

SUPPORTING MATERIALS

for

Deliberative Public Engagement with Science: An Empirical Investigation

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Please note that the data has been checked and cleaned and de-identified. Open-ended data is not included by default but specific open-ended variables are available by request. Aspects of the data and some of the limitations are included in the detailed methods files associated with each study. For questions or to notify the authors of any issues associated with the data or methods, please contact Lisa M. PytlikZillig at lpytlikz@nebraska.edu.

Study 5 Detailed Methods¹

1. Study Overview

Study 5, conducted in the fall of 2012, used experimental methods to examine the effects of (1) critical thinking prompts and (2) quality of information during reading activities, as well as (3) attitude heterogeneity within small group discussions, and (4) active moderation during group discussion activities. In addition, we used experimental procedures to examine (5) the effect of using a certain reflective prompt for facilitating integration of the deliberative engagement assignments into the course. As in our prior studies, we examined impacts of our manipulations on engagement, knowledge gains, and attitudes toward nanotechnology as well as toward deliberation.

2. Methods

2.1. Participants

Participants were 317 students enrolled in a freshman-level introductory biology course at the University of Nebraska-Lincoln during the fall semester of 2012. The demographics were 52% female, average age of participants was 20 (SD = 2.6 years), with ages ranging from 16 to 46 years old. Participants included primarily first (43%) and second (29%) year students, and fewer students in their third (19%) or fourth years (or beyond) (7%). The majority of students came from science-related majors, with biological science (23%), pre-veterinary science (13%), and pre-med (13%) having the most representation. The majority of participants reported a political affiliation with the Republican party (46%), while 24% reported an affiliation with the Democratic party and 22% identified as independent or other (8% preferred not to answer, and 2% were missing).

¹ Any statistics reported in this document can be computed using the Study 5 Methods SPSS syntax and Study 5 data set. The syntax generally follows the order of this report but may include additional analyses not reported here.

2.2. Participant Recruitment and Consent

All of the activities were part of course requirements. However, students could choose whether or not to allow researchers to use their data in the research. Approximately mid-semester and immediately prior to engaging in the activities that were evaluated as part of this research, students were informed that the researchers wished to examine different methods of engaging people with ethical, legal and societal implications (ELSI) topics related to science, and therefore would like to analyze their data from the course activities. Students were assured of their confidentiality and told that allowing the use of their data would provide no immediate benefits to them, and would have no impact on their grade in the course. Further, they were informed that their instructor would not know who consented and who did not.

A total of 341/363 (94%) of the students present at the beginning of the activities gave consent for their data to be used in study analyses. At the end of the activities, students were given an opportunity to revisit their decision to consent to research: 84% (235 of 281) indicated their willingness to participate at that time, including 224 who had given consent at the beginning of the activities, and 11 additional persons who had not given consent in Assignment 1; but omitting 34 students who had given consent during assignment 1 and retracted that consent during Assignment 4.² The final participants were 317 students out of an estimated 376 students in the course (84%). This included participants who gave consent to use their data in the last assignment ($n=235$), and those who were missing data at the last assignment but had given consent during the first assignment ($n=82$).

2.3. Research Design Overview

The study consisted of a series of four assignments completed over approximately two months. Each of the assignments used an online interface to facilitate data collection. These assignments were designed to simulate a typical public engagement exercise, including background reading on the subject of nanotechnology and small-group discussions of the possible ethical consequences of its application. Repeated measures were used to assess student knowledge and attitudes throughout the exercises.

Assignments also included experimental manipulations of certain factors. Only Assignment 4 (A4) did not include any experimental manipulations; it was designed to measure a variety of post-engagement attitudes, knowledge, and outcomes.

Within Assignment 1 (A1), students were randomly assigned to write about the importance of students learning about ELSI issues versus writing about their initial attitudes toward nanotechnology. This manipulation was intended to examine whether or not student attitudes toward the ELSI assignments might be impacted by their reflection on the importance of considering ELSI topics as students.

Assignment 2 (A2) used a 2x2 experimental design and randomly assigned participants to conditions. Conditions manipulated factors designed to deepen deliberative engagement—specifically, the presence/absence of prompts to think critically and strong versus weak background documents.

Assignment 3 (A3) used a 3x2 quasi-experimental design in which participants were randomly assigned to heterogeneous or homogenous discussion. Then groups were formed such that they were comprised of others with homogenous (positive or negative, based on pre-existing attitude measures)

² Note that students also were asked about the quality of their responding—that is, whether they gave thoughtful responses or merely answered randomly. A number of students indicated they were withdrawing their consent for the use of their data because they had not actually done the assignments or had answered assignment questions randomly in a hurry to finish.

vs. heterogeneous participant attitudes. For the second factor, each group was randomly assigned to active versus passive group moderators. The intent of these manipulations was to test whether these commonly varied features of public engagements significantly impacted participant learning, attitudes, engagement, or quality of student responses.

2.4. Procedures and Experimental Manipulations

Students were required to complete the assignments as part of the course, but most of their responses were not graded. To get credit, at the end of each assignment, the web-based assignment interface provided a confirmation page that students could print or email to their instructors, showing they did the assignment. The materials and measures used in each assignment are included as Appendix A.

2.4.1. Assignment 1 (A1): Introduction and Pre-measures (2-group design)

A1 was assigned mid-semester and students were given 1 week to complete it at home. A1 was comprised of an explanation of the upcoming assignments (A2-A4) and a pre-survey assessing *demographics, knowledge, attitudes, personality and motivation, political and religious attitudes*. Our earlier studies had suggested students were not always open to considering ethical, legal and societal issues as part of their science courses. They expected their science course to instead be focused on only the technical aspects of the science. Because we were experimenting with different ways to make the assignments acceptable to students, as part of A1, one half of the students were randomly assigned to answer the following open-ended question:

In your opinion, how important is it that science students--including beginning science students such as you and your classmates--learn how to think about the ethical, legal and social issues (ELSI) pertaining to science? In 2-3 sentences, give your answer and a brief explanation of why you think as you do. (Note: Your instructor will not know who answered in what way, although the researchers will let your instructors know of the overall student sentiment).

The other half of the students were assigned to instead give preliminary answers to a set of questions about nanotechnology future development and regulation. That is, all students saw the questions below, but only half of the students (students not receiving the “importance of ELSI” question above) wrote some preliminary answers to them.

At the end of the New Biology assignments, in addition to giving answers to the prior three questions regarding risk/benefits, regulations, and allowable applications to human enhancement, you will be asked to write a short essay explaining and justifying your views. As you write your explanations and justifications, you will be asked to cover the following points.

Please read these and keep them in mind as you learn more about nanotechnology this semester.

(1) Future development: What developments should be prioritized or avoided?

As you consider your answers this question, consider the questions below, indicate why

you feel the way you do, and do your best to look for and provide evidence for the statements you make.

- *In your opinion, what should the future of nano-biological technology development look like, especially when it comes to human enhancement applications?*
- *What should it not look like? That is, should any developments be avoided? Why do you feel that way? Is there evidence to support your views?*
- *What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the development of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why?*

(2) Regulation of Nanotechnology: What regulations should be in place or are needed?

As you answer this question, please consider the questions below, indicate why you feel the way you do, and do your best to provide evidence for the statements you make.

- *In your opinion, given current developments in nano-biological technologies and the various developments that are possible in the future, what social policies, rules, limits and regulations should be in place?*
- *What regulations should not be in place or should be avoided? Why do you feel that way? Is there evidence to support your views?*
- *What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why?*

The instruction to the one-half of students who were asked to write preliminary answers to the above questions was as follows:

Note: Your answer to this question WILL NOT be turned in to your instructors.

This question is just designed to get you to think about your initial starting point.

Your instructors will be informed IF you answered the question, but not HOW you answered it.

Please write down what comes to your mind as possible preliminary answers to these questions below. [Open-ended text box followed]

2.4.2. Assignment 2 (A2): Background Reading (2 x 2 design)

A2 took place approximately one month after A1. A2 was online assignment in which students read a background document pertaining to applications of nanotechnology with a focus on nanogenetics and nanomedicine. The materials concerning nanotechnology included peer-reviewed information suggested by the nanoscientists consulted for the project as well as information from other resources. All participants received materials containing descriptions of both current and potential future uses of nanotechnology for drug delivery and human enhancement, as well as numerous links to sources of additional information (see Appendix B). Students were told that they needed to read the background document as part of the course requirements, but were free to explore the links to additional information as much or as little as they wished. Students were randomly assigned by the online survey software to receive one of four different versions of this background assignment, according to a 2

(cognitive factor) x 2 (quality of information factor) between-groups design. Specifically, the background document varied in the presence or absence of explicit prompts to encourage critical thinking (cognitive factor), and whether the information was presented in a relatively “stronger” or relatively “weaker” fashion (quality of information factor).

Cognitive factor. While reading the background document, the online survey software randomly assigned the participants to either receive (critical thinking) explicit critical thinking prompts (e.g., prompting them to look for bias, or look at the quality and bases of various arguments) or (control) prompts to write down “1-2 interesting or surprising things that you learned by reading the information above or by visiting the links” or suggestions for improving the readings. Participants in the critical thinking and control conditions each received four such prompts (prompts are listed along with the reading material in Appendix B). After each prompt, participants were expected to write a brief response.

Quality of information. Participants also were randomly assigned to either a “weak” or a “strong” version of the background reading (see Appendix B for a comparative version that outlines the differences between the two). Both the stronger and weaker versions of the information materials contained similar facts and ideas about the broad subject of nanotechnology, but the “weak” condition removed description of some of the “risks” of nanotechnology so that the document would be more positive and seem less balanced. The weak document also provided fewer citations and links that would support information in the document, and included some insertions of biased language. For example, we added the following phrases in the following examples (additional words are indicated in *italics*): “...*everyone knows that* nanomedicine has been used for cutting-edge diagnostic purposes” and “*Doesn’t it seem likely that* such techniques will someday result in new treatments for cancer, diabetes and some neurological disorders?” without providing any citations to support the claims.

These manipulations were designed to help us determine if some of the negative effects of critical thinking prompts found in prior studies would be affected by the quality of information provided. For example, in a prior study we found that students reported being more negative and critical about the background document when they were in the critical thinking condition. In this study, we wished to see if those prompted to think critically were especially more critical about the background information when the background information was truly weaker.

Other procedures: Framing lecture. During the same week as the A2 reading was assigned, one of the project principal investigators and a seasoned instructor gave a 45-minute lecture to the all students in the course about the use of public engagement to inform policies around new technologies, and the importance of considering ethical, legal and social issues (ELSI) during the development of new technologies. The lecture used interactive approaches to enhancing student engagement with the material (e.g., posing multiple choice questions shown on a screen which students could answer) and considered questions such as whether or not regulation of science might stymie innovation and advancement, how science is a reflection of and part of society, and how science should be regulated. Toward the end of the lecture, the discussion turned specifically to the importance of gathering public input around nanotechnology developments and the importance of studies like ours, which examine *how* to best obtain such public input. (See Appendix B for lecture outline.)

Additional, optional, online interaction. After completing the background reading and associated exercises in A2, participants were invited (but were not required) to participate in an online discussion of nanotechnology policy with their peers. This optional activity was in order to test some new software for online discussion. The impacts of this online discussion opportunity are likely

minimized by low participation. Only 31% of the study participants reported visiting the discussion site and most of them (90% of those answering the question) reported spending 20 minutes or less exploring the site (the mean was about 9.8 minutes, and the modal response was 5 minutes).

The online interactions were facilitated by the use of a tool called *Consider.it* (Kriplean, Morgan, Freelon, Borning, & Bennett, 2012). This tool enabled participants to answer the question “What or to what extent should it be legal to use nanotechnologies for human enhancement?” using a sliding scale that ranged from “always” to “never” with “neutral” appearing at the midpoint. Participants were also asked to create a list of pros and cons associated with human enhancement involving nanotechnology. This list might include items that were first suggested by other peers participating in the online discussion or items that they invented themselves. After they had completed their lists, they could click a button to see the distribution of answers on the “always” to “never” scale that had been offered by their peers.

Consistent with the way that they would be grouped in their in-class discussions (in A3, described below), participants were assigned to one of three versions of this online discussion (comprised of other participants with homogenous positive, homogenous negative, or heterogeneous attitudes). We created preliminary groupings of the participants based on how they answered the human enhancement question on A1. The first group was composed of participants who were generally optimistic about nanotechnology (ranging from slightly to greatly), the second group was composed of participants who were generally skeptical of nanotechnology (ranging from slightly to greatly), and the third group was composed of participants holding different views. Any participants who could not be classified as positive or negative (e.g., because they had not completed A1) was assigned to the heterogeneous group. To promote discussion, the initial online discussions were seeded with some initial pros and cons taken from the readings. The positive leaning discussion was seeded with two pros and one con, the negative leaning discussion was seeded with one pro and two cons, and the heterogeneous discussion was seeded with two pros and two cons (using the same pros and cons as those used in the other two discussions). Participants could see the initially seeded pros and cons, and also those submitted by other participants assigned to their same experimental condition.

Finally, after completing the background reading and optional online interaction, students completed a post-survey consisting of items measuring their *knowledge* of nanotechnology, their *evaluation* of the background documents, and various levels of their *engagement* during the activities.

2.4.3. Assignment 3 (A3): Group Discussion (3 x 2 design)

Assignment 3 (A3) was an in-class activity occurring one week after having been assigned the reading assignment (A2). During A3, students also were randomly assigned to one of 6 conditions representing a 3 (attitude heterogeneity) x 2 (active/passive moderation) design.

Attitude heterogeneity. To manipulate group heterogeneity, individual students first were categorized as having positive, neutral, or negative attitudes on the basis of their answers (A2) to the question, “In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement?” (1=Never, 0% of the time, 2=Almost never, 12% of the time, 3=Rarely, 25%, 4=Not too often, 37%, 5=Sometimes, 50%, 6=A lot of the time, 63%, 7=Usually, 75%, 8=Almost always, 88%; 9 = Always, 100% of the time. We randomly assigned persons with negative attitudes (choosing one of the first four options) to either the heterogeneous (1/3 of the negative participants) or homogenous (2/3 of the negative participants) groups. We similarly randomly assigned people with positive views (those choosing one of the last four options). Those with neutral attitudes were randomly assigned to positive, negative or mixed attitude groups. In addition, to reduce between group variance in attitude extremity, we used stratified random assignment to individual groups within each of the

three types, to help ensure that each group was composed of participants of that varied in attitude extremity (i.e., so that each group contained a mix of participants leaning slightly, moderately or strongly for or against nanotechnology for human enhancement).³ Our procedures resulted in three approximately equal numbers of groups of negative (25 groups), positive (24 groups), or mixed attitude groups (27 groups). Groups were not exactly equal in number due to the need to occasionally combine groups if they were too small due to student absences. Whenever possible, combined groups were always of the same type.

IMPORTANT NOTES: Because random assignment was done ahead of time based on prior reported attitudes from A2, but actual groups depended upon which students showed up for A3, the result was that sometimes the “assigned” group condition (a3_gcondnum) does not match the facilitator’s record of which type of group they were moderating (see the a3recondition and a3homcond variables). In most cases, the facilitator’s record will be most accurate. However, during final data preparation, group 34 was found to be recorded as negative homogenous, when examination of A2 attitudes of its members makes it appear positive homogenous. Similarly, group 51 was planned and recorded as positive homogenous when examination attitudes toward human enhancement (based on A2_humanen) instead made it appear negative homogenous.

Group 41 also appears to be mostly negative homogenous, but one person reporting very positive attitudes toward human enhancement (based on A2_humanen) nonetheless appeared to join the group. Group 48 appears positive homogenous, perhaps due to a couple of students with more negative attitudes not showing up to class on the day of A3. Final corrections to data (after conducting published analyses) also found that students from section 252 were missing their group level data for unknown reasons, which initially meant the most accurate moderator-recorded group type was missing. This has now been fixed in the data but meant those data points were missing from prior reports, including the reports in the book associated with these data.

To get around such problems, in the attitudes chapter (chapter 4, PytlikZillig et al., 2018) we used actual attitudes to determine attitude heterogeneity. However, students who did not want their data included in the research may have been part of a discussion group (affecting actual heterogeneity of attitudes in the group) but not included in the data. The variable A3totgrp offers the number of group members which can be compared to the number of group members with actual data to estimate the extent of missing data for each group.

Active/passive moderation. Students were randomly assigned to groups accompanied by either active or passive moderation. Moderators consisted of staff researchers and Biology undergraduates hired for the exercise. Each moderator received a script containing the scenarios and scripted text and instructions guiding the discussion under one of two experimental conditions. Moderators also participated in two one-hour training sessions designed to explain the exercise and the use of the scripts. During the training the moderators were guided through the exercise and practiced using the scripted prompts during role-playing exercises. Passive moderators were trained to simply read the scenario and take notes on what was said with minimal prompting of participants when it was time to move to the next scenario. Active moderators used a list of questions for each scenario designed to

³ We categorized participant attitudes as slightly, moderately, or strongly positive or negative by first creating groups of relatively positive and negative attitudes using a median split of all responses, and then assigning the strongest one-third of positive attitudes to the “strongly positive” group, the next strongest one third responses to the “moderately positive” group, and the weakest (closest to the median) one-third to the “weakly positive” group. We used a similar procedure (dividing those with negative-leaning attitudes by thirds) to identify weakly, moderately and strongly negative attitudes.

encourage brainstorming (e.g., does anyone have a different view, are there other considerations that should be taken into account?), analysis (what are some of the pros and cons associated with the technology, what might you say to someone who disagrees with you?), and synthesis (could someone summarize the issues from the discussion, are there any tradeoffs that need to be considered?). Scripts used by the moderators are included as Appendix C.

As much as possible, we controlled for moderator effects by having each individual moderator lead equal numbers of passive and active groups. One-half of the groups were assigned to active moderation and one-half were assigned to passive notetaking, with approximately equal numbers of heterogeneous, homogenous positive, and homogenous negative groups in each condition (see Table).

Table S5.1. Number of groups and participants in each of the experimental conditions randomly assigned during A3

	Negative groups	<i>Negative-grouped participants</i>	Positive groups	<i>Positive-grouped participants</i>	Hetero Groups	<i>Hetero-grouped participants</i>	Total groups	<i>Total participants</i>
Passive	12	53	12	53	14	50	38	156
Active	16	53	9	32	13	50	38	135
Total	28	106	21	85	27	100	76	291

Other procedures. Students were asked to participate in small-group discussions during their normal recitation class. In order to “anchor” student discussions around initial views reported in A2, we asked students to bring the rating that they had given human enhancement to class. At the beginning of the discussion, they were asked to individually state what rating they had given on the 9-point scale (i.e., their response to the question: “In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement?”). If a participant failed to share their rating regarding the application of nanotechnology for human enhancement, the moderator prompted to do so. This was to increase the likelihood that participants would notice the homogeneity or heterogeneity of the initial group views. They also were asked to describe conditions under which human enhancement should be allowed versus restricted. To facilitate discussion of those conditions, participants were asked to write a “law” that they then could revise after discussion.

