of the time).

PowerPoint	0	1	2	3
In-class handout	0	1	2	3
Blackboard/equivalent	0	1	2	3
Personal Response System (PRS)	0	1	2	3
Overhead projector	0	1	2	3
Chalkboard/Whiteboard	0	1	2	3
Class discussion	0	1	2	3
Hands-on	0	1	2	3
Interactive/Socratic	0	1	2	3
Video	0	1	2	3
Internet	0	1	2	3
Role play	0	1	2	3
Small group discussions	0	1	2	3
Guest speaker	0	1	2	3
Lecture only	0	1	2	3

8. How comfortable do you feel teaching the following genetics content areas?

I. The Nature of the Genetic Material ——————*Not at all*
——————*somewhat* ——————*comfortable*
——————*quite comfortable*

II. Transmission ——————*Not at all*
——————*somewhat* ——————*comfortable*
——————*quite comfortable*

III. Gene Expression ——————*Not at all*
——————*somewhat* ——————*comfortable*
——————*quite comfortable*

IV. Gene Regulation ——————*Not at all*
——————*somewhat* ——————*comfortable*
——————*quite comfortable*

V. Evolution ——————*Not at all*
——————*somewhat* ——————*comfortable*
——————*quite comfortable*

VI. Genetics and Society ——————*Not at all*
——————*somewhat* ——————*comfortable*
——————*quite comfortable*

9. Would you say that attending this workshop has enhanced your comfort level in teaching genetic information in your courses?

- o Entirely
- o For the most part
- o Neutral
- o Somewhat
- o Not at all
- o Other (please specify)

10. Have you implemented some aspects of the Undergraduate Genetics Education workshop into your teaching plans this year?

- o Yes
- o No

11. Please explain your response to the previous question in detail:_____

_____

_____

12. Below is a list of the content from the workshop. Please indicate which aspects of the workshop you implemented (or plan to implement) in your courses.

0=I haven't implemented anything from this topic
1=I have implemented a very little amount of information from this topic
2=I have implemented a good amount of information from this topic
3=I have implemented almost all information from this topic
4=I have implemented everything from this topic

Presentation: Direct-to-Consumer Genetic Testing….	0	1	2	3	4	NA
Pedagogical Session #1: Getting Students Involved…	0	1	2	3	4	NA
Presentation: Genetics of Race……..	0	1	2	3	4	NA
Pedagogical Session #2: Integrating Social Issues Through Writing…….	0	1	2	3	4	NA
Presentation: PRS/Genetics in the News…….....	0	1	2	3	4	NA
Presentation: How the Media Mangle Science……...	0	1	2	3	4	NA

13. If you chose "NA" for any of the workshop components listed in the previous question, please explain.

_____

14. Have you used one or both of the textbooks (Human Genetics, 7th Ed. By Ricki Lewis, and Human Heredity, 7th Ed. By M. Cummings) **that were given to you at the workshop?**

- o Yes, Lewis.
- o Yes, Cummings.
- o Yes, Both.
- o No.

15. Of the resources that were provided to you at the workshop please rate the items that you have found useful as an instructor.

0= Not at all useful; 1=Somewhat useful; 2=Neutral; 3=Fairly useful; 4=Highly useful; NA (Resource NOT Considered/Utilized at this point)