After each group member had shared their initial views and written laws, the moderator asked students to briefly discuss their reactions to each other’s ratings and conditions. Then, for approximately 30 minutes, moderators guided a discussion about various scenarios. The moderator introduced each of four hypothetical future scenarios concerning human enhancement technology. In the first scenario, participants were asked to consider a hypothetical treatment to improve human memory, which has the potential to cure Alzheimer’s. In the second scenario, participants were presented with a disagreement between two parents about whether they should use an expensive treatment to ensure that their child is born without cystic fibrosis. In the third scenario, participants were asked to respond to a hypothetical letter from medical experts and university athletic directors endorsing the use of genetic engineering to produce athletes that were less prone to head injury. In the final scenario, participants were asked to respond to a hypothetical letter from experts concerned with over-population endorsing a global ban on the use of human enhancement to cure life-threatening disease. (See Appendix C for complete scenarios and moderator guidance.)

After discussing each scenario with their peers, and revising their “laws,” students were asked a series of questions to assess their thoughts about the ELSI concerns that were raised. After completing all of these exercises, students completed a survey consisting of items measuring their overall *attitudes* towards nanotechnology, their levels of *engagement* while completing the in-class discussion assignment, their use of various forms of *identity* in formulating their responses, and their assessment of

overall *group dynamics*.

2.4.4. Assignment 4 (A4): Final Views (Post-measures)

Assignment 4 (A4) was assigned immediately after the in-class discussions. This last assignment involved completing a post survey of attitudes and knowledge about nanotechnology and was assigned to be completed online during the week immediately following these discussions. The majority of students who were included in our final analysis (62%) completed this exercise between five and seven days after participating in group discussions. Specific items included questions regarding their *attitudes* about and *knowledge* of nanotechnology generally as well as the scientists who study it and the policymakers who regulate it, a variety of individual traits first recorded in A1, and an overall *evaluation* of all activities included in the study.

2.5. Outcome Measures

2.5.1. Knowledge and Experience

Subjective knowledge and learning. *Subjective knowledge* was assessed during A1, at the end of A2, and during A4. In A1 and A4, three questions were averaged to assess participants' subjective knowledge regarding nanotechnology (A1, $\alpha = .90$; A4, $\alpha = .90$). These included: "How familiar are you with nanotechnology?" as well as "How familiar are you with how nanotechnology is used in medical research and development?" and "How familiar are you with how nanotechnology is used in genetics research and development?" These items were created for the present study to reference the background information that students would read about. Response options to these three items fell along a five-point scale ranging from "not at all familiar" to "extremely familiar." In A2, students were asked: "Now that you've done some reading....How familiar do you feel with regard to nanotechnology and its biological applications?" followed by the same five-point scale.

In addition, *subjective learning* was assessed during A2. Participants were asked to assess whether and how much they learned about nanotechnology from the background reading and subsequent exercises. This consisted of the question "How much do you feel you learned about nanotechnology as a result of working on this assignment?" accompanied by a scale of five responses ranging from "nothing that I didn't know before" to "a great deal."

Objective knowledge. A series of objective knowledge questions were used to measure knowledge and learning in Assignments 1, 2 and 4. In A1 and A4, knowledge questions included three questions with a multiple choice format and 13 with a true/false format.⁴ Examples of multiple choice questions included "What is genetic engineering?" and "How many nanometers are in one meter?" Examples of true/false questions included statements such as "A good example of a nano-sized object is a red blood cell" (false) and "Most traditional pollutant filters are able to catch and stop nanoparticles" (false). These items bear resemblance to items used in other studies of public knowledge of nanotechnology (e.g., Cobb & Macoubrie, 2004; Lee, Scheufele, & Lewenstein, 2005; Xenos, Becker, Anderson, Brossard, & Scheufele, 2011), with some items created based on the background information presented to the students. The true/false questions were presented in a randomized order. (See Appendix A, A1, for all items.) After completing the background reading in A2, students were asked to revisit a selection of two of the multiple choice questions and five of the true/false questions. In A4,

⁴ Originally there were 4 multiple choice and 18 True/False. Some items appeared not to perform well and were eliminated.

students were asked to revisit the entire selection of knowledge questions first introduced in A1.

2.5.2. Attitudes toward Nanotechnology and Attitude Change

Repeated single item measures. A series of three attitude questions were asked in A1, and then repeated in A2, A3 and A4. The first question asked participants, “Based on what you know right now: Do you think the risks of nano-biological research and development outweigh the benefits? Alternatively, do you think the benefits outweigh the risks?” Risk versus benefit items have been commonly used in prior research on public attitudes toward nanotechnology (e.g., see review by Satterfield, Kandlikar, Beaudrie, Conti, & Harthorn, 2009). Participants selected responses from a seven-point scale ranging from “the risks greatly outweigh the benefits” to “the benefits greatly outweigh the risks”).

The second item asked participants “In your opinion, how much regulation is needed with respect to nano-biological research and development?” Participants indicated their response on a scale from 0 to 100 with 0 indicating that no regulation is needed and 100 indicating that every aspect of such research should be highly regulated.

The third question asked participants to consider specifically the use of nanotechnology in human enhancement, which was defined as follows:

...anything designed to ‘enhance’ human capabilities. In modern society, this can include activities ranging from higher education and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby’s eye color. It may even involve the enhancement of normal capabilities to be extraordinary.

After reading this definition, participants were asked “In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement?” Once again, participants indicated their attitudes on a scale ranging from 0 (indicating that the use of nanotechnology for human enhancement should never be legal) to 100 (indicating that the use of nanotechnology for human enhancement should always be allowed). On A2, the response scale was changed from a continuous “slider” that could adopt any value between 0 and 100 to a nine-point scale representing equidistant points on the original slider. This enabled for an easier division of discussion groups according to nanotechnology attitudes.

Mind changed or influenced by assignment. In A1, after reporting their initial attitudes, participants were asked “In your estimation, as you become more knowledgeable about nano-biological technologies, how likely are you to change your views about the development and regulation of those technologies?” and given a 7-point response scale ranging from very unlikely to very likely. They were also asked to comment on why they thought their attitudes might or might not change using an open-ended text box.

To assess whether participants perceived the assignments as influencing their views, in A2 and A3, immediately after each of the three nanotechnology attitude questions described above, participants were asked “How much did this assignment influence your answer to the... question above?” (across the 3 items, α in A2 and A3 = .88). In A4 they were asked how much their answer to each question changed overall since the beginning of the module (α = .85). Responses were recorded on a five-point scale ranging from “not at all” to “a great deal” and then averaged to create a scale.

General attitudes toward nanotechnology (post only). In A4, participants were asked a number

of more detailed questions regarding their attitudes toward nanotechnology, to characterize their final attitudes in more detail. Specifically, they were asked whether they agreed or disagreed with seven statements concerning nanotechnology research and regulation. These items were obtained or adapted from prior research (Hamlett & Cobb, 2006; Scheufele & Lewenstein, 2005). Examples of these items include “The government will effectively manage any risks associated with nanotechnology” and “There are serious ethical problems associated with *not* quickly developing nanotechnologies.” Responses fell on a seven-point scale ranging from “strongly disagree” to “strongly agree.”

Participants also were presented with six goals related to nanotechnology development and asked to assess their importance. Examples of these goals included “minimizing potential environmental risks” and “maximizing potential benefits for human enhancement.” Responses fell on a five-point scale ranging from “unimportant” to “extremely important.”

To reduce the number of variables we z-scored the items individually (so they would be on a common scale) and then conducted a PC factor analysis (using varimax rotation) which suggested factors resulting in the following scales: *general perceptions of importance of maximizing benefits and minimizing risks* (5 items, $\alpha = .82$), *General perceptions of [low] risks* (3 items, $\alpha = .77$, e.g., “The risk of nanotechnology directly affecting physical things like human health, wildlife or the environment in general is currently too high”), and *general perceptions of high benefits* (3 items, $\alpha = .64$, e.g., “There are serious ethical problems associated with not quickly developing nanotechnologies”). Three items, however, were not included in the scales—two were items resembling our trust items (“The government will effectively manage any risks associated with nanotechnology” and “scientists working with nanobiological technologies will develop them in directions that are positive for society”) and one was a general statement of importance (“nanotechnology is one of the more important issues confronting government today”).

Likelihood/Importance of specific risks and benefits. In A4, participants were asked to consider a list of 12 potential risks and benefits from nanotechnology research and to rate them according to both their relative importance and likelihood to be realized. These items were taken or adapted from prior research on public attitudes toward nanotechnology (Cobb & Macoubrie, 2004; Lee et al., 2005). Examples of potential risks/benefits included nanotechnology leading to “The extension of human life expectancy” and “Pollution of the environment by nanomaterials.” Responses fell on two different scales. The first, concerning likelihood, was a five-point scale ranging from “not at all likely” to “extremely likely” (1= Not at all likely, 2= Slightly likely, 3= Somewhat likely, 4= Very likely, 5= Extremely likely). The second, concerning importance, was a seven-point bi-polar scale ranging from “very important to AVOID” to “very importance to ACHIEVE,” with “NOT IMPORTANT to avoid or achieve” representing the midpoint (-3= Very important to avoid, -2= Moderately important to avoid, -1= Slightly important to avoid, 0= Not important to avoid or achieve, 1= Slightly important to achieve, 2= Moderately important to achieve, 3= Very important to achieve). Each likelihood and importance item was multiplied by its counterpart to create approach/avoidance of specific risk/ben scales. Factor analyses suggested 2 or 3 scales, the 2 scale solution resulted in scales that made sense and that had adequate internal reliability. One scale comprised of 5 items ($\alpha = .76$) reflecting the *importance of various benefits of nanotechnology* (disease cures and economic benefits). The second scale included 6 items ($\alpha = .81$) reflecting *[low] avoidance of various risks* (e.g., economic disruption, widened gap between the rich and the poor). The item concerning human enhancement loaded equally highly on risk and benefit scales 1 and 2, and thus was kept as a separate single-item measure.

2.5.3. Trust and confidence in nanoscientists.

In A4, a series of questions were used to assess trust and confidence in nanoscientists. These

items were created based on prior reviews of trust and confidence measures (PytklikZillig et al., 2016). Factor analyses of the items used in the present study were conducted to examine item intercorrelations, and based on results, four trust-relevant scales were created. Three items were averaged to create a measure of student *confidence in nanoscientists to do their jobs* ($\alpha = .77$). Each question began with the phrase “To what extent do you have confidence in nanoscientists to...” and included “do their jobs well?” “meet their professional responsibilities?” and “make decisions about the most important directions for future development.” Responses fell on a five-point scale ranging from “not at all” to “a great deal.”

An additional 16 items were used to measure student perception of nanoscientists’ trustworthiness in terms of being caring and having integrity (5 items, $\alpha = .89$), distrustworthiness in terms of not being caring or having integrity (5 items, $\alpha = .77$), trustworthiness in terms of shared values (3 items, $\alpha = .77$), and competence (3 items, $\alpha = .64$). The stem for these items was “To what extent do you feel nanoscientists probably...” Examples of these items include “are trustworthy?” and “are primarily motivated by what will benefit them personally?” Responses fell on a five-point scale ranging from “not at all probable” to “very probable.”

2.5.4. Process and policy acceptance

To assess acceptability of policies resulting from experimentally varied public engagement procedures, in A4, participants were randomly assigned to receive and read about one of two hypothetical scenarios wherein the government used a public engagement process similar to the one they just participated in to help determine the shape of new nanotechnology regulations. In the first scenario, it was reported that Americans had been involved in a public engagement identical to the one the participants had engaged in and most were enthusiastic about nanotechnology, and the government decided to dramatically increase its investment in related research and development. In the second, it was reported that, of those involved, most people were skeptical of nanotechnology, and the government decided to dramatically increase its regulation of related research and development. Because participants had been randomly assigned to the scenario, they were approximately equally likely to receive a scenario consistent with or against their personal views. Together, the items administered after the scenario allowed us to examine the extent to which experimentally varied processes were viewed as fair and whether people would support decisions made through those processes, even when the decision was not consistent with their preferred policy.

After reading the scenario, participants were asked whether they agreed or disagreed with ten statements evaluating the government’s decision-making process. These statements included “The process used by the government was a good one” and “I would resist this decision made by the government.” Responses fell on a six-point scale ranging from “strongly disagree” to “strongly agree.” Based on the factor analyses of the items, 3 scales were created reflecting *support for the government’s process and decision* (4 items, $\alpha = .90$, e.g., “Because of the processes used, I would support this decision made by the government,” “I would resist the decision made by the government,” reverse scored), *perceptions of government listening and caring* (3 items, $\alpha = .76$, e.g., “people influenced the government’s choices”), and *perception of government competence* (2 items, $\alpha = .68$, e.g., “the government made its decisions in an INcompetent manner,” reverse scored). A single item about fairness (“the process used by the government to make decisions about this issue was fair”) was not uniquely correlated with any of these scales and therefore was left as a single item.

Finally, so that we would know whether they had received a policy/decision scenario that was consistent with their preferences or not, participants were asked whether they would *favor or be opposed to the policy produced* as a result of the public engagement process. Responses fell on a six-point scale ranging from “strongly AGAINST” to “strongly FOR.”

An additional measure of overall *valuing of public engagement* and its use in political processes and policy decisions came from answers to an item administered after students wrote down some of their opinions and that read: “Some people feel that the government should primarily rely on expert opinions, not citizen opinions when making policy decisions. What do you think? In your opinion, how much weight should government give to citizen opinions (like you wrote above) when making decisions about the future of nanotechnological development and regulation?” This question was accompanied by a five-point response scale ranging from “None! The government shouldn't be considering opinions of everyday people like me” to “A lot of weight! The government should take opinions like mine very seriously.”

2.6. Predictor and Control Variables

2.6.1. Demographics

Demographic questions were assessed in A1 and included reports of participant age, gender, year in school, and major. In addition, due to a relatively large number of students who completed their last assignment (comprising our post measures) late (past the 1 week due date for the assignment), we created a variable identifying late A4 completions.

2.6.2. Individual Differences, Personality, and Motivation

Grades. During A1, participants were asked to self-report whether, on average, they would say they were an A, B, C, or D student.

Experience with ELSI. To control for any effects related to previous exposure to ELSI, students were asked two questions to identify how often ELSI had been incorporated into previous coursework. The first of these asked students to identify, on a five point scale, “About how much previous academic work have you done that covered ethics (human, animal, environmental)?” Response options included none, a little, some, a moderate amount, and a great deal. The second question simply asked “How many courses have you taken in the past that touched on ethics (human, animal, environmental)?” accompanied by a 7-point scale ranging from 0 (none) to 7 (more than 5). The items were correlated ($r(310) = .79$) and thus z-scored and averaged to create a scale (Cronbach's $\alpha = .88$).

A variety of other scales were used to assess student individual differences and personality characteristics during A1, with a subset re-administered during A4, as indicated below. Nine of these measures (the first nine listed below) were assessed in a single block of questions. Specific items were given in random order by the survey program, so that items for different personality characteristics were intermixed. Participants responded using a six-point scale ranging from “strongly disagree” to “strongly agree” (for a full list of items contained in each, see Appendix A).

Need for cognition. In A1, a set of seven items was averaged to measure the extent to which participants were inclined to invest effort in cognitive activities ($\alpha = .81$). Examples of these items include the statements “The notion of thinking abstractly is appealing to me” and “Thinking is not my idea of fun.” These items were taken from Cacioppo and Petty (1982); and Cacioppo, Petty, Feinstein, and Jarvis (1996).

Trait openness. In A1, a set of four items was averaged to measure student's openness to new

experiences ($\alpha = .68$). Examples of these items include the statements “I have a vivid imagination” and “I enjoy hearing new ideas.” These statements were taken from the Openness to Experience scale of the International Personality Item Pool (<http://ipip.ori.org>).

Disposition to trust. In A1, a set of three items was averaged to create a measure of student’s general inclination to trust others ($\alpha = .70$). These items included the statements “I believe that others have good intentions,” “I trust what people say,” and “I believe most people try to be fair.” These items were taken or adapted from the National Opinion Research Center (1994) and the Trust scale included in the International Personality Identity Pool (<http://ipip.ori.org>).

Trait conscientiousness. In A1, a set of ten items was averaged to measure student’s conscientiousness ($\alpha = .84$). Examples of these items include the statements “I am always prepared” and “I find it difficult to get down to work.” These statements were taken from the Conscientiousness scale of the International Personality Item Pool (<http://ipip.ori.org>).

Political efficacy. In A1 and A4, a set of four or six items was averaged to measure a student’s evaluation of their own ability to meaningfully participate in the political process (A1, four items, $\alpha = .84$; A4, six items which had been slightly revised, $\alpha = .86$). Examples of these items include the statements “Sometimes politics and government seem so complicated that a person like me can’t really understand what’s going on” and “I consider myself well-qualified to participate in politics.” These statements were adapted from similar items used in the American National Election Study (ANES, 2000).

Political motivation. Three types of political motivation were assessed in both A1 and A4: Intrinsic, introjected, and extrinsic. The items used for these measures were adapted from Koestner, Losier, Vallerand, and Carducci (1996) and Losier and Koestner (1999). Koestner and colleagues’ items were similar except that they asked participants to select from a range of responses to a general question (eg. “Why do you follow current events?” with potential responses including “Because I am supposed to” and “For the pleasure of doing it). Our items also differed in that they explicitly identified social issues in addition to political issues and current events. Specifically, two or three items were averaged to measure the extent to which a student felt motivated to be politically engaged by factors that reflect *intrinsic motivation* (A1, two items, $\alpha = .82$; A4, three items, $\alpha = .88$). These included the statements “I follow political and social issues because I want to learn more things” and “I follow political and social issues because I think it’s important.” One or two items were averaged to measure *introjected motivation*, or the extent to which a student felt motivated to be politically engaged by factors they had internalized from outside sources (A1, one item; A4, two items, $\alpha = .79$). These included “I follow political and social issues because it bothers me when I don’t” and “I follow political and social issues because I feel bad about myself if I don’t.” One or two items were used/averaged to measure *extrinsic motivation*, or the extent to which a student felt motivated to be politically engaged by factors that are completely external to themselves (A1 one item; A4, two items, $\alpha = .84$). These included “I follow political and social issues because that’s what I’m supposed to do” and “I follow political and social issues because that’s what I’m expected to do.”

Deliberative values. In A1 and A4, a set of five items was averaged to measure the extent to which a student valued deliberation as an element of active citizenship (A1, $\alpha = .75$; A4, $\alpha = .80$). Examples of these items include the statements “A good citizen should listen to people who disagree with them politically” and “A good citizen should be willing to justify their political views.” These items were taken from Muhlberger and Weber (2006).

Cultural cognition. In A1, a set of 12 items was used to assess cultural cognition including subscales for individualism (6 items, $\alpha = .71$, e.g., “Sometimes government needs to make laws that keep people from hurting themselves,” reversed coded) and hierarchical (6 items, $\alpha = .78$, e.g., “we need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women,” reverse coded) cultural worldview cognitive beliefs. These items were taken from Kahan, Jenkins Smith, and Braman (2011).

2.6.3. Political and religious attitudes

The remainder of the individual difference variables were administered in the following order and had their own response scales. Each of these scales appeared only on A1.

Interest in politics. Two items were averaged to measure the extent of a student’s interest in political issues ($\alpha = .71$). These included the questions “How interested are you in *national* politics and *national* affairs?” and “Thinking about your community, how interested are you in *local* community politics and *local* community affairs?” Answers were recorded on a seven-point scale ranging from “not interested” to “extremely interested.” These questions were based on similar items used in the Citizen Participation Study (1990) (see <http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/6635>).

Political ideology/affiliation. Participants were asked to assess their political ideology in three general areas: “overall,” “when it comes to ECONOMIC issues” and “when it comes to SOCIAL issues.” Responses were recorded on a seven-point scale ranging from “strongly liberal” to “strongly conservative.” “Prefer not to answer” was also provided as a possible response and then treated as missing. These items were based on similar self-assessments used in Rosenstone, Behr, and Lazarus (1996). Participants also were asked to identify themselves on a seven-point scale ranging from “strong Democrat” to “strong Republican,” with “Independent/Other” in the middle. This item was based on a similar assessment included in the American National Election Study (2000). The ideological and political party questions were highly correlated and therefore responses were then averaged to create a measure of political ideology/affiliation ($\alpha = .91$).

Religiosity. Participants were asked “With regard to religion, which of the following best describes you?” Responses were recorded on a four-point scale ranging from “not at all religious” to “very religious.” “Prefer not to answer” was also provided as an option, and treated as missing.

Religious affiliation. Participants were asked “With regard to religion, which of the following most closely describes you?” Responses included “Mainline Protestant,” “Evangelical Protestant,” “Black Protestant,” “Roman Catholic,” “Jewish,” “Muslim,” “Agnostic,” “Atheist,” and “Other (please specify).” “Prefer not to answer” was also provided as an option.

2.7. Process Measures

2.7.1. Engagement

Engagement. Because participant engagement is believed to be an important element of either public education or the solicitation of public policy input, we also measured different forms of student engagement during A2 and A3. Specifically, participants were asked to assess 31 statements, each beginning with the stem “During the assignment, I...”. Responses fell on a five-point scale ranging from “not at all” to “a great deal.” All items were taken from PytlikZillig et al. (2013) and were intended to

assess one of eight different types of engagement described below. Specific items were given in random order by the survey program, so that items for different scales were intermixed.

Conscientious engagement. A subscale of four items was averaged to measure the extent to which participants were effortful, careful and thorough in completing the assignment (A2, $\alpha = .80$; A3, $\alpha = .79$). Examples of these items include the statements “felt focused” and “gave careful consideration to all of the options presented.”

Open-minded engagement. A subscale of three items was averaged to measure the extent to which participants felt open to changing their opinions while completing the assignment (A2, $\alpha = .73$; A3, $\alpha = .71$). These included the statements “felt open to hearing new ideas about the topics,” “tried hard to understand perspectives that were different from mine” and “felt open-minded.”

Active learning/metacognitive engagement. A subscale of five items was averaged to measure the extent to which participants actively engaged with the learning process, as opposed to becoming passive recipients of information (A2, $\alpha = .76$; A3, $\alpha = .77$). Examples of these items include the statements “tried to find answers to my questions about the topics” and “identified questions I still had about the topics.”

Social engagement. A subscale of four items was averaged to measure the extent to which participants engaged with others about the assignment (A2, $\alpha = .85$; A3, $\alpha = .79$). Examples of these items include the statements “discussed my ideas about the topics with others” and “asked others what they thought about the topics and issues.”

Creative engagement. A subscale of four items was averaged to measure the extent to which participants attempted to approach the assignment creatively (A2, $\alpha = .76$; A3, $\alpha = .78$). These included the statements “used my imagination” and “felt inspired.”

Disinterested engagement. A subscale of four items was averaged to measure disinterest as a form of *disengagement* in the learning process (A2, $\alpha = .87$; A3, $\alpha = .84$). Examples of these items include the statements “was impatient to get this over” and “wish I were doing something else.”

Angry engagement. A subscale of four items was averaged to measure the extent to which participants felt angry while completing the assignment (A2, $\alpha = .90$; A3, $\alpha = .91$). Examples of these items include the statements “felt angry” and “found it aggravating.”

Close-minded engagement. A subscale of three items was averaged to measure the extent to which participants felt unwilling to changing their opinions while completing the assignment (A2, $\alpha = .80$; A3, $\alpha = .78$). These included the statements “felt like my mind was already made up,” “knew how I would feel about the topic even before doing the task,” and “felt like new information would not change my opinions.”

Time spent on A2 assignment. After completing Assignment 2, participants were asked to indicate the “time spent completing this assignment (in *Minutes*).” These instructions were also given: *Please only include the time you spent actively reading, writing and exploring the discussion. Do not include any breaks you took, or interruptions or other activities not relevant to the assignment that may have lengthened your time.*

2.7.2. Evaluation measures

Background document evaluation. After completing this background reading in Assignment 2, participants were asked to evaluate the document by indicating how strongly they agreed or disagreed with a series of 21 descriptive statements divided into three subscales. Each statement began with the stem “The information provided in this assignment was...” Responses were recorded on a five-point scale ranging from “strongly disagree” to “strongly agree.” The three subscales resulting from these items were: *Background document evaluation: biased*. A series of 10 items was used to measure the extent to which participants rated the background document as biased or not neutral ($\alpha = .83$). Examples of these items include the evaluative statements “unbalanced” and “fair in its presentation of the issues,” reverse coded. *Background document evaluation: not trustworthy*. A series of 9 items was used to measure the extent to which participants rated the background document as not trustworthy in terms of its accuracy, thoroughness, and being well-written ($\alpha = .88$). Examples of these items include the evaluative statements “untrustworthy” and “a high quality source of information,” reverse coded. *Background document evaluation: not clear*. Two items were used to assess how clear and easy to understand participants found the document ($\alpha = .76$).

Online peer discussion evaluation. Recall that participants were invited to visit an online discussion area after reading the background information. A series of five questions was used to evaluate the online discussion experience. The first asked simply whether students were able to access and contribute to the external discussion site. The second asked students which specific activities students performed on this site (activities included “set up an account,” “used the slider to show my view” and “submitted my views”). The third asked how long the students spent exploring and contributing to the online discussion. The fourth asked “How useful was the online discussion for thinking about the human enhancement question?” with responses on a six-point scale ranging from “not useful at all” to “extremely useful.” The final question asked “How did you like the online discussion interface?”

A2 assignment evaluation. Participants were asked to consider the quality of A2 as a whole, including both the background reading and the subsequent exercises. Specifically, participants were asked to indicate the extent to which they agreed with nine statements beginning with the phrase “Overall, to what extent did this assignment help me to...” Examples of these items include “more clearly articulate my own perspective” and “think critically about the evidence.” These statements were presented in a random order. Responses were recorded on a five-point scale ranging from “not at all” to “a great deal.” Participants were also asked to rate, “Overall, how useful was this assignment for helping you to think more about nanogenomics and nanomedicine and preparing you to form opinions and policy input related to nanotechnology development and regulations relating to nanotechnology development and regulations relating to human enhancement?” and “How much do you feel you learned about nanotechnology as a result of working on this assignment?” on five-point ordinal response scales ranging from “not at all” to “extremely” and “nothing I didn’t know before” to “a great deal.” A Principal Component Analysis supported that these items formed a single scale. These 11 items were then averaged to create a single scale ($\alpha = .92$).

2.7.3. Group Processes

A3 group dynamics reported by participants. After completing the discussion of hypothetical ethical scenarios in Assignment 3, participants were asked a series of questions intended to reflect their attitudes toward group members and level of agreement within the group. Six statements were relevant

to identification with the group ($\alpha = .89$). Examples of these items include “I identified with my group during the discussion” and “I felt like an ‘outside’ member of my group,” reverse coded. Responses were on a seven-point scale ranging from “strongly disagree” to “strongly agree.”

Four questions measured group consensus such as: “How much disagreement was there within your group at the beginning of discussion?” and “How much agreement was there within your group at the end of discussion?” (2 items at each time point, $\alpha = .73$, beginning and $.77$ at end).

Two additional questions included “Overall, how do you feel about the other people in your group?” (7-point scale from very negative to very positive) and “How satisfied were you with your small group discussion in class today?” (5-point scale from not at all satisfied to extremely satisfied).

Participants also were asked to identify each member of their group by first name and last initial. They were then asked the following 2 questions of *each* individual: “Before today’s discussion, how familiar would you say you were with _____?” (with responses falling on a five-point scale ranging from “not at all familiar” to “extremely familiar”) and “Regarding the ethical scenarios you just discussed, how similar do you think _____’s opinions are to your opinions?” Response options were comprised of five-point scales ranging from “not at all similar” to “extremely similar.” The first of these questions allowed us to assess familiarity between group members, while the second helped serve as a check for our manipulation of perceived group homogeneity.

Perceptions of active moderator. On A3, participants were asked to indicate the extent of their agreement with eight statements regarding their group moderator, six of which were averaged into a “perception of active moderator” scale ($\alpha = .93$). These statements all began with the phrase “The moderator of our group...” Examples of these items include “was very active in leading our group discussion” and “summarized what he/she heard the group saying.” Responses fell on a seven-point scale ranging from “strongly disagree” to “strongly agree.” These questions served as a check for our manipulation of moderator activity.

Two items were not included in the scale, one was a statement that the moderator “was unbiased,” and the other that the moderator “mostly let students lead” the group discussion.

A3 group dynamics reported by moderators. Throughout the group discussions in Assignment 3, moderators were asked to code for the presence of topics that were common in discussions in previous studies of public engagement on nanotechnology. These codes were associated with each scenario, so that moderators could indicate, for instance, whether concerns regarding potential health risks came up in the discussion of Scenario 1 but not in Scenario 2. Moderators in the “active moderator” condition were also asked to indicate which of a list of 12 scripted prompts they employed in the discussion following each scenario. These prompts were divided into three categories: brainstorming, analysis and synthesis. Active moderators were asked to use one prompt from each category during the discussion of each scenario. Moderators assigned to the “note-taking” condition were asked to perform a self-check and write a note explaining when and how they deviated from their assigned role (for instance, by using one of the 12 scripted prompts). After the discussion had finished, moderators were asked a series of seven questions designed to evaluate the quality of the discussion for all four scenarios as a whole. These questions included “To what extent did the student discussion stay ‘on topic’?” and “To what extent did participants explicitly talk about bias?” Responses were coded on a five-point scale ranging from “Not at all” to “Very/Extremely.” A copy of the moderator script, and the questions answered by the moderators, is reproduced in Appendix C.

Satisfaction with process. Finally, in Assignment 4, participants were asked to assess their level of satisfaction with all four assignments as a module. Specifically, they were asked “Overall, to what extent was the public participation module a beneficial part of your learning in this course?” with

responses on a five-point scale ranging from “not at all” to “a great deal.”

2.8. Open-ended Questions

The main open-ended questions asked throughout the assignments were as follows. These may be considered process or outcome variables depending on how the answers are used.

ELSI attitudes or attitudes toward nano. As detailed in section 2.4.1., in A1 participants were randomly assigned to either write about their opinion toward the consideration of ELSI issues in science classes, or about their initial attitudes toward nanotechnology.

In A4, all students were asked to give their opinion about the consideration of ELSI issues in science classes. These open-ended responses might be analyzed to see if those who wrote their opinion about the inclusion of ELSI discussions in science classes at A1 were more or less positive about it at A4.

Personal reflections. In A1, after answering the question “In your estimation, as you become more knowledgeable about nano-biological technologies, how likely are you to change your views about the development and regulation of those technologies?” participants were asked to “Write at least one or two sentences explaining why you gave the answer above. Why or how might things you learn impact your views about the regulation and development of these technologies?”

After answering personality and demographics questions in A1, participants were asked to “Think about the unique personality traits, political views, religious views, beliefs, and interests that make you, “you.” How do your characteristics impact your views? How might someone who differs from you in these characteristics and beliefs be “starting out” approaching new technologies differently than you? Write at least 2-3 sentences in response to these reflection questions.”

Reflections and attitudes toward nanotechnology. Those in the control condition were asked, at three different points during the A2 readings, to stop and reflect on what they just read: “Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links. You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!”

Those in the critical thinking condition were asked to respond to different open-ended prompts after being provided with information about critical thinking. After a tip for detecting bias, they were asked to “give one example of bias that you see in the background information so far -- or in links that you visited -- and indicate the changes that would be needed to make the information or source less biased.” After a tip focused on considering the quantity and quality of evidence, they were asked to “, give one example of a claim made above (in the text or a link that you explore) that you think is poorly supported, OR one example of a claim that is well-supported. For the claim, explain why the evidence for the claim is good, or not very good. For example, is the evidence relevant? Accurate? Typical? And/or sufficient?” Finally, after a tip concerning the need to consider bases of arguments, they were asked to, “Examine the issues and arguments above and describe one place where people seem to disagree on the facts and one place where they seem to disagree on values. Describe the disagreements and what facts or values they disagree on. Then describe your opinion. Which facts do you think are true and why? What values match your values?”

Written policy views. All participants were asked to write a letter to policy makers, starting with a first draft of the policy letter in A2, with a final draft submitted in A4.

A2 Instructions were as follows:

During the last New Biology assignment, in addition to giving your final answers to the prior three questions, you will be asked to write an essay, in the form of a letter to policymakers, saying what you would like them to do with regard to the future of nanotechnology related to human enhancement, and explaining and justifying your views. Your letter to policymakers should cover the points outlined below.

(1) Future development: What developments should be prioritized or avoided?

As you consider your answers this question, consider the questions below, indicate why you feel the way you do, and do your best to look for and provide evidence for the statements you make.

In your opinion, what should the future of nano-biological technology development look like, especially when it comes to human enhancement applications?

What should it not look like? That is, should any developments be avoided? Why do you feel that way? Is there evidence to support your views?

What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the development of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why?

(2) Regulation of Nanotechnology: What regulations should be in place or are needed?

As you answer this question, please consider the questions below, indicate why you feel the way you do, and do your best to provide evidence for the statements you make.

In your opinion, given current developments in nano-biological technologies and the various developments that are possible in the future, what social policies, rules, limits and regulations should be in place?

What regulations should not be in place or should be avoided? Why do you feel that way? Is there evidence to support your views?

What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why? Write a preliminary draft of your policy input below.

In A4, the instructions were the same except that the beginning instructions read:

Finally, based on all you learned, and the issues that you just considered, please give your final policy recommendations. Refer to your work from prior assignments (e.g., the law you wrote, and your justification; your prior first draft of this, and your answers to the risks & benefits questions in this assignment) as you write. This is the PRIMARY answer that you will be graded on for this assignment.

Written laws. In A3, participants were asked, at the beginning of their group discussion to do as follows:

Compose a brief law (2-3 sentences) describing under what circumstances the government should prohibit the use of nanotechnology for human enhancement, and under what circumstances the use of such technology should be allowed. Recall that human enhancement can refer very generally to anything designed to "enhance" human capabilities. In modern society, this can include activities ranging from higher education

and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby's eye color. It may even involve the enhancement of normal capabilities to be extraordinary.

Then after sharing and discussing their “laws” in their small groups, and also discussing some potential future scenarios, participants were asked to revise their law if desired, and to provide reasons for their final law, as follows:

The first draft of your human enhancement law is below. As you discuss with your classmates, please revise and refine your law. Please also justify your final law, including making note of WHY you made the changes that you made.

Additional A4 explanations. In A4, participants were given the opportunity to write open-ended responses to explain their answers or view on a hypothetical policy passed by the government and on the extent to which they felt government should weigh public opinions when making decisions about the future or nanotechnology.

2.9. Data Quality Measures

We also included in our measures some assessments of data quality. This was important because the assignments were not graded. In A1, A2, and A4 we directly asked participants if they answered the questions honestly (vs. randomly, without reading, or felt they should answer in a certain way that differed from their honest response). In all, 93%, 97%, and 97% of respondents to A1, A2 and A4 respectively indicated giving honest answers. Open-ended responses appeared to indicate that some students, due to fatigue, answered some questions honestly and some randomly or after skimming the items.

In A1 and A4 there also were items explicitly asking participants to choose a certain response (e.g., directing them to choose “strongly agree”). In A1, approximately 8% of those answering the question chose the wrong response and in A4 approximately 4% chose the wrong option.

On the A4 measure of potential negative or positive outcomes of nanotechnology, 31 participants (about 10%) did not classify one or more of five outcomes as expected (e.g., not classifying pollution as a negative rather than as a positive outcome).

We created a variable that counted the number of data quality checks missed by a given participant. A total of 76% of participants missed 0, and 96% missed 0-2 checks. Three persons had five or more failed data quality checks. This variable, called “poordata,” may be used to select out those with questionable data.

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4. Appendices

4.1. Appendix A – Assignments

APPENDIX A: Study 5 Survey Questions and materials

4.1.1. Study 5 Assignment 1

Note that in many/most cases the order of the items and answer options (e.g., on multiple choice questions) were administered by the survey software in random order to reduce order effects.

[consent language was included here, in original survey]

a1_CONSENT Do you consent to participate in the research by allowing us to use your coursework-related data as indicated above?

- ☐ Yes (1)
- ☐ No (2)

a1_Q3 PLEASE NOTE This assignment is best done in one sitting. Make sure that you have enough time to finish it (30-40 minutes), so that you do not need to start over later. If you leave it and come back, you will need to use the same computer and browser, and have browser cookies enabled, in order to continue where you left off. Otherwise you will have to start over.

a1_Name This assignment is worth 7 points. The points are awarded simply for making an effort to reflect on the issues raised -- not for the specific views that you express. In order to get credit for completing this assignment, please fill out the following information.

[Certain information, highlighted, is removed from the data file for purposes of de-identification.]

First Name (1)

Last Name (2)

a1_RECI Please indicate which Bio 102 recitation you are enrolled in (see list below):

Your course Instructor (1)

Recitation section number (Please check list below for accuracy) (2)

Recitation instructor name (3)

Reci Day & Time (4)

a1_t3 Timing

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a1_Q5 “In the end... success or failure will come down to an ethical decision, one on which those now living will be judged for generations to come.” --Edward O. Wilson, biologist and author “Learn what is true in order to do what is right.” --Thomas Henry Huxley, evolutionary biologist Science cannot be limited to the confines of a laboratory or a classroom. Discoveries made today can have an impact on the progress of society for generations to come. One purpose of a university education is to create well-informed citizens who can participate in the process of a democratic government. Whereas "facts" might be determined by experts, in a democracy, it is the public that decides ethical and "value-related" issues. More and more people are adopting the viewpoint that it is not enough to teach science students "science" removed from society. Science developed apart from a consideration of its role in society may not be utilized or utilized correctly.