DVD: Evolution	0	1	2	3	4	NA
DVD: Race: The Power of an Illusion	0	1	2	3	4	NA
DVD: Learning From Patients The Science of Medicine	0	1	2	3	4	NA
Nature Collections – Human Genome (scientific articles)	0	1	2	3	4	NA
Poster: Human Genome Landscape	0	1	2	3	4	NA
Resource Packet: Website (handout)	0	1	2	3	4	NA
Resource Packet: Genomics and it's Impact on Science and Society (handout)	0	1	2	3	4	NA
Resource Packet: Copy of article in Genetics – Teaching resources for Genetics, Haga, S.B. 2006	0	1	2	3	4	NA
Resource Packet: Copy of article in Cell Biology Education – Approaches to Cell Biology Teaching, Allen and Tanner 2003	0	1	2	3	4	NA
Resource Packet: Copy of article in Journal of Animal Science – Writing Across the Curriculum, Aaron, D.K. 1996	0	1	2	3	4	NA
Resource Packet: Race The Power of an Illusion (handout)	0	1	2	3	4	NA
Resource Packet: Race, Genetics, and Health Care (DVD/CD-ROM)	0	1	2	3	4	NA
Speaker Handouts: Vence Bonahm, Genetics of Race	0	1	2	3	4	NA
Speaker Handouts: Ricki Lewis, How the Media Mangle Science	0	1	2	3	4	NA
Nature Genetics Volume 38: Number 7, July 2006	0	1	2	3	4	NA
Nature Milestones: Gene Expression, December 2005	0	1	2	3	4	NA
Textbook: Human Genetics, 7th Ed. By Ricki Lewis	0	1	2	3	4	NA
Textbook: Human Heredity, 7th Ed. By M. Cummings	0	1	2	3	4	NA

16. Have you made changes in more than one course based on your participation in the workshop?

- o Yes
- o No
- o I only teach one course

17. Approximately how many lessons plans did you prepare for your course (with genetics content) this academic year?

_____

18. Of the lesson plans/lectures you prepared (from the previous question) about how many of them were prepared using at least some of the information (via workshop resources, your experiences at the workshop, etc.) you gained from attending the workshop?

- o 0
- o 1-3
- o 4-6
- o 7-9
- o 10-12
- o 13-15
- o 16+
- o Other (please specify)

19. On a scale of 1-100% please indicate the relative amount of changes you made in a course (with genetics content) as a result of attending the workshop.

- o 0-10%
- o 11-20%
- o 21-30%
- o 31-40%
- o 41-50%
- o 51-60%
- o 61-70%
- o 71-80%
- o 81-90%
- o 91-100%
- o I haven't made any changes yet, but plan on doing so
- o I didn't teach this academic year

20. The following is a space for you to provide any additional feedback regarding the workshop and its impact on you as an educator.

_____

_____

_____

Thank YOU!

Appendix G: The Genetic Literacy Concept Inventory (GLCI)

1. What is the relationship among genes, DNA, and chromosomes?
a. Genes are composed of DNA and lie within chromosomes.
b. Genes are separate entities from either DNA or chromosomes.
c. Genes are found only in chromosomes and not DNA.
d. Genes are found only in DNA and not chromosomes.
e. Genes are composed of chromosomes and lie within DNA.

2. Which of the following accurately describes why we have genetic screening programs?
a. Adults are screened to treat chromosome anomalies.
b. Adults are screened to detect chromosome anomalies.
c. Newborns are screened for early detection and treatment of genetic disorders.
d. Newborns are screened for early detection and treatment of chromosome anomalies.
e. Fetuses are screened for treatment of chromosome anomalies.

3. Adult height in humans is partially determined by our genes. When environmental conditions are held constant, humans have a wide variety of heights (not just short, medium, and tall). Height is probably influenced by:
a. one gene with two alleles.
b. a single recessive gene.
c. a single dominant gene.
d. several genes.
e. only paternal genes.

4. Our understanding of how genes function indicates that:
a. different species of organisms use different genetic mechanisms for producing individual traits.
b. there are no interactions among genes in producing individual traits.
c. gene products can be carbohydrates, fats, or proteins.
d. genes do not produce specific products but code directly for individual traits.
e. genes code for proteins, which in turn produce individual traits.

5. What is the most likely way the genetic system (genetic material and the genetic code) of living organisms evolved?
a. The same genetic system repeatedly developed at different times in various organisms.
b. One genetic system developed early in the evolution of life in all organisms and remained.
c. One genetic system developed early but later changed into quite different genetic systems in different organisms.
d. One genetic system developed but well after numerous different species existed.
e. Different genetic systems evolved in different species.