Display This Question:

If write Is Equal to elsiimpt

a1_elsiimp What do you think? In your opinion, how important is it that science students--including beginning science students such as you and your classmates--learn how to think about the ethical, legal and social issues (ELSI) pertaining to science? In 2-3 sentences, give your answer and a brief explanation of why you think as you do. (Note: Your instructor will not know who answered in what way, although the researchers will let your instructors know of the overall student sentiment).

a1_t4 Timing

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a1_Q6 The New Biology assignments used in this course will provide you with the opportunity to practice applying your biological knowledge across and within different scientific and social disciplines. Specifically, the New Biology assignments in this course will take you through a specific method of public engagement focused on biology and nanotechnology, that has been developed by the University of Nebraska Public Policy Center. Public engagement refers to a whole class of methods designed to facilitate public involvement with policy issues. The public engagement process includes the following steps: 1. Opening Reflections. This is the step you are on right now. During this step you will reflect on what you know, what you feel, who you trust, and who you are. The purpose is just to reflect on your "starting point" related to the discussion. 2. Information Investigation & Exploration. In the second step in the process, you will learn more about the issues at hand. For example, you will have a reading assignment about nanotechnology and hear a guest lecture on Ethical, Legal and Social Issues (ELSI) in science. 3. Issue Deliberation. Following the reading, in recitation, you will consider some ethical scenarios pertaining to nanotechnology and biology, and deliberate in groups about the best courses of action in light of those scenarios. 4. Your Input. During the final step in the process, you will give your input on the issues. Based on what you learned, you will write about what you think nano-biological scientists should pursue, and how policy makers should regulate nano-biological developments. Remember...if you gave consent, your (anonymous) answers will become part of the research base regarding what people think should be the future of nanotechnology. So please do your best to give thoughtful answers.

a1_t5 Timing

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a1_Q7 Demographics Note: Your answers to these questions will *not* be shared with anyone. They will ONLY be used (in anonymous form) if you give permission for your work on the New Biology assignments to be analyzed as part of the evaluation and research being conducted on the assignments. Before we get started, please answer the questions below.

[Note that some variables only administered at one time point, and not expected to change, may not have the 'a1' designation.]

a1_Age [may be 'Age' in data set]

What is your age? (1)

a1_Gender [may be 'gender' in data set]

What is your gender?

- ☐ Male (1)
- ☐ Female (2)

a1_Yearpre What is your year in school?

- ☐ Freshman (1)
- ☐ Sophomore (2)
- ☐ Junior (3)
- ☐ Senior (4)
- ☐ Graduate student (5)
- ☐ Other (6)

a1_Major What is your major?

	Biochemistry (3)	Biological science (1)	Biological Science Engineering (2)	Chemistry (5)	Pre- Med (6)	Pre-Vet (4)	Psychology (8)	Other (7)
(1)								

A1_MajrTxt If you answered "Other" to the above question, or if you have more than one major, please type in your other or additional major here.

a1_grades On average, would you say you are you an A, B, C, or D student?

- ☐ an "A" student (1)
- ☐ a "B" student (2)

- ☐ a "C" student (3)
- ☐ a "D" student (4)

a1_ethcla About how much previous academic work have you done that covered ethics (human, animal, or environmental)?

- ☐ None (1)
- ☐ A little (2)
- ☐ Some (3)
- ☐ A moderate amount (4)
- ☐ A great deal (5)

a1_ethcla2 How many courses have you taken in the past that touched on ethics (human, animal, or environmental)?

- ☐ 0 (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ More than 5 (7)

a1_t6 Timing

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a1_Q9 What do you know? The "New Biology" issues that you will consider this semester will involve thinking about biological applications of nanotechnology. Take a moment to consider your current levels of knowledge of nanotechnology and its biological applications.

a1_famnano How familiar are you with nanotechnology?

- ☐ Not at all familiar (1)
- ☐ Slightly familiar (2)

- ☐ Somewhat familiar (3)
- ☐ Very familiar (4)
- ☐ Extremely familiar (5)

a1_fammed How familiar are you with how nanotechnology is used in medical research and development?

- ☐ Not at all familiar (1)
- ☐ Slightly familiar (2)
- ☐ Somewhat familiar (3)
- ☐ Very familiar (4)
- ☐ Extremely familiar (5)

a1_famgen How familiar are you with how nanotechnology is used in genetics research and development?

- ☐ Not at all familiar (1)
- ☐ Slightly familiar (2)
- ☐ Somewhat familiar (3)
- ☐ Very familiar (4)
- ☐ Extremely familiar (5)

a1_t8 Timing

- First Click (1)
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a1_Q10 What do you know? Next, see if you can answer the following questions. Please don't "Google" the answers! (You will learn more about these things in later assignments.)

[correct answers are highlighted below]

a1_know2 What is genetic engineering?

- ☒ The changing of the structure of genetic material (1)

- ☐ The engineering of new organisms and life forms (2)
- ☐ The engineering of electronic devices using genetic materials (3)
- ☐ The method by which taxonomists edit transgenic traits (4)

a1_know4 Which of the following is between 2 and 100 nanometers wide?

- ☒ DNA (1)
- ☐ The head of a pin (2)
- ☐ A human hair (3)
- ☐ DNA base-pairs (4)
- ☐ A hydrogen atom (5)

a1_know1 How many nanometers are in one meter?

- ☐ 1,000,000,000,000 (One trillion) (1)
- ☒ 1,000,000,000 (One billion) (2)
- ☐ 1,000,000 (One million) (3)
- ☐ .000001 (One millionth) (4)
- ☐ 10-9 (One billionth) (5)

a1_know6 What are "second order effects" of technology?

- ☒ Social impacts, or changes in society that result indirectly from the new technology (1)
- ☐ Impacts of new technology on the offspring of the individual who was exposed to the technology (2)
- ☐ The increase in choices that are available as a result new technologies (3)
- ☐ All of the above (4)
- ☐ None of the above (5)

a1_t9 Timing

First Click (1)
 Last Click (2)
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a1_ktfConf Please indicate whether the following statements are True or False:

Correct answers are shaded.

	True (1)	False (2)
Materials that are harmless at the macro-level could be harmful at the nano-level. (1)	☒	☐
Researchers have used nanomedicine technologies to create biological weapons that have already fallen into the wrong hands and are currently being used by organized crime groups. (2)	☐	☒
One outcome already identified as possible with nanotechnology is innovative diabetes treatments that stimulate insulin production from outside the body. (3)	☐	☒
Biologics (biological medications) may be able to benefit from nanotechnology because nanotechnology may allow for a delivery system that can make smaller doses of biologics possible. (4)	☒	☐
Nanotechnology has already been used to develop materials to improve products such as tennis rackets. (5)	☒	☐
Liposomes have been used to house and deliver drugs in a way that organs and tissues that are otherwise hard to reach, like the brain, can be reached. (6)	☒	☐
A good example of a nano-sized object is a red blood cell. (7)	☐	☒
Nanomaterials in the environment can enter the body and certain nanoparticles have already been shown to interfere with normal bodily processes. (8)	☒	☐
The term "human enhancement" includes advancements like curing diseases. (9)	☒	☐
Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines. (10)	☒	☐
Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research. (11)	☐	☒
Due to the increased cost of surgical and diagnostic tools, nanotechnology will definitely increase the cost of health care. (12)	☐	☒
The major risks associated with the use of nanomedicine have been identified. (13)	☐	☒
Currently, it is really hard to predict the potential second order-effects of nano-technology. (14)	☒	☐
Numerous nanotechnology products are already on	☒	☐

the market; therefore, research and development in nanotechnology is already affecting economic systems. (15)		
The government currently uses nano-scale devices to monitor people. (16)	☐	☐
The "second order effects" of nanotechnology can be accurately predicted from "first order effects." (17)	☐	☐
Most traditional pollutant filters are able to catch and stop nanoparticles. (18)	☐	☐

a1_t10 Timing

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a1_Q13 What do you think?

a1_Q14 How might you answer the following attitude questions? Next, please reflect on the following questions. These questions will be the focus of your thinking and discussion of nano-biological policy-related topics this semester. Don't worry if you do not know much about nanotechnology -- that is OK! You will have a chance to change your answers at the end of the semester once you know more. For now, just reflect on your initial impressions by answering the questions based on your "gut" feelings-It's perfectly fine just to guess!

a1_riskben Based on what you know right now: Do you think the risks of nano-biological research and development outweigh the benefits? Alternatively, do you think that the benefits outweigh the risks?

- ☐ The risks greatly outweigh the benefits (1)
- ☐ The risks somewhat outweigh the benefits (2)
- ☐ The risks slightly outweigh the benefits (3)
- ☐ The risks and benefits are equal (4)
- ☐ The benefits slightly outweigh the risks (5)
- ☐ The benefits somewhat outweigh the risks (6)
- ☐ The benefits greatly outweigh the risks (7)

a1_regslid In your opinion, how much regulation is needed with respect to nano-biological research and development? Move the slider to reflect your view. 0 means that you believe there should be NO regulation of nano-biological developments. 100 means that you believe EVERY ASPECT of nano-biological research and development should be HIGHLY regulated.

_____ None at all (1)

Q357 What do you think?

A1_humanen

Human enhancement can refer very generally to anything designed to “enhance” human capabilities. In modern society, this can include activities ranging from higher education and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby's eye color. It may even involve the enhancement of normal capabilities to be extraordinary. There are many conflicting views on whether and how much human enhancement should be allowed, or whether some methods of human enhancement are allowable and others not. In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement? Move the slider to reflect your view. Use the following guidelines regarding the meaning of different levels.

0 = NEVER, that is, you believe that no amount of nanotechnology-supported human enhancement should be allowed, not even for life-threatening illnesses or medical purposes.

25 = RARELY, that is, you believe that nanotechnology-supported human enhancement should only be allowed RARELY, and only under a small set of situations. For example, you may approve of it to cure life-threatening illnesses and disabilities.

50 = SOMETIMES, that is, you believe that nanotechnology-supported human enhancement should be allowed SOMETIMES, but not too often. For example, you may approve of it to treat medical conditions, including those that are not life-threatening, but perhaps not for enhancing appearance.

75 = USUALLY, that is, you believe that nanotechnology-supported human enhancement USUALLY should be allowed, but perhaps with some specific restrictions. For example, you may feel its use is ok for many or most non-medical purposes, but maybe not to create “super humans” or modify one's children.

100 = ALWAYS, that is, you believe human enhancement should ALWAYS be allowed in all cases. For example, uses could include superficial and “superhuman” purposes, and may include enhancing

yourself or others (e.g., your children).

_____ To what extent should nanotechnologically-supported human enhancement be allowed? (1)

Q359 Timing

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Q358 What do you think?

a1inputQyv Finally, at the end of the New Biology assignments, in addition to giving answers to the prior three questions regarding risk/benefits, regulations, and allowable applications to human enhancement, you will be asked to write a short essay explaining and justifying your views. As you write your explanations and justifications, you will be asked to cover the following points. Please read these and keep them in mind as you learn more about nanotechnology this semester. (1) Future development: What developments should be prioritized or avoided? As you consider your answers this question, consider the questions below, indicate why you feel the way you do, and do your best to look for and provide evidence for the statements you make. In your opinion, what should the future of nano-biological technology development look like, especially when it comes to human enhancement applications? What should it not look like? That is, should any developments be avoided? Why do you feel that way? Is there evidence to support your views? What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the development of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why? (2) Regulation of Nanotechnology: What regulations should be in place or are needed? As you answer this question, please consider the questions below, indicate why you feel the way you do, and do your best to provide evidence for the statements you make. In your opinion, given current developments in nano-biological technologies and the various developments that are possible in the future, what social policies, rules, limits and regulations should be in place? What regulations should not be in place or should be avoided? Why do you feel that way? Is there evidence to support your views? What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why?

Display This Question:

If write Is Equal to yourview

a1_input_text Note: Your answer to this question WILL NOT be turned in to your instructors. This question is just designed to get you to think about your initial starting point. Your instructors will be informed IF you answered the question, but not HOW you answered it. Please write down what comes to your mind as possible preliminary answers to these questions below.

a1_t7 Timing

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a1_Q11 What do you know?

a1_attchg What Do You Know: Question for Reflection In your estimation, as you become more knowledgeable about nano-biological technologies, how likely are you to change your views about the development and regulation of those technologies?

- ☐ Very Unlikely (1)
- ☐ Unlikely (2)
- ☐ Somewhat Unlikely (3)
- ☐ Undecided/ Cannot Judge (4)
- ☐ Somewhat Likely (5)
- ☐ Likely (6)
- ☐ Very Likely (7)

a1_chgrefl Write at least one or two sentences explaining why you gave the answer above. Why or how might things you learn impact your views about the regulation and development of these technologies?

Note: Your answer to this question WILL be turned in to your instructors. This question, like the other opinion questions, will only be graded for whether or not you made an effort to reflect -- **not** for content.

a1_t11 Timing

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a1_Q21 Who are you?

a1_Q22 So far, we've considered: Where do you start? What do you know? and What do you think? Last but not least, think about who you are -- your traits, your attitudes about related topics, your beliefs, and your place in society. As you answer the questions below, consider -- are your initial reactions to nanotechnology impacted by your other characteristics, traits, and beliefs? Would people with different characteristics and beliefs likely "start out" viewing nanotechnology differently from you? Remember: Your answers are confidential. None of these answers will be shared with any of your instructors or classmates. Your answers also cannot be used in research unless you give your consent.

a1_Traits Please indicate your level of agreement with the following statements. Please answer these as honestly as you can. Also, the questions are meant to be easy and are most accurate if you give your first "gut reaction" rather than thinking too hard about them.

	Extent of Agreement					
	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)

I believe that others have good intentions. (a1_Traits_3)

I trust what people say. (a1_Traits_2)

I believe most people try to be fair. (a1_Traits_5)

The notion of thinking abstractly is appealing to me. (a1_Traits_6)

I like to have the responsibility of handling a situation that requires a lot of thinking. (a1_Traits_7)

Thinking is not my idea of fun. (a1_Traits_8)

I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something. (a1_Traits_9)

I really enjoy a task that involves coming up with new solutions to problems. (a1_Traits_10)

Learning new ways to think doesn't excite me very much. (a1_Traits_11)

I usually end up deliberating about issues even when they do not affect me personally. (a1_Traits_12)

A good citizen should listen to people who disagree with them politically. (a1_Traits_13)

A good citizen should allow others to challenge their political beliefs. (a1_Traits_14)

A good citizen should discuss politics with those who disagree with them. (a1_Traits_15)

A good citizen should be willing to justify their political views. (a1_Traits_16)

If a citizen is dissatisfied with the policies of government, he or she has a duty to do something about it. (a1_Traits_17)

I follow political and social issues because I want to learn more things. (a1_Traits_18)

I follow political and social issues because that's what I'm supposed to do. (a1_Traits_19)

I follow political and social issues because it bothers me when I don't. (a1_Traits_20)

I follow political and social issues because I think it's important. (a1_Traits_24)

Sometimes politics and government seem so complicated that a person like me can't really understand what's going on. (a1_Traits_27)

I consider myself well-qualified to participate in politics. (a1_Traits_25)

I think that I am better informed about political and social issues than other students. (a1_Traits_28)

I feel I have a pretty good understanding of current political and social issues facing my world. (a1_Traits_23)

I have a vivid imagination. (a1_Traits_36)

I enjoy hearing new ideas. (a1_Traits_39)

I do not like art. (a1_Traits_41)

I am not interested in abstract ideas. (a1_Traits_40)

The government interferes far too much in our everyday lives. (a1_Traits_28.0)

It's not the government's business to try to protect people from themselves. (a1_Traits_30)

The government should stop telling people how to live their lives. (a1_Traits_31)

Sometimes government needs to make laws that keep people from hurting themselves. (a1_Traits_29)

The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals. (a1_Traits_32)

Government should put limits on the choices individuals can make so they don't get in the way of what's good for society. (a1_Traits_33)

We have gone too far in pushing equal rights in this country. (a1_Traits_34)

Our society would be better off if the distribution of wealth was more equal. (a1_Traits_35)

We need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women. (a1_Traits_36.0)

Discrimination against minorities is still a very serious problem in our society. (a1_Traits_37)

It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them. (a1_Traits_38)

Society as a whole has become too soft and feminine. (a1_Traits_39.0)

I am always prepared. (a1_Traits_44)

I pay attention to details. (a1_Traits_45)

I get chores done right away. (a1_Traits_46)

I carry out my plans. (a1_Traits_47)

I make plans and stick to them. (a1_Traits_48)

I waste my time. (a1_Traits_49)

I find it difficult to get down to work. (a1_Traits_50)

I do just enough work to get by. (a1_Traits_51)

I don't see things through. (a1_Traits_52)

I shirk my duties. (a1_Traits_53)

If you are reading each item as you answer, choose strongly agree. (a1_Traits_54)

a1_t18 Timing

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a1_Q23 Who are you? Remember: Your answers are confidential. None of these answers will be shared with any of your instructors or classmates. Your answers also cannot be used in research unless you give your consent.

a1_intrnat How interested are you in national politics and national affairs?

- ☐ Not Interested 0 (0)
- ☐ 1 (1)
- ☐ 2 (2)
- ☐ Moderately Interested 3 (3)
- ☐ 4 (4)
- ☐ 5 (5)
- ☐ Extremely Interested 6 (6)

a1_intrloc Thinking about your local community, how interested are you in local community politics and local community affairs?

- ☐ Not Interested 0 (0)
- ☐ 1 (1)
- ☐ 2 (2)
- ☐ Moderately Interested 3 (3)
- ☐ 4 (4)

- ☐ 5 (5)
- ☐ Extremely Interested 6 (6)

a1_ideolog Ideologically, which of the following best describes you...

	Strongly Liberal (1)	Moderately Liberal (2)	Weakly Liberal (3)	Centrist / Middle of the Road (4)	Weakly Conservative (5)	Moderately Conservative (6)	Strongly Conservative (7)	Prefer not to answer (8)
Overall (1)								
When it comes to ECONOMIC issues (2)								
When it comes to SOCIAL issues (6)								

a1_partyid In politics today, do you consider yourself a Republican, Democrat, or Independent/Other?

- ☐ Strong Democrat (1)
- ☐ Democrat (2)
- ☐ Weak and Leaning Democrat (3)
- ☐ Independent / Other (4)
- ☐ Weak and Leaning Republican (5)
- ☐ Republican (6)
- ☐ Strong Republican (7)
- ☐ Prefer not to answer (8)

a1_relig With regard to religion, which of the following best describes you?

	Not at all religious (1)	A little bit religious (2)	Moderately religious (3)	Very religious (4)	Prefer not to answer (5)
Overall (1)					

a1_religty With regard to religion, which of the following most closely describes you?

- ☐ Mainline Protestant (1)
- ☐ Evangelical Protestant (2)

- ☐ Black Protestant (3)
- ☐ Roman Catholic (4)
- ☐ Jewish (5)
- ☐ Muslim (6)
- ☐ Agnostic (7)
- ☐ Atheist (8)
- ☐ Other (9) _____
- ☐ Prefer not to answer (10)

a1_reflect Who Are You: Final Questions for Reflection Think about the unique personality traits, political views, religious views, beliefs, and interests that make you, "you." How do your characteristics impact your views? How might someone who differs from you in these characteristics and beliefs be "starting out" approaching new technologies differently than you? Write at least 2-3 sentences in response to these reflection questions. Note: Once again, the rest of the questions on this page are confidential. However, your answer in the text box below WILL be turned in to your instructors. Again, this question will only be graded for whether or not you made an effort to reflect -- *not* for content.

a1_t19 Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
- Click Count (4)

Q361 Next, please answer the following question. The reason for the question below is to ensure the accuracy of the data if you agreed to let researchers use your assignments.

Q363 Did you read the questions and answer the questions in this assignment honestly? (You will not be penalized for your answer. Your instructors will not know how you answered.) .

- ☐ Yes, my answers reflect my honest answers (1)
- ☐ No, I answered the questions randomly (2)
- ☐ No, I felt like I should answer in a certain way, so I gave those answers instead of my honest responses (3)
- ☐ No, I did not even read the questions as I answered them (4)
- ☐ Other (Please explain) (5) _____

a1_Q24 Print this Page. You will need to hand it in at your next recitation to be graded. Note: On the next page, you will also have the option to have the information from this page emailed to you. It is still a good idea to save the information below because some students report that the email option has not been 100% reliable. This is a record of your answers to the open-ended questions. Please print this page from your browser, or copy and paste into a document that you can print, and hand it in at your next recitation.

a1_Q25 Name: xxxqx://QID80/ChoiceGroup/AllChoicesTextEntryxx Recitation:
xxxqx://QID82/ChoiceGroup/AllChoicesTextEntryxx Your Open-ended Reflections Your reflections on how the following impact your "starting point" or might change your views as you learn about the topics. What do you know? "xxxqx://QID258/ChoiceTextEntryValuexx" Who are you?
"xxxqx://QID327/ChoiceTextEntryValuexx"

a1_email Get an Email copy of your assignment: This assignment is worth up to 7 points. It will be graded on effort, not content. Enter your email address below, and a copy of this assignment will be emailed to you after you have completed it. You should save a printed or emailed copy of your assignment as verification that you completed the assignment in case there is a grading discrepancy later. Email:

a1_comment Feedback? As you know, the New Biology assignments are being evaluated by your instructor with the help of researchers from the Public Policy Center. So, if you have any feedback, comments, or questions about this first New Biology Assignment, please write them below.

a1_Q27 When you are done, click continue to submit your assignment.

4.1.2. Study 5, Assignment 2

Note that in many/most cases the order of the items and answer options (e.g., on multiple choice questions) were administered by the survey software in random order to reduce order effects.

a2_Q1 IMPORTANT: This assignment is best done in one sitting. ALL your open-ended responses will be printed at the end of the assignment so that you can hand them in for grading. If you think you will need to leave it and come back, you should be sure that you come back to the same computer and that your browser is set to save cookies so that you can resume the assignment where you left off. If cookies are not enabled, you may have to start the assignment over if you leave and come back.

a2_name This assignment will be graded and to receive credit for this assignment, the following information is needed:

[Certain information will be removed from the data file for purposes of deidentification.]

First Name (1)

Last Name (2)

a2_reci Please indicate which Bio 102 recitation you are enrolled in (see list below if you are not sure):

Recitation section number (Please check list below for accuracy) (1)

Recitation instructor name (2)

Day and time of recitation (3)

a2_time1 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

Display This Question:

If CTcond Is Equal to 1

Q422 Put on your Thinking Cap! Because nanotechnology is a relatively new area and many people do not know much about it, we've prepared a brief introduction. But don't let the background information that you are about to read limit or replace your own critical thinking about nanotechnology and human enhancement. When it comes to providing useful answers to questions about the future of nanotechnology, the more critically you have analyzed the various options, the better. Critical thinking is one of the challenges of public engagements, because it requires a lot of hard mental work. Throughout this document, watch for links to additional information that you may want to consider as you weigh the options, and "Tips for Critical Thinking" to help you practice critical thinking skills as you read.

Display This Question:

If CTcond Is Equal to 0

Q494 Get Ready to Explore! Because nanotechnology is a relatively new area and many people do not know much about it, we've prepared a brief introduction. But don't let the background information that you are about to read limit or replace your own exploration of nanotechnology and human enhancement. When it comes to providing useful answers to questions about the future of nanotechnology, the more you can learn about the topic, the better.

Q424 Timing

First Click (1)

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Click Count (4)

Q463

Q426 Introduction: Working at the Nano-Scale Note: Throughout the document you will notice blue underlined text. These are links to additional information. Click a link to view the information in a new tab. When you are done, close the tab to return to the assignment. Clicking links will not cause you to lose your place in the assignment. You are encouraged to click on these links to further pursue any information that catches your attention. Such exploration will only make your input better.

Display This Question:

If InfoCond Is Equal to strong

Q428

Nanotechnology refers to a variety of scientific and technological developments that involve the very precise manipulation of matter at the nanoscale. One nanometer (nm) equals one-billionth of a meter. Nanoparticles are typically between 1 and 100 nanometers in length or width. As illustrated in Figure 1, DNA and silver nanoparticles are examples of "nano"-sized materials, red blood cells are bigger and considered to be "micro"-sized, and objects we can see easily are "macro"-sized. Powerful microscopes are needed to visualize objects at the nanoscale. An important feature of nanoscale materials is how their properties differ from macroscale materials. Everyday common materials take on new and different properties when reduced to nano-sized objects. For example, substances may change color and how they react to other substances. In fact, scientists have found that they can manipulate carbon atoms and molecules to create nanosized carbon tubes and fibers with unique properties. Although normal-scale carbon does not conduct electricity, carbon nanotubes are effective electrical conductors, as well as extremely hard and durable and yet very light. The changes in properties at the nanoscale can be beneficial (as in the case of carbon) or negative--because some materials that are harmless at their normal size could be dangerous at the nanoscales. The discovery of the changing properties of nano-sized materials has resulted in the creation of a number of revolutionary technologies that are already impacting our lives. For example, some nanocomposites and nanocrystals are more scratch-resistant, light-weight, rust-proof, stronger, or longer-lasting than traditional materials, leading to their use in tennis rackets, tennis balls, and display screens. Because of their water dispersion properties, nanoparticles are also being incorporated into things like exterior paints, adhesives, paper, textiles, and even stain-resistant clothing. Certain nanoparticles are extremely effective in absorbing light and are being used in cosmetics and sunscreens. Aluminum and copper nanoparticles are being used to create rocket propellants that burn at double the rate of traditional propellants and automotive lubricants that reduce engine wear. Additionally, nanofilters are being used to sterilize water much more efficiently than any other means discovered to date. These developments are having broad impacts on society as a whole. For example, a company in China has licensed nanocatalyst technology that will enable it to liquefy coal and turn it into gas, which may make the company much more competitive on a global scale. Similarly, the automotive industry is adopting the use of nanocatalysts in its catalytic converters, thus making certain chemical reactions more efficient and resource-saving, which have various industrial implications. Additionally, the United States stands to gain from nanotechnological developments related to renewable energy. This is especially important because many believe the U.S. is falling behind in its use of "green" energy. On the other hand, many people are concerned about the potential risks of these developments. Sandler and Bosso (2007) argue that more attention needs to be directed at the social context of nanotechnology, including who has access to resources, social and political power, individual rights, and justice in general. Sandler and Bosso also criticize U.S. federal regulatory organizations as often being too slow in reacting to technological breakthroughs that require regulatory oversight, and recommend that caution be used in pursuing advances in nanotechnology. Hoet et al. (2004) discuss some specific known risks of nanotechnology. Such risks include the ability of nanomaterials to enter the body through various ports, most likely via the lungs, and pass to other vital organs via the bloodstream. Given that human skin, lungs and the intestinal tract are always in direct contact with the environment, there are many ways in which nanomaterials can enter the body. This is of concern because nanoparticles have been shown to be active at the cellular level. For example,

carbon black nanoparticles have been implicated in interfering with cell signaling and causing inflammation and even tumors in the lungs. Experiments on laboratory animals also have shown that carbon nanotubes, used in many applications due to their unique properties, can damage the lungs of rats and mice. Beyond harm to humans, a report from the Health Council of the Netherlands explains how the ability of nanomaterials to cross barriers, as well as the high reactivity and toxicity of some, can make them hazardous to both humans and the environment. Although nanoparticles exist naturally in the environment, fossil-fuel combustion has substantially increased their volume in the air. Some research has shown that iron nanoparticles are capable of travelling with groundwater twenty meters into the soil and can remain reactive for four to eight weeks. These reactive nanomaterials can make their way into soil-eating organisms, accumulate in the fatty tissue of those organisms, and move up the food chain to humans. In addition, "free form" nanoparticles can be released into the air or water during the process of manufacturing nanomaterials and most traditional pollutant filters are unable to catch nano-sized particles.

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If InfoCond Is Equal to weak

Q83 Nanotechnology refers to a variety of scientific and technological developments that involve the very precise manipulation of matter at the nanoscale. One nanometer (nm) equals one-billionth of a meter. Nanoparticles are typically between 1 and 100 nanometers in length or width. As illustrated in Figure 1, DNA and silver nanoparticles are examples of "nano"-sized materials, red blood cells are bigger and considered to be "micro"-sized, and objects we can see easily are "macro"-sized. Powerful microscopes are needed to visualize objects at the nanoscale. An important feature of nanoscale materials is how their properties differ from macroscale materials. Everyday common materials take on new and different properties when reduced to nano-sized objects. For example, For example, substances may change color and how they react to other substances. In fact, scientists have found that they can manipulate carbon atoms and molecules to create nanosized carbon tubes and fibers with unique properties. Although normal-scale carbon does not conduct electricity, carbon nanotubes are effective electrical conductors, as well as extremely hard and durable and yet very light. The changes in properties at the nanoscale can be beneficial (as in the case of carbon) or negative--because some materials that are harmless at their normal size could be dangerous at the nanoscales. The discovery of the changing properties of nano-sized materials has resulted in the creation of a number of revolutionary technologies that are already impacting our lives. For example, some nanocomposites and nanocrystals are more scratch-resistant, light-weight, rust-proof, stronger, or longer-lasting than traditional materials, leading to their use in tennis rackets, tennis balls, and display screens. Because of their water dispersion properties, nanoparticles are also being incorporated into things like exterior paints, adhesives, paper, textiles, and even stain-resistant clothing. Certain nanoparticles are extremely effective in absorbing light and are being used in cosmetics and sunscreens. Aluminum and copper nanoparticles are being used to create rocket propellants that burn at double the rate of traditional propellants and automotive lubricants that reduce engine wear. Additionally, nanofilters are being used to sterilize water much more efficiently than any other means

discovered to date. These developments are having broad impacts on society as a whole. For example, a company in China has licensed nanocatalyst technology that will enable it to liquefy coal and turn it into gas, which may make the company much more competitive on a global scale. Similarly, the automotive industry is adopting the use of nanocatalysts in its catalytic converters, thus making certain chemical reactions more efficient and resource-saving, which have various industrial implications. Additionally, the United States stands to gain from nanotechnological developments related to renewable energy. This is especially important because many believe the U.S. is falling behind in its use of “green” energy. On the other hand, many people are concerned about the potential risks of these developments. Some argue that more attention needs to be directed at the social context of nanotechnology, including who has access to resources, social and political power, individual rights, and justice in general. Some also criticize U.S. federal regulatory organizations as often being too slow in reacting to technological breakthroughs that require regulatory oversight, and recommend that caution be used in pursuing advances in nanotechnology.

Display This Question:

If CTcond Is Equal to 1

Q430 TIP for Critical Thinking: Detecting Bias Your goal is to provide useful input on the future of nanotechnology. To provide useful input on the future of nanotechnology, you need to be able detect and see past biased presentation of information. As you read about nanotechnology—especially as you visit the links to additional information that are provided—look for signs of bias. Signs of bias include: Selective use of adjectives and examples Strong, persuasive language Presentation of only one perspective on an issue If mostly positive or negative adjectives are used, or if mostly (or exclusively!) positive or negative examples are given, then ask yourself how someone with a different viewpoint might describe the same “facts.” Although such examples do not guarantee bias, they do suggest the possibility the author is giving a one-sided perspective on something that may be less clear-cut. You may want to do some of your own research to see how others are describing the same topics. Below, give one example of bias that you see in the background information so far -- or in links that you visited -- and indicate the changes that would be needed to make the information or source less biased.

Display This Question:

If CTcond Is Equal to 0

Q496 Explore and Reflect Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links. You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!

Your reflection:

Q434 Timing

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Display This Question:

If InfoCond Is Equal to strong

Q436 Biology Meets Nanotechnology Two technologies that exist at the interface of nanotechnology and biology are nanomedicine and nanogenomics. Both technologies have shown potential for use in human enhancement applications. Human enhancement refers very generally to anything designed to “enhance” human capabilities. In modern society, methods for human enhancement include common activities ranging from higher education and athletic training, to less common methods such as plastic surgery and the development and use of prosthetic limbs. Thus, human enhancement includes both removal of negative human characteristics (e.g., curing diseases and disabilities) as well as the enhancement of positive capabilities. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing genetic diseases to choosing a baby's eye color. Some think it may even involve the enhancement of normal capabilities to be extraordinary. We'll next talk a bit more in detail about human enhancement developments specific to nanomedicine and nanogenomics.

Nanomedicine Nanomedicine refers to the application of nanotechnology to medical work, such as health diagnoses and treatments. Doctors use nanotechnology in a variety of ways, including research with liposomal nanoparticles, in order to find new and better ways to treat various diseases. Liposomes are man-made, sphere-shaped cell organelles (a type of vesicle), only 100 nanometers in diameter, that are generally used to house and deliver drugs. For example, liposomes have been used to administer highly potent anticancer chemotherapy drugs in a way that delivers a higher proportion of the drug to the target and less to the rest of the body, possibly minimizing serious side-effects (LaVan, McGuire, & Langer, 2003). Liposomes have also been used to deliver drugs to organs and tissues that are otherwise hard to reach, such as the brain. This is important because roughly 90% of drugs showing therapeutic benefits for treating diseases like Alzheimer's, Multiple Sclerosis and brain tumors cannot reach the brain in sufficient concentrations to be effective without assistance from nanotechnology (Freitas, 2005). Only with the aid of liposome delivery systems are these medicines able to penetrate the blood-brain barrier, which normally prevents the passage of large polar molecules. Additionally, there is a newer class of “biological medications” (called biologics), which are destroyed in the stomach and thus cannot be taken as traditional tablets. Biologics are much more expensive than traditional medications, so some scientists hope that the smaller doses that are

made possible by nanotechnology-enabled delivery systems could make these drugs cheaper and thus accessible to more people (Freitas, 2005). Also, nanoparticles are being incorporated for their water dispersion properties into certain vitamins and pharmaceuticals that have precursors that are insoluble in water.

In addition to drug delivery, nanomedicine has been used for cutting-edge diagnostic purposes. For example, injecting iron oxide nanoparticles into the bloodstream prior to an MRI (magnetic resonance imaging) significantly enhances the MRI's ability to detect the spread of cancer from its point of origin to lymph nodes in the body (Cavalcanti et al., 2007). Further diagnostic techniques that utilize nanotechnology are being studied for their potential to detect early signs of skin cancer, Alzheimer's disease and other cell diseases. Currently, researchers are also working to develop a variety of novel medical treatments. Some research involves using mice to test the internal use of engineered nanosized gold-coated silica particles. These nanoshells accumulate in tumor tissues and can be selectively heated when illuminated from outside the body with near infrared light. The heat then destroys the tumor tissue (Nanoscale Informal Science Education, 2007). Clusters of heated, magnetic nanoparticles have been used to control ion channels in cell membranes, and some scientists hope that such techniques will someday result in new treatments for cancer, diabetes and some neurological disorders. Doctors are hopeful that this research will one day allow us to target and treat tumors more efficiently and with fewer side effects than traditional treatments.

Nanogenomics Nanogenomics is an area of study within both genetics and nanotechnology. The term "nanogenomics" implies the use of nanotechnology to aid in the study of the genes of cells at microscopic levels (DNA, mRNA and protein). Sometimes the term "nanogenetics" is used to refer to the study of how nanotechnologies might be applied to change single genes within the genetic code. Here, however, we are using the term nanogenetics or nanogenomics broadly to refer to any research and development involving both nanotechnology and genetics. For example, since 2003, researchers have been able to use nanotechnology to manufacture mechanical devices that are DNA-based, including DNA "scaffolds," which have the same double helix shape, that can help scientists build smaller-than-ever computer chips (Seeman, 2003; Kershner, 2009). Though this line of research focuses on the technology industry, its concepts are rooted in biology, through the architectural design of DNA. This technology could potentially allow computer chips to be made that are faster, more energy efficient and less expensive than they were before.

Other developments in nanogenomics overlap with nanomedicine. For example, some nanogenomic medicines consist of a manufactured strand of RNA that can be delivered to a set of cells to reduce the expression of, or target the destruction of, a specific gene. This technique, called RNA interference (or RNAi) is being explored for its potential to treat diseases such as cancer (Wang et al., 2008) and inflammatory bowel disease (Wilson, 2010), but with some debate regarding the likelihood of its eventual success (e.g., see Ledford, 2010).

Nanotechnology is also currently being used in the area of genetics to investigate new means for mapping the human genome (referred to as "nano-sequencing" of DNA) and to provide new methods for transforming genetic code or genetic expression and, thus, for genetic engineering (defined as the changing of the structure of genetic material). In general, genetic engineering techniques can be used to modify products such as the stress resistance of agricultural crops (Moeller & Wang, 2008) and for tissue engineering (Ernest & Shetty, 2005), in which new tissues are created outside the body and then surgically placed in the body.

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If InfoCond Is Equal to weak

Q86 Biology Meets Nanotechnology Two technologies that exist at the interface of nanotechnology and biology are nanomedicine and nanogenomics. Both technologies have shown potential for use in human enhancement applications. Human enhancement refers very generally to anything designed to “enhance” human capabilities. In modern society, methods for human enhancement include common activities ranging from higher education and athletic training, to less common methods such as plastic surgery and the development and use of prosthetic limbs. Thus, human enhancement includes both removal of negative human characteristics (e.g., curing diseases and disabilities) as well as the enhancement of positive capabilities. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing genetic diseases to choosing a baby’s eye color. Some think it may even involve the enhancement of normal capabilities to be extraordinary. We’ll next talk a bit more in detail about human enhancement developments specific to nanomedicine and nanogenomics.