6. Which of the following is INCORRECT regarding meiosis?
a. It occurs only in species of organism that have sexual reproduction.
b. It halves the chromosome number in reproductive cells.
c. It provides for genetic variation in the offspring.
d. It occurs in most body cells at some time during the life of the individual.
e. It keeps the chromosome number constant from generation to generation.

7. Sometimes a trait seems to disappear in a family and then reappear in later generations. If neither parent has the trait, but some of the offspring do, what would you conclude about the inheritance of the trait?
a. Both parents are carriers of the recessive form of the gene.
b. Only one parent has two copies of the recessive form of the gene.
c. Only one of the parents has a dominant form of the gene.
d. Only one parent has a copy of the recessive form of the gene.
e. It is most likely the result of new mutations in each parent.

8. An individual is found to have a mutation in a gene associated with breast cancer. In which cells is this form of the gene located?
a. Only in cells of the breast where cancer occurred.
b. Only in cells of both breasts.
c. Only in those cells found in females.
d. Only in the cells of the breast and ovaries.
e. All the cells of the individual.

9. Mutations in DNA occur in the genomes of most organisms, including humans. What is the most important result of these mutations?
a. They produce new genes for the individual.
b. They produce new enzymes for the individual.
c. They provide a source of new cells for the individual.
d. They provide a fundamental source of genetic variation for future generations.
e. They produce new chromosomes for future generations.

10. Multiple genes are associated with complex diseases such as cancer and mental disorders. When an individual is tested for these genes, what do the results indicate?
a. Whether or not s/he has the disease or disorder.
b. Whether or not s/he has an increased risk for developing the disease or disorder.
c. Whether or not s/he will definitely develop the disease or disorder.
d. Whether or not his/her children will definitely develop the disease or disorder.
e. How severe the disease or disorder will be if the individual has the gene.

11. Which of the following is a current benefit of the application of genetics and genetic technology to health care?
a. The ability to significantly increase human life expectancy.
b. The ability to conquer complex diseases like cancer.
c. The creation of inexpensive and easily administered drugs.
d. The ability to identify individuals and groups who are at increased risk of disease.
e. The ability to routinely use gene therapy to cure genetic diseases.

12. A woman has been told she carries a mutation associated with breast cancer. How does this influence her likelihood of developing breast cancer?
a. Her risk will be no different from any other healthy woman.
b. She will likely not get breast cancer.
c. She is at an increased risk for breast cancer.
d. She will definitely get breast cancer.
e. She already has breast cancer since she carries the mutated gene.

13. Many geneticists study the genetic material of organisms such as mice, fruit flies, and yeast. They are able to apply what they learn from these organisms to humans because virtually all different types of organisms:
a. have DNA as their genetic material.
b. have the same genetic code.
c. have the same amount of genetic material.
d. a and b are correct.
e. all of the above are correct.

14. As HIV has spread around the world, we know some individuals are resistant to the effects of the virus even though they are HIV positive. Why?
a. They carry genetic differences that provide the resistance.
b. Genetic changes that provide resistance are produced in response to infection by the virus.
c. Natural selection causes genetic differences to be produced that result in resistance.
d. The environment in which the individual lives determines resistance.
e. All of the above except d are correct.

15. Which of the following is a characteristic of mutations in DNA?
a. They are usually expressed and result in positive changes for the individual.
b. They are usually expressed and cause significant problems for the individual.
c. Those that occur in the body cells of a parent are usually passed on to their children.
d. They usually occur at very high rates in most genes.
e. They result in different versions of a gene within the population.

16. What is the relationship between DNA and chromosomes in higher organisms?
a. Chromosomes are found within DNA.
b. DNA is found within chromosomes.
c. There is no difference between DNA and chromosomes.
d. DNA and chromosomes are completely separate structures.
e. Chromosomes produce DNA.