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In addition to drug delivery, it is commonly known that nanomedicine has been used for important cutting-edge diagnostic purposes. For example, injecting iron oxide nanoparticles into the bloodstream prior to an MRI (magnetic resonance imaging) significantly enhances the MRI’s ability to detect the spread of cancer from its point of origin to lymph nodes in the body. Further, diagnostic techniques that utilize nanotechnology are being studied for their potential to detect early signs of skin cancer, Alzheimer’s disease and other cell diseases.

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when illuminated from outside the body with near infrared light. The heat then destroys the tumor tissue (Nanoscale Informal Science Education, 2007). Clusters of heated, magnetic nanoparticles have been used to control ion channels in cell membranes. It thus seems likely that such techniques will someday result in new treatments for cancer, diabetes and neurological disorders. Many doctors also are hopeful that this research will one day allow us to target and treat tumors more efficiently and with fewer side effects than traditional treatments.

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Display This Question:

If CTcond Is Equal to 1

Q438 TIP for Critical Thinking: Consider the Quantity and Quality of Evidence In the above text (and links you visit), consider the claims that are made. Ask yourself: What is the evidence for the claims that are being made? Keep in mind that good evidence: Will be relevant. For example, if one claims that something is expensive, one needs to give evidence of its price, not refer to the numbers of people who use it (which would instead support a claim about wide use, not cost of use). Will be accurate. For example, it will be typical evidence--there will not be a lot of other evidence that would contradict the evidence presented. A short cut for looking for accurate information is to look for a credible source. Will be sufficient. Is there sufficient evidence that the claim is true? Or are the claims made based on

only a little evidence? Below, give one example of a claim made above (in the text or a link that you explore) that you think is poorly supported, OR one example of a claim that is well-supported. For the claim, explain why the evidence for the claim is good, or not very good. For example, is the evidence relevant? Accurate? Typical? And/or sufficient?

Display This Question:

If CTcond Is Equal to 0

Q501 Explore and Reflect Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links. You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!

a2_refl_evid2

Your Reflection:

Q442 Timing

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Q516 (We hope so!) But regardless...wake up now...because that's it for the background on: What nanotechnology is What human enhancement is And some of the current developments taking place at the interface between nanotechnology and biology. We hope you enjoyed hearing about this new science, and maybe learned some things you didn't know before. Momentarily, we will be asking you: What developments and regulations do YOU think should be prioritized? But first, prior students have said that, in forming their opinions, it would be helpful to know a little bit about what others think about nanotechnology and human enhancement. On the next page we outline some issues and perspectives. After that, you'll be able to see what your classmates think. [a.rollover:link xx color: blue; text-decoration: underline; font-size: 14px xx a.rollover:active xx color: blue; text-decoration: underline; font-size: 14px xx a.rollover:visited xx color: blue; text-decoration: underline; font-size: 14px xx a.rollover:hover xx color: blue; text-decoration: underline; font-size: 18px xx](#) **IMPORTANT NOTE! <--** Click here Remember, additional information opens up when you click on blue bold underlined text. On the next page, reading this additional information will be a tremendous help in providing information for your answers, so be sure to click on them and read them! Then, click on the link again to close it. The next page is written in "interactive" format. Only the bare bones of the different issues and perspectives are shown, while details can be seen by clicking on the bold, blue, underlined text. DO click on these and read them! They contain important details for helping you decide what you think about the issues.

Q505 Nano-biological Human Enhancement: Ethical, Legal and Social Issues (ELSI)

Q507 Approaches & Perspectives: An Overview So far this background document has focused on describing current developments at the interface of nanotechnology and biology. As with any issue that holds significant implications for society, however, there exist many opinions about the role of nanotechnology in today's world—and what future development and regulation should look like. In this section, we review two major approaches or perspectives on the ethical, legal and social issues pertaining to these topics, in order to provide you with a starting point for exploring your own opinion.

Approach 1: Human Enhancement as "Human Progress" According to the Human Progress perspective, the benefits of nanogenomic and nanomedical research that have already been discovered (as reviewed above), as well as those potentially available in the future, far outweigh the risks that might accompany such research. Those with this opinion argue that it is our nature as humans to progress, and we should take advantage of new technology as it is developed. We have the potential to save many lives, and the longer we wait, the more lives go unsaved. The costs of slowing down research and development can be measured in numbers of lives lost while waiting for the research. Action Implications: The major implication of the Human Progress perspective is that we should keep regulation of nanogenomic and nanomedical research to a minimum, and fund such research aggressively. Support: In support of the Human Progress perspective, many proponents argue points such as the following: [a.rollover:link xx color: blue; text-decoration: underline; font-size: 14px xx a.rollover:active xx](#)

color: blue; text-decoration: underline; font-size: 14px xx a.rollover:visited xx color: blue; text-decoration: underline; font-size 18px xx

Quality of life: With nanobiological technologies, we may be able to increase the quantity and quality of life.

Related to quality of life, advocates of the Human Progress perspective argue that it is possible that future developments in nanomedicine and nanogenomics toward human enhancement could increase life expectancy and the quality of life. Consistent with this viewpoint, new technologies in medicine have already allowed us to increase life expectancy at a substantial rate over the centuries.

Further enhancements in the quantity (life expectancy) and quality (health) of life could follow from a multitude of factors. For example, nanobiological developments could lead to higher rates of survival for those with otherwise terminal illnesses (e.g. cancer) as we develop new and better ways to treat and detect human diseases (Holland et al. 2007), as well as drastic reductions in the effects of aging due to technologies that can cosmetically repair tissues associated with aging (Konovalenko, 2010). It may also be possible to decrease the number of side effects of medicines because targeting the medicine right to specific cells that need it would require much less medicine. Over a longer time period, we may also be able to improve individuals' physical abilities and muscle function, and eventually, individuals' mental abilities and brain function (Kurzweil and Grossman, 2004).

In general, these examples address the capabilities to improve humans, as a whole, through genetic manipulation. Some Human Progress advocates also believe and value the idea that nanogenomic research and development may someday allow us to choose the traits of our children (e.g., gender, hair color, height, intelligence, and so on). Further, advocates of this perspective suggest that we would no longer have to worry about passing on genetic diseases, because nanotechnology might provide us with alternatives to "viral transfection," or gene transfer, which would change and potentially improve us as a species by reforming how we treat inherited diseases (Hassoun, 2008).

Universal healthcare: We may be able to provide cheaper and more universal healthcare.

On a more economic note, some Human Progress advocates argue that healthcare, due to this new technology, could become cheaper and more universal. Surgical and diagnostic tools can be made more elegant and cheap because in a molecular manufacturing system, production costs are not influenced by the complexity of a product. This would lead to cheaper, longer lasting consumer products, not only in healthcare but also in related industries, such as materials that go into health care products.

A stronger country: We could make the country stronger and more independent. This would include creating a new industry based on nanobiological research and human enhancement developments that could produce jobs.

If we were the first country to make certain discoveries and developments, we might also experience economic development through investment and research in nanogenomics techniques and nanomedicines, especially those that could then be marketed internationally. Another economic argument made by advocates of this perspective is that nanotechnological research could also allow the United States to become stronger and more independent as a nation by allowing us to utilize renewable energy more efficiently (see this article about how the U.S. is already falling behind in its use of "green" energy), as well as create new and better ways to clean up and monitor the environment. We could also potentially increase our national security and defense capabilities.

Human autonomy: Individuals have the right to self-improvement, if they want it.

People who adhere to the Human Progress perspective also argue that use of nanotechnology for human enhancement is consistent with our inherent rights to

autonomy. In the United States, we value individual freedom, part of which includes the right to make changes to ourselves and (to some extent) our children. Some proponents of the Human Progress perspective believe these rights apply to the manipulation of genetic codes through nanogenomics as well.

Trade-offs: Even though the proponents of the Human Progress perspective may strongly believe the points above, they still tend to admit that rapid advances in nanobiological human enhancements would probably include the following likely trade-offs: Potential side effects: There could be some side effects of nanomedical and nanogenomic treatments. Some note that

there could, as with any new medicine, be some unforeseen side effects or problems that arise from nanomedicines or the use of nanogenomics to alter genetic code. Traditional job loss: Some

traditional jobs might be lost. Some admit that traditional jobs might be lost due to a shift in medicine and technology away from traditional methods to nanotechnology, nanomedicine, and nanogenomics. Social Changes: There would be significant structural changes in society that could

change how we think about many aspects of life, including our understanding of concepts like "disease" and "age". There would also be implications for how we think about "human nature." If you

take into account the potential of nanogenomic and nanomedical research to get rid of diseases, you might have to ask: "What exactly is a disease?" Maybe genes that alter phenotypes are disease-related.

Or, perhaps a disease is any condition (physical, mental, or emotional) that is undesirable (Freitas, 1999). By this definition, maybe aging is a disease. We already know that nanotechnology has the potential to address the effects of aging, but the implications of such change on our society (seeing aging as a disease) would be tremendous. There is also much discussion as to what the implications of such research would be for the concept of "human nature." Some say that it is not in our nature as humans to be so resilient to death and illness, and rightfully so. We rely on a balance between our health and our environment. On the other hand, some argue that to progress with nanobiological research is perfectly "natural." Technological advancements have done great things for society over time, and if we do not embrace these advancements, we are sacrificing many people to otherwise preventable illnesses and catastrophes. However, according to this approach, these tradeoffs are

not severe enough to warrant heavy regulation. Opposition: Of course, a number of people oppose the Human Progress perspective, and offer the following opposing points: Unacceptable risks: There

would be unpredictable (and unacceptable) risks, including potentially devastating biological and genetic problems. Critics of this approach note that there are not only serious medical and biological

implications to consider, but there are also many social, ethical, and economic issues that must be acknowledged in the conversation about nanogenomic and nanomedical research. The immediate health concerns might include side effects of new medications and treatments, but changes in the structure of the human genome may also have severe negative consequences. Unrealistic

promises: Many of the benefits and promises are unrealistic. Many of the proposed benefits

of the Human Progress approach aren't even seen as generally foreseeable in the near future by many scientists. It is generally accepted that currently, the process of mapping one's DNA sequence is very tedious, and to carry out this process on each individual would be very inefficient (Kircher & Kelso, 2010). It is also suggested that the practicality of passing on manipulated genes to offspring is quite slim (see King for more information). Economic disruption: Economic disruption could result from the

introduction of this new industry. This would also have unpredictable ramifications for economic development and certain industries that would be significantly affected by the new industry

of nanogenomics. Employment patterns would more than likely be disrupted, especially since nanotechnological manufacturing would allow for extremely rapid change in manufacturing industries. Also, an abundance of cheap products can put manufacturing companies out of business as products are made faster and cheaper.

Q509 Approach 2: Human Enhancement as "Unnecessary Risk"

According to a second perspective, the risks of nanogenomic and nanomedical research are too great, especially if human enhancement is the goal. For example, it is often suggested that there could be unforeseen side effects of nanomedicines and nanogenomic treatments. Alternatively, using such technology could interfere with the nature of the human body and have devastating consequences. People in this approach wonder if there could be severe, negative biological and social implications that would stem from such rapid changes to the human genome and human biology. Action Implications: The major implication of the Unnecessary Risk perspective is that nanogenomic and nanomedical research should be extremely regulated, if allowed (and if funded) at all. Very limited amounts of funding should only be used for clearly beneficial research. Support: In support of the Unnecessary Risk perspective, many proponents argue points such as the following:

- a.rollover:link xx color: blue; text-decoration: underline; font-size: 14px xx a.rollover:active xx color: blue; text-decoration: underline; font-size: 14px xx a.rollover:visited xx color: blue; text-decoration: underline; font-size 14px xx a.rollover:hover xx color: blue; text-decoration: underline; font-size: 18px xx

Over population: Overpopulation could result from increased life expectancy and new treatments of diseases. One major potential problem of using nanogenomics and nanomedicine to increase life expectancy would be overpopulation due to the eradication of genetic inheritance of disease. With genetic illnesses gone or easily cured, population sizes would skyrocket, making resources (such as food, oil, medicine) extremely scarce and expensive. Unacceptable risks: There could be unpredictable and unacceptable health and genetic-related problems. New, previously nonexistent health problems could also arise due to the use of nanomedicine. This could be due to breathing in tiny nano-sized particles that may accumulate in your body, or unforeseen side-effects of nanomedicine. Due to the relatively new and unknown nature of nanobiological human enhancement (especially nanogenomics), there could be many side effects (both immediate and in the long-term) of manipulating human biology and the human genome. For example, through gene therapy, specific types of viruses are used to treat diseases like cancer. However, these viruses may sometimes infect healthy cells as well as cancer cells, and may even in some instances cause cancer. Also, some research has already shown increases in toxicity (specifically, oxidative stress and apoptosis) as a result of certain nanomedicines (Moghimi et al., 2005). Additionally, if there are harmful genetic modifications, they can be passed down to future generations. This effect would be highly unpredictable. The human gene pool could even become contaminated as nanoparticles become part of human DNA and are passed on to future generations. Second-order effects: Unexpected and unpredictable "second order" effects could occur. People supporting the Unnecessary Risk perspective also have concerns with regard to the economy and the state of the nation in general. This addresses the idea of "second-order effects." Second-order effects refer to the ways in which technologies change society more indirectly. For example, a first order effect of the creation of cell

phone technology is that people are able to communicate more easily in more locations and situations. Some of the second-order effects cell phone technology relate to how culture responded to the technology. Use of cell phones while driving or by students during classes could be seen as having negative second-order effects detrimental to safety and learning. In addition, use of cell phones has resulted in new social norms and social pressures that influence when people use or do not use their phones. For example, you may notice many signs at businesses asking people not to use their cell phones while paying for their purchases. These second-order effects are not easy to predict and that is one reason why, during the development of new technologies, scientists and policy makers solicit the public's help in considering what sorts of second-order effects might occur. In general, this process is founded on the belief that it is easier to avoid the negative impacts of second-order effects if you think about them ahead of time than if you wait until they are a large part of the culture. One example of a potential second-order effect would be that the loss of traditional jobs due to shifts in funding to nanogenomic and nanomedical research could cause a disruption in the economy. This could also lead to a siphoning of U.S. funds away from more important purposes. There is also the potential for environmental deterioration due to pollution by nanomaterials (see Walker for more details on the harmful effects of nanomaterials on the environment). More extremely, this sort of technology could lead to a nanotechnology inspired arms race between the U.S. and other nations. A genetics gap: A genetics gap might result, where people with "good genes" are significantly different than those with "bad genes." This could spark a new eugenics movement. Some of the major concerns, however, of people who agree with the Unnecessary Risk perspective, lay in the potential ethical and moral consequences nanogenomic and nanomedical research could have. One possible moral implication of nanogenomics is the start of a new eugenics movement in the United States. During the start of the twentieth century, certain lines of thought (usually associated with the Nazi movement) lead to a social and political movement that supported sterilization of people who had what some deemed to be genetic deficiencies. If the gap between those with "good" genes and those with "bad" genes expands, many fear that a eugenics movement will be powerfully resurrected. This "genetic gap" could also lead to greater deficiencies between the rich and the poor, since human enhancement and genetic manipulation using nanogenomics could be very expensive. This could lead to an increase in prejudice and discrimination in general, and even the loss of religious liberties, since the nanogenomics movement in society might be contradictory to some religious beliefs. Personal privacy: Personal privacy could be threatened. Eventually, even personal privacy might be at stake due to the development of tiny new surveillance devices. The extremely small scale of nanotechnological devices, combined with their ability to generate power, collect and store data, and share and process large sets of information may make developing nano-scale surveillance devices much easier and cheaper, as well as a very invasive form of surveillance. The increase in ease and cost-efficiency of production of these devices could easily lead to invasions of privacy. Rights of children: Children could be (and should not be) genetically altered subject to the desires of their parents. Like those in the Human Progress approach, people in the Unnecessary Risk approach also bring autonomy into the discussion. However, people in the Unnecessary Risk approach emphasize the rights of children who, under their parents' authority, might be subject to genetic alterations that they personally would not want. This perspective would argue that our offspring should not have to deal with the ramifications of genetic manipulation just so that they can become what their parents intend them to be, especially because nanogenomics is such a complex field

and these ramifications may very well be negative. Trade-offs: Even though the proponents of the Unnecessary Risk perspective may strongly believe the points above, they still tend to admit that overregulation of nanobiological human enhancements would probably include the following likely trade-offs: Admitted benefits: Some forms of nanotechnological research might be okay to fund, and some people might be helped that wouldn't be helped if there was heavy regulation. Although the benefits are not worth the risk, nanotechnological research does hold some positive potential. Whereas human enhancement and genetic alteration might be too risky, smaller-scale research that uses nanotechnology to address diseases and has less risk involved might be acceptable to fund. Also, there is the possibility that there are people that would have been helped by nanogenomic or nanomedical research but weren't because of regulations. Varied risk likelihood: Some risks are somewhat unlikely. Some of the potential risks of nanogenomic and nanomedical research would entail a multitude of other factors happening simultaneously in order to occur. For example, a new eugenics movement, although possible, would entail a broad, anti-democratic social movement to gain any substantial momentum. Also, the difference between eugenics through sterilization versus eugenics through gene selection is seen as hazy by some (Leung, 2004). However, for those who oppose nanobiological research, these tradeoffs are not convincing enough to warrant a lack of regulation on nanogenomic and nanomedical research. Opposition: Of course, a number of people oppose the Unnecessary Risk perspective, and offer the following opposing points: Importance of benefits: The existence of risks does not mean you should completely refuse to fund this research. Critics note that just because there are risks involved with nanogenomic research does not mean that we should regulate it to the point of near nonexistence. Critics feel that it must be acknowledged that there are many benefits (both potential and immediate) of funding and promoting such research, and as such, we should do what we can to give nanogenomic scientists the tools they need to develop their research. Funding nanotechnological research also allows us to maintain a competitive stature among other countries that are developing these technologies. Each risk has a benefit: There are benefits that accompany and outweigh most risks. Some of the risks mentioned by those in the Unnecessary Risk approach could equally be countered by benefits of nanotechnology. For example, a loss of traditional jobs in the economy would be accompanied by economic development due to investment in nanogenomic and nanomedical research. Additionally, the possible danger of nanomaterials to the environment would be accompanied by new and better ways to clean and monitor the environment. We must progress: We must progress as a society and as a race when we can, or we are lost. If we maintained an attitude of sacrificing progress to avoid risk in other aspects of life and society, we would remain stuck in a world with no improvement or hope of overcoming the challenges of today. We rely on ground-breaking research like the potential research in nanogenomics and nanomedicine to thrive and move forward as a society. If we really want to stand a chance against unknown catastrophes of the future and succeed as a society, we must embrace nanogenomic and nanomedical research.

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Q511 TIP for Critical Thinking: Consider the Bases of Arguments Next week you will take what

you've learned about nanotechnology, and use it to think about some potential ethical scenarios. One problem with ethical scenarios is that they typically involve shades of grey and controversy. Understanding the bases of different arguments can help you sort through the controversy, gain a clearer understanding of why people disagree, and form your own perspective and clearly articulate why you hold it. Consider the claims that are made by different perspectives above and especially the points of disagreement. If two perspectives disagree, do they disagree because they disagree on the facts? This is a disagreement over whether certain claims are accurate. Or values? This is often a disagreement over which claims are most important. Examine the issues and arguments above and describe one place where people seem to disagree on the facts and one place where they seem to disagree on values. Describe the disagreements and what facts or values they disagree on. Then describe your opinion. Which facts do you think are true and why? What values match your values?

Display This Question:

If CTcond Is Equal to 0

Q516 Explore and Reflect Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links. You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!

a2_refl_evid3

refl_evid3 Your Reflection:

Q515 Timing

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Q517 For your in-class discussion at your next recitation, you will need access to the information you just read. We therefore created a pdf of the information for you. Please download it [HERE](#).

a2_bkgdevl Please help! Tell us your opinion of the quality of information provided in downloaded

background information. Although these questions are optional, your answers will help improve the background documents for future students. Did you know? To measure constructs like "quality" reliably, measures such as the one below contain similarly worded questions. This may seem a bit redundant (at best) or annoying (at worst), but it helps to eliminate measurement error so that constructs can be accurately measured. The information presented in this assignment was...

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
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Trustworthy. (a2_bkgdevl_1)
 Untrustworthy. (a2_bkgdevl_2)
 A biased portrayal of the issues. (a2_bkgdevl_3)
 A neutral portrayal of the issues. (a2_bkgdevl_4)
 Not always fair in its presentation of the issues. (a2_bkgdevl_5)
 Fair in its presentation of the issues. (a2_bkgdevl_6)
 Balanced. (a2_bkgdevl_7)
 Unbalanced. (a2_bkgdevl_8)
 Written to try to persuade people of a certain viewpoint. (a2_bkgdevl_9)
 Written to allow people to make up their own minds on the issues. (a2_bkgdevl_10)
 Inaccurate. (a2_bkgdevl_14)
 Not always accurate in its characterization of the facts. (a2_bkgdevl_15)
 Pretty accurate in its characterization of the facts. (a2_bkgdevl_16)
 Thorough. (a2_bkgdevl_17)
 Not thorough enough. (a2_bkgdevl_18)
 A good resource for understanding multiple perspectives on the issues. (a2_bkgdevl_19)
 Not very good for understanding multiple perspectives on the issues. (a2_bkgdevl_20)
 A high quality source of information. (a2_bkgdevl_21)
 Clear and easy to understand. (a2_bkgdevl_23)
 Unclear and difficult to understand. (a2_bkgdevl_24)
 Well-written. (a2_bkgdevl_25)

a2_comment Please make any other comments that you would like, that could help to improve the background information.

Q418 Your Policy Input You were asked the questions below during Assignment 1. As promised, now that you've explored some different information and perspectives about nanotechnology and human enhancement, you have the chance to change your opinions. You will have one more chance to change your mind during the very last New Biology assignment. You will be sharing your answers to these questions and discussing them with your classmates.

a2_riskben 1. Based on what you now know: Do you think the risks of nanogenomic and nanomedical research and development outweigh the benefits? Alternatively, do you think that the benefits outweigh the risks?

- The risks greatly outweigh the benefits (1)
- The risks somewhat outweigh the benefits (2)
- The risks slightly outweigh the benefits (3)
- The risks and benefits are equal (4)
- The benefits slightly outweigh the risks (5)
- The benefits somewhat outweigh the risks (6)
- The benefits greatly outweigh the risks (7)

a2_chngmnd How much did this assignment influence your answer to the risk/benefits question above?

- Not at all (1)
- Just a little (2)
- Some (3)
- Quite a bit (4)
- A great deal (5)

A2_regslid 2. In your opinion, how much regulation is needed with respect to nanogenomic and nanomedical research and development? Slide the slider to reflect your view. Zero means that you believe there should be NO regulation of nanogenomics. 100 means that you believe EVERY ASPECT of nanogenomic research and development should be HIGHLY regulated.

_____ None at all (1)

a2_chgmnd2 How much did this assignment influence your answer to the regulation question above?

- Not at all (1)
- Just a little (2)
- Some (3)

Quite a bit (4)
A great deal (5)

A2_humanen 3. Human enhancement can refer very generally to anything designed to “enhance” human capabilities. In modern society, this can include activities ranging from higher education and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby's eye color. It may even involve the enhancement of normal capabilities to be extraordinary. There are many conflicting views on whether and how much human enhancement should be allowed, or whether some methods of human enhancement are allowable and others not.

3. In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement? Choose a level below to reflect your view. Use the following guidelines regarding the meaning of different levels. 0% of the time = NEVER, that is, you believe that no amount of nanotechnology-supported human enhancement should be allowed, not even for life-threatening illnesses or medical purposes. 25% of the time = RARELY, that is, you believe that nanotechnology-supported human enhancement should only be allowed RARELY, and only under a small set of situations. For example, you may approve of it to cure life-threatening illnesses and disabilities. 50% of the time = SOMETIMES, that is, you believe that nanotechnology-supported human enhancement should be allowed SOMETIMES, but not too often. For example, you may approve of it to treat medical conditions, including those that are not life-threatening, but perhaps not for enhancing appearance. 75% of the time = USUALLY, that is, you believe that nanotechnology-supported human enhancement USUALLY should be allowed, but perhaps with some specific restrictions. For example, you may feel its use is ok for many or most non-medical purposes, but maybe not to create “super humans” or modify one’s children. 100% of the time = ALWAYS, that is, you believe human enhancement should ALWAYS be allowed in all cases. For example, uses could include superficial and “superhuman” purposes, and may include enhancing yourself or others (e.g., your children).

NEVER 0% of the time (1)
ALMOST NEVER 12% (2)
RARELY 25% (3)
NOT TOO OFTEN 37% (4)
SOMETIMES 50% (5)
A LOT OF THE TIME 63% (6)
USUALLY 75% (7)
ALMOST ALWAYS 88% (8)
ALWAYS 100% of the time (9)

a2_chgmnd3 How much did this assignment influence your answer to the human enhancement question above?

Not at all (1)

Just a little (2)

Some (3)

Quite a bit (4)

A great deal (5)

A2_input_text 4. Draft your written policy input. During the last New Biology assignment, in addition to giving your final answers to the prior three questions, you will be asked to write an essay, in the form of a letter to policymakers, saying what you would like them to do with regard to the future of nanotechnology related to human enhancement, and explaining and justifying your views. Your letter to policymakers should cover the points outlined below. Note: You will discuss your essay with your classmates during recitation in New Biology Assignment 3. You then will write a FINAL essay during the last New Biology assignment. (1) Future development: What developments should be prioritized or avoided? As you consider your answers this question, consider the questions below, indicate why you feel the way you do, and do your best to look for and provide evidence for the statements you make. In your opinion, what should the future of nano-biological technology development look like, especially when it comes to human enhancement applications? What should it not look like? That is, should any developments be avoided? Why do you feel that way? Is there evidence to support your views? What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the development of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why? (2) Regulation of Nanotechnology: What regulations should be in place or are needed? As you answer this question, please consider the questions below, indicate why you feel the way you do, and do your best to provide evidence for the statements you make. In your opinion, given current developments in nano-biological technologies and the various developments that are possible in the future, what social policies, rules, limits and regulations should be in place? What regulations should not be in place or should be avoided? Why do you feel that way? Is there evidence to support your views? What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why? Write a preliminary draft of your policy input below. (You will be able to print this answer at the end of the assignment, so that you can discuss it with your classmates at your next recitation.)

Display This Question:

If hetrocondnum Is Equal to -1

A2online_neg See what your classmates are saying. Join the discussion. Note: This is an Optional Task Visit this link: [Online discussion 11](#) (Link will open in new tab/window) If you are having trouble with the online discussion area, please contact Ryan Anderson at the University of Nebraska Public Policy Center at ryan.anderson@huskers.unl.edu Ryan will help you get your account set up so that you can see what you classmates are saying. Within the small group discussion linked above, you will need to create an account. You can do this using the "sign in/create account" link in the upper right corner of the small group discussion web page. Play with the discussion area, and familiarize yourself with it. Try making contributions! Once you submit your views, you then will be able to explore the views of your classmates, and read and comment on them. Explore!

Display This Question:

If hetrocondnum Is Equal to 0

A2online_mix See what your classmates are saying. Join the discussion. Note: This is an Optional Task Visit this link: [Online discussion 18](#) (Link will open in new tab/window) If you are having trouble with the online discussion area, please contact Ryan Anderson at the University of Nebraska Public Policy Center at ryan.anderson@huskers.unl.edu Ryan will help you get your account set up so that you can see what you classmates are saying. Within the small group discussion linked above, you will need to create an account. You can do this using the "sign in/create account" link in the upper right corner of the small group discussion web page. Play with the discussion area, and familiarize yourself with it. Try making contributions! Once you submit your views, you then will be able to explore the views of your classmates, and read and comment on them. Explore!

Display This Question:

If hetrocondnum Is Equal to 1

A2online_pos See what your classmates are saying. Join the discussion. Note: This is an Optional Task Visit this link: [Online discussion 88](#) (Link will open in new tab/window) If you are having trouble with the online discussion area, please contact Ryan Anderson at the University of Nebraska Public Policy Center at ryan.anderson@huskers.unl.edu Ryan will help you get your account set up so that you can see what you classmates are saying. Within the small group discussion linked above, you will need to create an account. You can do this using the "sign in/create account" link in the upper right corner of the small group discussion web page. Play with the discussion area, and familiarize yourself with it. Try making contributions! Once you submit your views, you then will be able to explore the views of your classmates, and read and comment on them. Explore!

a2_cntrib1 Were you able to get to the discussion, create an account, and figure out how to contribute?

Yes! I visited the site (1)

I'm not sure (please explain below) (2) _____

No, I had problems (please describe the problems you encountered) (3) _____

No, I chose not to (please explain why you chose not to, e.g., lack of time, interest, etc.) (4)

Display This Question:

If Last Task! See what your classmates are saying. Join... No, I chose not to (please explain why you chose not to, e.g., lack of time, interest, etc.) Is Not Selected

a2_cntrib2 What did you do when visiting the site? (check all that apply)

- ☐ Set up an account (1)
- ☐ Used the slider to show my view (2)
- ☐ Chose some pros/cons to add to my pro/con lists (3)
- ☐ Added my own contributions (e.g., pros and cons, or comments on pros/cons) (4)
- ☐ Submitted my views (5)
- ☐ Explored and read what others were saying about the pros/cons (6)
- ☐ Other (please specify) (7) _____

Display This Question:

If Last Task! See what your classmates are saying. Join... No, I chose not to (please explain why you chose not to, e.g., lack of time, interest, etc.) Is Not Selected

And Last Task! See what your classmates are saying. Join... No, I had problems (please describe the problems you encountered) Is Not Selected

a2_sptimeOL_text About how long did you spend (in minutes) exploring and contributing to the online discussion?

NOTE: A2_sptimeOL_num was created by transforming the text to a number.

Display This Question:

If Were you able to get to the discussion, create and... No, I had problems (please describe the problems you encountered) Is Not Selected

And Were you able to get to the discussion, create and... No, I chose not to (please explain why you chose not to, e.g., lack of time, interest, etc.) Is Not Selected

a2_discuse How useful was the online discussion for thinking about the human enhancement question?

Not useful at all (1)

A little useful (2)

Moderately useful (3)
Pretty useful (4)
Very useful (5)
Extremely useful (6)

Display This Question:

If Last Task! See what your classmates are saying. Join... Yes! I did visit the site and set up an account and contribute. Is Selected

Or Last Task! See what your classmates are saying. Join... I'm not sure (please explain below) Is Selected

a2_dsclike How did you like the online discussion interface?

I hated it (1)
I didn't really like it (2)
It was ok, but not my cup of tea (3)
I was neutral about it (4)
I thought it was ok (5)
I liked it pretty well (6)
I loved it!! (7)

a2_cmment2 If you'd like to comment on the online discussion area, please do so below.

Q520 Assignment Evaluation

a2_Q20 The following questions are to see how much you have learned as a result of reading the background materials. You are not graded on this --- this is simply part of the assignment evaluation. So, please don't Google the answers!

a2_know2 What is genetic engineering?

The changing of the structure of genetic material (1)
The engineering of new organisms and life forms (2)
The engineering of electronic devices using genetic materials (3)

The method by which taxonomists edit transgenic traits (4)

a2_know1 How many nanometers are in one meter?

1,000,000,000,000 (One trillion) (1)

1,000,000,000 (One billion) (2)

1,000,000 (One million) (3)

.000001 (One millionth) (4)

10⁻⁹ (One billionth) (5)

a2_ktf Please indicate whether the following statements are True or False:

	True (1)	False (2)
Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research. (11)		
Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems. (15)		
The government currently uses nano-scale devices to monitor people. (16)		
A good example of a nano-sized object is a red blood cell. (7)		
Due to the increased cost of surgical and diagnostic tools, nanotechnology will definitely increase the cost of health care. (12)		

Q467 Timing

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a2_Q21 Assignment Evaluation Please Help! (Again!) These "New Biology" assignments are being developed with assistance from the University of Nebraska Public Policy Center, which is made possible by a grant from the National Science Foundation. In order to improve the assignments for future students, please evaluate your experience with this assignment. Although many of these questions are optional, your answers are very important for improving the assignments. NOTE: Your answers to these questions will not affect your grade in any way; your instructor will only see the data after it has been separated from the assignment (and thus all answers will be anonymous). Also, any written comments made will be compiled into a list of comments without any identifying information.

a2_sptime_assign Estimated time spent completing this assignment (in *Minutes*). Please only include the time you spent actively reading, writing and exploring the discussion. Do not include any breaks you took, or interruptions or other activities not relevant to the assignment that may have lengthened your time.

Total time (number of minutes) (3)

a2_engage As you read the materials and worked on the assignment, to what extent did you feel or think each of the following? During the assignment, I...

	Not at all (1)	Just a little (2)	Some (3)	Quite a bit (4)	A great deal (5)
Gave careful consideration to all of the options presented. (a2_engage_1) Thought it was important to be thorough in my consideration of the issues. (a2_engage_2) Tried hard to understand perspectives that were different from mine. (a2_engage_3) Felt open to hearing new ideas about the topics. (a2_engage_5) Felt focused. (a2_engage_6) Carefully evaluated the relevance of various arguments. (a2_engage_7) Felt open-minded. (a2_engage_8) Tried to find answers to my questions about the topics. (a2_engage_9) Explored topics related to the issues in order to satisfy my own curiosity. (a2_engage_10) Checked myself to see how well I understood the issues related to the topics I was learning about. (a2_engage_11) Identified questions that I still had about the topics. (a2_engage_12) Thought about how the topics related to other things I know. (a2_engage_14) Discussed my ideas about the topics with others. (a2_engage_15) Talked to others about the topics to get their opinions. (a2_engage_16) Asked others what they thought about the topics and issues. (a2_engage_17)					

Listened to what others thought about the issues. (a2_engage_18)

Used my imagination. (a2_engage_20)

Felt inspired. (a2_engage_21)

Worked to think of novel or inventive issues related to the topic. (a2_engage_22)

Tried to be innovative in my ideas. (a2_engage_23)

Was impatient to get this over. (a2_engage_24)

Wished I were doing something else. (a2_engage_25)

Felt bored. (a2_engage_26)

Was uninterested in the task I was asked to do. (a2_engage_28)

Felt angry. (a2_engage_32)

Found it aggravating. (a2_engage_33)

Felt frustrated. (a2_engage_35)

Became irritated. (a2_engage_36)

Felt like my mind was already made up. (a2_engage_37)

Knew how I would feel about the topic even before doing the task. (a2_engage_38)

Felt like new information would not change my opinions. (a2_engage_40)

a2_time16 Timing

First Click (1)

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Q519 Assignment Evaluation

a2_asseval_ Overall, to what extent did this assignment, help to...

	Not at all (1)	Just a little (2)	Some (3)	Quite a bit (4)	A great deal (5)
Understand nanotechnology (a2_asseval_1)					
Learn about nanotechnology (a2_asseval_2)					
More clearly articulate my own perspective (a2_asseval_3)					
Compare the positives and negatives related to nanogenomics (a2_asseval_4)					
See the issues from multiple perspectives (a2_asseval_5)					
Formulate my arguments better (a2_asseval_6)					
Think critically about evidence (a2_asseval_7)					
Better understand what it means to think critically (a2_asseval_8)					
Motivate me to look at the evidence for different claims, rather than just accepting the claims (a2_asseval_9)					

If you are reading this question, please mark 'not at all' as your answer. (a2_asseval_10)

a2_prepare Overall, how useful was this assignment for helping you to think more about nanogenomics and nanomedicine and preparing you to form opinions and policy input related to nanotechnology development and regulations relating to human enhancement?

Not at all (1)

Slightly (2)

Somewhat (3)

Quite (4)

Extremely (5)

a2_learn How much do you feel you learned about nanotechnology as a result of working on this assignment?

Nothing I didn't know before (1)

Just a little (2)

Some (3)

Quite a bit (4)

A great deal (5)

a2_fnanops Now that you've done some reading....How familiar do you feel with regard to nanotechnology and its biological applications?

Not at all familiar (1)

Slightly familiar (2)

Somewhat familiar (3)

Very familiar (4)

Extremely familiar (5)

a2_time18 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a2_Q22 Finally, answer the following question. The reason for the question below is to ensure the accuracy of the data if you allow it to be analyzed for research purposes.

a2_honest For those questions you answered: Did you read the questions carefully and answer them honestly? (You will not be penalized for your answer. Your instructors will not know how you answered.)

Yes, my answers reflect my honest answers (1)

No, I answered the questions randomly (2)

No, I felt like I should answer in a certain way, so I gave those answers instead of my honest responses (3)

No, I answered the questions, but I did not read the questions as I answered them (4)

Other (Please explain) (5) _____

a2_comment Please make any other comments that you would like, that could help to improve these assignments.

a2_time19 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a2_Q23 Please Print Your Answers Now You will need to hand them in at your next recitation. This is a record of your answers to the open-ended questions. Please print this page from your browser now so that you have a page to turn in at recitation. Your Name:

xxxxq://QID255/ChoiceTextEntryValue/1xx xxxxq://QID255/ChoiceTextEntryValue/2xx Reflection 1.

xxxxq://QID425/ChoiceTextEntryValue/1xx Reflection 2. xxxxq://QID429/ChoiceTextEntryValue/1xx

Reflection 3. xxxxq://QID508/ChoiceTextEntryValue/1xx How much or how often should nanobiological-supported human enhancement be allowed? You chose:

xxxxq://QID405/ChoiceGroup/SelectedChoices/1xx Preliminary policy input.

xxxxq://QID403/ChoiceTextEntryValue/1xx

a2_email If you would also like this page emailed to you (highly recommended!), enter your email below:

Email address for assignment copy: (1)

a2_Q24 Be sure to click "Next" below to make certain your assignment is submitted. This will also trigger the copy to be sent to your email (if you chose that option).

a2_time20 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

4.1.3. Study 5 Assignment 3

Note that in many/most cases the order of the items and answer options (e.g., on multiple choice questions) were administered by the survey software in random order to reduce order effects.

a3_name This assignment will be graded and is worth 8 points. To receive credit for this assignment, the following information is required:

[Certain information will be removed from the data file for purposes of deidentification.]