17. Huntington's disease is a genetic disorder caused by a dominant gene. Symptoms begin in adulthood and the disease is ultimately fatal. What is an ethical dilemma presented by Huntington's disease when a parent is diagnosed with the disease?
a. Whether that parent should be tested for the gene.
b. Whether the other parent should be tested for the gene.
c. Whether and when any of the children should be tested for the gene.
d. Whether the parent should be treated for the disease.
e. Whether that parent should be told s/he has Huntington's disease.

18. Regarding complex traits such as IQ, lung cancer, prostate cancer, etc, how do geneticists describe the contributions of ones' genetic makeup and the environment?
a. The environment sets the potential for a trait; how much of that potential is realized depends upon the genetic make-up of the individual.
b. Each person inherits a genetic potential; how much of that potential is realized depends upon the environment.
c. Geneticists typically accept that most traits are determined heavily by genetics with the environment having little effect on complex traits.
d. The environment plays a major role in determining complex traits, with genetics playing a relatively minor role.
e. Genetic differences among humans are so minor that essentially all variations observed among individuals are due to the environment in which they were reared.

19. How is the expression of genes regulated or controlled?
a. The expression of genes is not regulated or controlled.
b. Genes are turned on during development and stay on throughout one's life.
c. Genes are only turned on and off during development.
d. Genes are turned on and off at appropriate times throughout one's life.
e. The expression of genes is only controlled by external factors.

20. If an individual has a genetic test for a mutation causing a particular disease, and the result is positive, what will that most likely mean?
a. The individual will definitely exhibit the disease, regardless of whether it is due to a dominant or recessive mutation.
b. The individual will definitely exhibit the disease only if it is due to a dominant mutation.
c. A positive test for the mutation indicates that the individual already has the disease.
d. It depends upon the disease involved, as testing positive for some mutations only show a higher risk for getting the disease.
e. The environment during the individual's development will be the primary determinant of whether the individual exhibits the disease.

21. What effect, if any, does an individual's environment have on the development of his or her traits?
a. It has little or no effect on most traits in an individual.
b. It sets the potential for the development of most traits in an individual.
c. It affects to varying degrees most traits in an individual.
d. It is a dominant factor for determining most traits in an individual.
e. It does not have any effect on an individual's traits, but can have an effect on the traits of an individual's offspring.

22. Your muscle cells, nerve cells, and skin cells have different functions because each kind of cell:
a. contains different kinds of genes.
b. is located in different areas of the body.
c. activates different genes.
d. contains different numbers of genes.
e. has experienced different mutations.

23. At what times during an individual's life does the environment influence the expression of his or her genes?
a. Beginning at conception and lasting throughout life.
b. Beginning at birth and lasting throughout life.
c. Beginning at birth and lasting until adulthood.
d. Occurring only during key stages of life such as puberty and menopause.
e. Environment has little or no effect on how genes are expressed.

24. Which of the following is INCORRECT regarding the genetic differences among ethnic groups?
a. There is much more genetic variation within ethnic groups than among them.
b. Differences in appearance represent only minor genetic differences among ethnic groups.
c. Genetic diseases, such as sickle cell disease, have an increased prevalence within certain ethnic groups.
d. The DNA sequence is more than 99.9% similar among all humans.
e. Genetic differences responsible for skin color represent a substantial portion of the human genome.

25. What is the relationship between genes and traits expressed in individuals?
a. Genes code for DNA, which is responsible for individual traits.
b. Genes code for proteins, which are responsible for individual traits.
c. Genes code for chromosomes, which are responsible for individual traits.
d. Genes code for carbohydrates, which are responsible for individual traits.
e. The environment rather than genes is primarily responsible for individual traits.

26. Which of the following does NOT accurately reflect Charles Darwin's basic principles of evolution?
a. The capacity of biological species to reproduce is limited.
b. The capacity of the earth to sustain continuous population growth is limited.
c. Differences among individuals are transmitted from generation to generation.
d. Some individuals are better equipped than others to survive changes in the environment.
e. Natural selection is the driving force of evolution.

27. Which of the following is NOT considered an ethical or legal concern?
a. Allowing prenatal sex selection.
b. Counseling couples not to have abnormal babies that require costly care.
c. Utilizing embryonic stem cells for research.
d. Giving insurance companies the right to deny insurance to those individuals known to have a high risk or genetic disease.
e. Offering mothers 35 years of age or older the opportunity to have prenatal diagnosis for chromosome anomalies.

28. Cystic fibrosis (CF) is a recessive disorder, meaning that an individual must have two copies of an abnormal CF gene to be affected. What is the probability that a child of two individuals who each have one copy of the abnormal gene will be affected with CF?
a. 0%
b. 25%
c. 50%
d. 66%
e. 75%

29. Which of the following is a correct statement about science and the scientific method?
a. They are rarely able to provide explanations of the natural world.
b. They are able to provide explanations that include the supernatural world.
c. They are processes of inquiry which include repeatable observations and testable hypotheses.
d. They are unlikely to contribute significantly to improving the human condition.
e. Their conclusions are not open to question in the light of new data and observations.

30. The muscle cells of humans contain 46 chromosomes. How many chromosomes do unfertilized human egg cells contain?
a. 11
b. 22
c. 23
d. 46
e. 92

31. What is an example of an unexpected consequence when current genetic technologies are used?
a. Determining the genetic make-up of an early embryo through preimplantation genetic diagnosis.
b. Determining the genetic make-up of a new baby through newborn genetic screening program.
c. Learning about a different paternity of a child upon testing for a genetic disorder.
d. Learning the carrier status of individuals who request adult genetic screening.
e. Finding a chromosome abnormality in a fetus where the mother has sought prenatal diagnosis.

Appendix H: Student Informed Consent Document

University of Cincinnati
Consent for Undergraduates to Participate in a Research Study
McMicken College of Arts and Sciences
Department of Biological Sciences
Christine L. Moskalik, Principle Investigator
(513) 556-2044/moskalcl@email.uc.edu

Title of Study:
Impact of an Undergraduate Genetics Education Workshop on Faculty Participants and Their Students.

Introduction:
Before agreeing to participate in this study, it is important that the following explanation of the proposed procedures be read and understood. It describes the purpose, procedures, and the potential risks and benefits of the study. It also describes the right to withdraw from the study at any time. It is important to understand that no guarantee or assurance can be made as to the results of the study.

Purpose:
The purpose of my study is to assess the effectiveness of an Undergraduate Genetics Education workshop. One component of doing this workshop assessment involves an evaluation of undergraduate genetic literacy. You will be one of approximately 800 undergraduates who participate in this study.

Duration:
Your participation in the study will involve completion of two approximately 30-minute online surveys (a pre-course survey and a post-course survey). Upon completion of the second survey your participation in this research study will be over. This consent, unless you choose to withdraw it, shall remain in effect until the end of the academic quarter/semester in which you take a course with of genetics information.

Procedures:
You will complete two online questionnaires that should take about 30 minutes each.

Exclusion:
You will not be able to participate in this study if you:
1) are under the age of 18.
2) are a science major.

Risks/Discomforts:
There are no foreseeable risks associated with participating in this study.

Benefits:
There may not be direct benefits for you to participate in this research project. The investigators hope that your participation will help college faculty and undergraduate institutions better understand how undergraduates learn genetics information.

Alternatives:
An alternative to participating in this study is to not participate. There are no foreseen risks or benefits for choosing not to participate.

Confidentiality:
The survey will ask for your name, but your name will only be used for appropriate designation of extra credit. Extra credit will be given based on the name you provide. The investigator will not access any of the survey responses until after the final grades for the class have been posted. Data obtained from your participation will be

stored on a password-protected online database. Only the investigator will have access to your data. Research data will be destroyed by expunging at the completion of the project.

The data from the study may be published; however, you will not be identified by name.

Financial costs to the participant:
There are no costs for your participation in this study.

Right to refuse or withdraw:
Your participation is voluntary and you may refuse to participate, or may discontinue participation AT ANY TIME, without penalty or loss of benefits to which you are otherwise entitled. The investigator has the right to withdraw you from the study AT ANY TIME. Your withdrawal from the study may be for reasons related solely to you (for example, not following study-related directions from the investigator, etc.) or because the entire study has been terminated.

Offer to answer questions:
If you have any other questions about this study, you may call Christine Moskalik at 513-556-2044 or Dr. Carl Huether at 513-556-2044. If you have any questions about your rights as a research participant, you may call the Chair of the Institutional Review Board – Social and Behavioral Sciences, at 513-558-5784.

LEGAL RIGHTS:
Nothing in this consent form waives any legal right you may have nor does it release the investigator, the institution, or its agents from liability for negligence.

I HAVE READ THE INFORMATION PROVIDED ABOVE. I VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY. I WILL RECEIVE A COPY OF THIS CONSENT FORM FOR MY INFORMATION.

_____ _____
Participant Signature Date

_____
Print Name Clearly

July 1, 2006

Appendix I: Complete list of comments from anonymous post-even evaluation regarding what participants have gained by attending the workshop:

(#) represents the number of individuals who had this response

- Different resources available on the internet for genetics, current news, etc. (4)
- Networking, websites, publications, places to get ideas
- Hott's social Issues through writing
- PRS (2)
- Interaction w/ the teaching community (2)
- A variety of pedagogy tools to increase engagement, involvement of students/Interactive learning (3)
- An increased awareness of the importance of race (2)
- Methods for collaborative/active learning
- Specific ideas to enhance teaching effectiveness
- Most useful- ricki lewis' exercise on writing news release
- Enthusiasm and motivation to improve my genetics class
- Increased comfort level including race topics
- Different Pedagogies
- I greatly appreciate the lists of resources
- Different ways to promote discussion & relate topics to life and social issues
- A better appreciation for "genetics and society" that is missing from any pure science class

Appendix J: Results from general seven-month follow-up question regarding workshop resource usage

Resource:	% reporting use of resource	Average Rating	Range
DVD: Evolution	**64%**	**2.44**	**1-4**
DVD: Race – The Power of an Illusion	**71%**	**2.60**	**1-4**
DVD: Learning From Patients – The Science of Medicine	**50%**	**2.29**	**1-4**
Nature Collections – Human Genome (Scientific Articles)	**57%**	**3.00**	**1-4**
Poster: Human Genome Landscape	**71%**	**2.40**	**1-4**
Resource Packet: Website Handout	**71%**	**2.00**	**1-4**
Resource Packet: Handout Genomics and it's Impact on Science and Society	**64%**	**2.11**	**1-4**
Resource Packet: Copy of article in Genetics – Teaching Resources for Genetics, Haga, S.B. 2006	**64%**	**2.22**	**1-4**
Resource Packet: Copy of article in Cell Biology Education – Approaches to Cell Biology Teaching, Allen and Tanner 2003	**57%**	**2.00**	**1-4**
Resource Packet: Copy of article in Animal Science – Writing Across the Curriculum, Aaron, D.K. 1996	**64%**	**1.89**	**1-3**
Resource Packet: Race – The Power of an Illusion Handout	**71%**	**2.30**	**1-4**
Resource Packet: Race, Genetics, and Health Care (DVD/CD-Rom)	**71%**	**1.89***	**1-4**
Speaker Handouts: Vence Bonahm, Genetics of Race	**64%**	**2.11**	**1-4**
Speaker Handouts: Ricki Lewis, How the Media Mangle Science	**71%**	**2.10**	**1-4**
Nature Genetics – Volume 38, No. 7, July 2006	**64%**	**2.63***	**1-4**
Nature Milestones: Gene Expression, December 2005	**64%**	**2.78**	**1-4**
Textbook: Human Genetics, 7th Edition, Ricki Lewis	**79%**	**2.64**	**1-4**
Textbook: Human Heredity, 7th Edition, M. Cummings	**79%**	**2.64**	**1-4**

*One response missing