First Name (1)

Last Name (2)

a3_groupnm Please enter your Group Number here (ask your moderator for this number):

Group number (1)

a3_reci Please indicate which Bio 102 recitation you are enrolled in (see list below if you are not sure):

Recitation section number (Please check list below for accuracy) (1)

Recitation instructor name (2)

Day and time of recitation (3)

a3_t1 Timing

First Click (1)

Last Click (2)

Page Submit (3)

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Q129 Writing of Policy The responsibility of a democracy is to transform personal values into concrete policy. Any such policy must take into account the realities and limitations of law enforcement, the costs and benefits of new regulations, and the complex realities of our everyday lives. The purpose of this exercise is to think through some of these challenges as they apply to regulating nanotechnology. When instructed by your group moderator, please complete the exercise below.

A3_lawv1 Compose a brief law (2-3 sentences) describing under what circumstances the government should prohibit the use of nanotechnology for human enhancement, and under what circumstances the use of such technology should be allowed. Recall that human enhancement can refer very generally to anything designed to “enhance” human capabilities. In modern society, this can include activities ranging from higher education and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby's eye color. It may even involve the enhancement of normal capabilities to be extraordinary.

Q131 Timing

First Click (1)

Last Click (2)

Page Submit (3)

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Q133 Discussing Complexities The first draft of your human enhancement law is below. As you discuss with your classmates, please revise and refine your law. Please also justify your final law, including making note of WHY you made the changes that you made.

A3_lawv2 Your revised law:

A3_whychange_text Justification for your final law, including why you made changes in your initial law:

A3_tp3_ Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

Q154 DO NOT GO PAST THIS PAGE UNTIL YOUR TA (OR GROUP MODERATOR) DIRECTS YOU TO DO SO!

a3_Q5 Answers to the Overarching Questions Now that you have considered some scenarios involving nanogenomics, you have a chance to indicate if you changed your mind on the overarching questions. Here are those questions again.

a3_riskben 1. Based on what you now know: Do you think the risks of nano-biological technology research and development outweigh the benefits? Alternatively, do you think that the benefits outweigh the risks?

- ☐ The risks greatly outweigh the benefits (1)
- ☐ The risks somewhat outweigh the benefits (2)
- ☐ The risks slightly outweigh the benefits (3)
- ☐ The risks and benefits are equal (4)
- ☐ The benefits slightly outweigh the risks (5)
- ☐ The benefits somewhat outweigh the risks (6)
- ☐ The benefits greatly outweigh the risks (7)

a3_influ1 2. How much did today's discussion influence your answer to the risk/benefits question above?

- ☐ Not at all (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_regslid 3. In your opinion, how much regulation is needed with respect to nano-biological technology research and development? Slide the slider to reflect your view. Zero means that you believe there should be NO regulation of nanogenomics. 100 means that you believe EVERY ASPECT of nanogenomic research and development should be HIGHLY regulated.

_____ None at all (1)

a3_influ2 4. How much did today's discussion influence your answer to the regulation question above?

- ☐ Not at all (1)

- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_enhance Human enhancement can refer very generally to anything designed to “enhance” human capabilities. In modern society, this can include activities ranging from higher education and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby's eye color. It may even involve the enhancement of normal capabilities to be extraordinary. There are many conflicting views on whether and how much human enhancement should be allowed, or whether some methods of human enhancement are allowable and others not. 5. In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement? Move the slider to reflect your view. Use the following guidelines regarding the meaning of different levels. 0 = NEVER, that is, you believe that no amount of nanotechnology-supported human enhancement should be allowed, not even for life-threatening illnesses or medical purposes. 25 = RARELY, that is, you believe that nanotechnology-supported human enhancement should only be allowed RARELY, and only under a small set of situations. For example, you may approve of it to cure life-threatening illnesses and disabilities. 50 = SOMETIMES, that is, you believe that nanotechnology-supported human enhancement should be allowed SOMETIMES, but not too often. For example, you may approve of it to treat medical conditions, including those that are not life-threatening, but perhaps not for enhancing appearance. 75 = USUALLY, that is, you believe that nanotechnology-supported human enhancement USUALLY should be allowed, but perhaps with some specific restrictions. For example, you may feel its use is ok for many or most non-medical purposes, but maybe not to create “super humans” or modify one’s children. 100 = ALWAYS, that is, you believe human enhancement should ALWAYS be allowed in all cases. For example, uses could include superficial and “superhuman” purposes, and may include enhancing yourself or others (e.g., your children).

_____ To what extent should nanotechnologically-supported human enhancement be allowed? (1)

a3_influ3 6. How much did today's discussion influence your answer to the human enhancement question above?

- ☐ Not at all (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_engage Activity Evaluation And lastly, once again, to assist in improving these activities for future students, please answer this last page of questions. As you discussed in class and worked on the assignment today, to what extent did you feel or think each of the following? 7. During the assignment, I...

	Not at all (1)	Just a little (2)	Some (3)	Quite a bit (4)	A great deal (5)
Gave careful consideration to all of the options presented. (a3_engage_1)					
Thought it was important to be thorough in my consideration of the issues. (a3_engage_2)					
Tried hard to understand perspectives that were different from mine. (a3_engage_3)					
Felt open to hearing new ideas about the topics. (a3_engage_5)					
Felt focused. (a3_engage_6)					
Carefully evaluated the relevance of various arguments. (a3_engage_7)					
Felt open-minded. (a3_engage_8)					
Tried to find answers to my questions about the topics. (a3_engage_9)					
Explored topics related to the issues in order to satisfy my own curiosity. (a3_engage_10)					
Checked myself to see how well I understood the issues related to the topics I was learning about. (a3_engage_11)					
Identified questions that I still had about the topics. (a3_engage_12)					
Thought about how the topics related to other things I know. (a3_engage_14)					
Discussed my ideas about the topics with others. (a3_engage_15)					
Talked to others about the topics to get their opinions. (a3_engage_16)					
Asked others what they thought about the topics and issues. (a3_engage_17)					
Listened to what others thought about the issues. (a3_engage_18)					
Used my imagination. (a3_engage_20)					
Felt inspired. (a3_engage_21)					
Worked to think of novel or inventive issues related to the topic. (a3_engage_22)					
Tried to be innovative in my ideas. (a3_engage_23)					
Was impatient to get this over. (a3_engage_24)					
Wished I were doing something else. (a3_engage_25)					
Felt bored. (a3_engage_26)					
Was uninterested in the task I was asked to do. (a3_engage_28)					
Felt angry. (a3_engage_32)					
Found it aggravating. (a3_engage_33)					
Felt frustrated. (a3_engage_35)					
Became irritated. (a3_engage_36)					
Felt like my mind was already made up. (a3_engage_37)					
Knew how I would feel about the topic even before doing the task. (a3_engage_38)					
Felt like new information would not change my opinions. (a3_engage_40)					

a3_learn 8. How much do you feel you learned about nanotechnology as a result of today's in-class discussion and assignment?

- ☐ Nothing I didn't know before (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_t8 Timing

First Click (1)

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a3_Q7 On the next couple of pages, we would like to know a little bit about what you thought about working in a group. Please answer the following questions regarding the discussion group that you were in. Remember: Neither your classmates nor your instructors will see the answers that you put down. Any information we obtain will be completely confidential.

a3_grpsat 9. How satisfied were you with your small group discussion in class today?

- ☐ Not at all satisfied (1)
- ☐ Slightly satisfied (2)
- ☐ Somewhat satisfied (3)
- ☐ Quite satisfied (4)
- ☐ Extremely satisfied (5)

a3_grpfeel 10. Overall, how do you feel about the other people in your group?

- ☐ Very negative (1)
- ☐ Somewhat negative (2)
- ☐ Slightly negative (3)
- ☐ Neither negative nor positive (4)
- ☐ Slightly positive (5)
- ☐ Somewhat positive (6)

- ☐ Very positive (7)

a3_grpdis1 11. How much disagreement was there within your group AT THE BEGINNING of the discussion?

- ☐ No disagreement at all (1)
- ☐ Slight disagreement (2)
- ☐ Some disagreement (3)
- ☐ A lot of disagreement (4)
- ☐ Total disagreement (5)

a3_grpdis2 12. How much disagreement was there within your group AT THE END of the discussion?

- ☐ No disagreement at all (1)
- ☐ Slight disagreement (2)
- ☐ Some disagreement (3)
- ☐ A lot of disagreement (4)
- ☐ Total disagreement (5)

a3_grpcon1 13. How much consensus was there within your group AT THE BEGINNING of the discussion?

- ☐ No consensus at all (1)
- ☐ Little consensus (2)
- ☐ Some consensus (3)
- ☐ A lot of consensus (4)
- ☐ Total consensus (5)

a3_grpcon2 14. How much consensus was there within your group AT THE END of the discussion?

- ☐ No consensus at all (1)
- ☐ Little consensus (2)
- ☐ Some consensus (3)
- ☐ A lot of consensus (4)
- ☐ Total consensus (5)

a3_t9 Timing

First Click (1)

Last Click (2)

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Click Count (4)

a3_grpmemb On the next page are a few questions about your group members. Please provide the first name or initials of your fellow group members. If you cannot recall someone's name, you can use some other designation that you will remember (e.g., the guy sitting to my right, the girl with a red shirt, etc.). Do NOT list the group moderator. ONLY list classmates who were in your group.

1. (1)

2. (2)

3. (3)

4. (4)

5. (5)

6. (6) [NOTE: Names/initials removed from data]

a3_Q8 Please answer the following questions about your group members. If you had fewer than four group members, choose "N/A (blank)" for the extra/blank row ratings.

Carry Forward All Choices - Entered Text from "On the next page are a few questions about your group members.

 Please provide the first name or initials of your fellow group members. If you cannot recall someone's name, you can use some other designation that you will remember (e.g., the guy sitting to my right, the girl with a red shirt, etc.).

 Do <u>NOT</u> list the group moderator. <u>ONLY list classmates</u> who were in your group."

a3_grpfam 15. Before today's discussion: How familiar would you say you were with:

	Not at all familiar (1)	Slightly familiar (2)	Somewhat familiar (3)	Quite familiar (4)	Extremely familiar (5)	N/A (blank) (6)
1. (x1)						
2. (x2)						
3. (x3)						
4. (x4)						
5. (x5)						
6. (x6)						

Carry Forward All Choices - Entered Text from "On the next page are a few questions about your group members.

 Please provide the first name or initials of your fellow group members. If you cannot recall someone's name, you can use some other designation that you will remember (e.g., the guy sitting to my right, the girl with a red shirt, etc.).

 Do <u>NOT</u> list the group moderator. <u>ONLY list classmates</u> who were in your group."

a3_simopin 16. Regarding the ethical scenarios you just discussed, how similar do you think each person's opinions are to your opinions?

	Not at all similar (1)	A little similar (2)	Somewhat similar (3)	Quite similar (4)	Extremely similar (5)	N/A (blank) (6)
1. (x1)						
2. (x2)						
3. (x3)						
4. (x4)						
5. (x5)						
6. (x6)						

a3_t10 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a3_grpatt 16. To what extent do you agree with the following statements?

	Strongly disagree (1)	Disagree (2)	Slightly disagree (3)	Neither agree nor disagree (4)	Slightly agree (5)	Agree (6)	Strongly agree (7)
I felt strong ties with my group. (1)							
I felt like a member of my group during the discussion. (2)							
I identified with my group during the discussion (3)							
I "liked" or had positive feelings toward my group. (4)							
I felt like an "outside" member of my group (5)							
I "disliked" or had negative feelings toward my group. (6)							

a3_modeval Next, please indicate your agreement or disagreement with the following statements about the MODERATOR of your group. 17. The MODERATOR of our group...

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Neither Agree nor Disagree (4)	Slightly Agree (5)	Agree (6)	Strongly Agree (7)
Was very active in leading our group discussion. (1)							
Mostly let the students lead the discussion. (2)							
Summarized what he/she heard the group saying. (3)							
Made the group discussion more productive. (4)							
Encouraged our group to think more deeply about the topics under discussion. (5)							
Was unbiased while leading the group. (6)							
Was helpful. (7)							
Encouraged group members to actively engage in the discussion. (8)							

a3_comment If you have any other comments you would like to make on the activities today, especially concerning how they might be improved, please write them here.

a3_t11 Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
- Click Count (4)

a3_Q9 Finally, here is your response to the essay questions. Your First Draft: [[q://QID137/ChoiceTextEntryValue]]

Your Second Draft: [[q://QID142/ChoiceTextEntryValue]]

Justification: [[q://QID150/ChoiceTextEntryValue]]

a3email Remember to print these for your records (e.g., print to a pdf). And to receive a copy of your

work on this assignment via email, please put your email below. The printed copy and the email as well as your signature on the sign-in sheet will be your proof that you completed the assignment in case questions arise later.

a3_Q10 Be sure to click continue to submit your work, and to have your work emailed to you.

4.1.4. Study 5, Assignment 4

Note that in many/most cases the order of the items and answer options (e.g., on multiple choice questions) were administered by the survey software in random order to reduce order effects.

a4_Q1 Final Analysis: Where Do You Stand? Please think carefully about the questions in the following assignment. If you work relatively carefully, it should take approximately 30-40 minutes to complete -- please complete it in one sitting if possible. If you leave the assignment and come back to finish it later, your browser must be set to "save cookies" and you must use the same computer and browser -- otherwise you will need to start over.

a4_name This assignment will be graded and is worth 8 points. In order to get credit for completing this assignment, please fill out the following information.

[Certain information will be removed from the data file for purposes of deidentification.]

First Name (1)

Last Name (2)

a4_reci Please indicate which Bio 102 recitation you are enrolled in (see list below):

Recitation section number (Please check list below for accuracy) (1)

Recitation instructor name (2)

Day and time of recitation (3)

a4_t1 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a4_traits Before we get started, please complete the following questions about your general views about citizenship and social issues.

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
A good citizen should listen to people who disagree with them politically. (1) A good citizen should allow others to challenge their political beliefs. (2) A good citizen should discuss politics with those who disagree with them. (3) A good citizen should be willing to justify their political views. (4) If a citizen is dissatisfied with the policies of government, he or she has a duty to do something about it. (5) I follow political and social issues because I want to learn new things. (6) I follow political and social issues because that's what I'm expected to do. (7) I follow political and social issues because it bothers me when I don't. (8) Being politically and socially conscious is important to who I am. (9) I follow political and social issues because that's what I'm supposed to do. (10) I follow political and social issues because I will feel bad about myself if I don't. (11) I follow political and social issues because I think it's important. (12) People like me don't have any say about what the government does. (13) Sometimes politics and government seem so complicated that a person like me can't really understand what's going on. (14) I consider myself well-qualified to participate in politics. (15) I think that I am better informed about political and social issues than other students. (16) I feel I have a pretty good understanding of current political and social issues facing my world. (17) I consider myself well qualified to provide input on political and social issues. (18)						

a4_t16 Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
- Click Count (4)

a4_Q3 The New Biology assignments used in this course were intended to provide you with the opportunity to practice applying your biological knowledge across and within different scientific and social disciplines. Specifically, the New Biology assignments in this course took you through a specific method of public engagement focused on biology and nanotechnology, that has been developed by the University of Nebraska Public Policy Center. The public engagement process includes the following steps: 1. Opening Reflections 2. Information Investigation & Exploration 3. Issue Deliberation 4. Your Input. This is the step you are on right now. During the final step in the process, you will be asked first to think about the risks and benefits that you think might be afforded by future nanobiological developments. Then you will be asked to give your final input on the issues. Based on what you learned,

you will write about what you think nano-biological scientists should pursue, and how policy makers should regulate nano-biological developments. Remember...if you gave consent, your (anonymous) answers will become part of the research base regarding what people think should be the future of nanotechnology. So please do your best to give thoughtful answers.

a4_t2 Timing

First Click (1)
 Last Click (2)
 Page Submit (3)
 Click Count (4)

a4_Q6 Final Input Before writing your final input, think about the following questions.

a4PREATT04_ What are your opinions about these specific issues relating to nanotechnology and human enhancement?

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Undecided/ Cannot Judge (4)	Slightly Agree (5)	Agree (6)	Strongly Agree (7)
Nanotechnology is one of the more important issues confronting government today. (a1ATTPRE04_1) The risk of nanotechnology directly affecting physical things like human health, wildlife or the environment in general is currently too high. (a1ATTPRE04_2) The risk of nanotechnology affecting social systems like the economy, trade and sustainable food supply is currently too high. (a1ATTPRE04_3) The government will effectively manage any risks associated with nanotechnology. (a1ATTPRE04_4) Scientists working with nano-biological technologies will develop them in directions that are positive for society. (a1ATTPRE04_5) We should develop nanotechnology at full speed despite its possible risks, in order to keep the U.S. from falling behind other countries. (a1ATTPRE04_6) There are serious ethical problems associated with not quickly developing nanotechnologies. (a1ATTPRE04_7) Due to the fact that some have expressed strong concern about nanotechnology's risks, we should have a world ban on new nanotechnology products. (a1ATTPRE04_8)							

a4_genrate When it comes to nanobiological technologies, how important are the following general goals?

	Unimportant (1)	Slightly	Important (3)	Very important	Extremely
--	-----------------	----------	---------------	----------------	-----------

		important (2)		(4)	important (5)
Minimizing potential risks for humans. (1) Minimizing potential environmental risks. (2) Making decisions about the most important directions for future development. (3) Studying the social and ethical impacts and implications of future developments and regulations. (4) Maximizing potential benefits for human enhancement. (5) Maximizing potential environmental benefits. (6)					

a4_t5 Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
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a4speckly SPECIFIC RISKS & BENEFITS -- How likely? As research in nanotechnology and biology develops, people say that some of the benefits and risks listed below might be possible. Meanwhile other risks and benefits are not very likely or possible. Before writing your final input, consider what YOU think about the following. Based on what you know now, how likely do you think it is that each of these potential benefits or risks will become a reality as a result of developments in nanobiological technologies?

	Not at all likely (1)	Slightly likely (2)	Somewhat likely (3)	Very likely (4)	Extremely likely (5)
The extension of human life expectancy. (a4speckly_1) Cheap and more universal healthcare. (a4speckly_2) Higher rates of terminal illness survival (e.g., cancer survival). (a4speckly_3) The ability to improve humans through genetic manipulation. (a4speckly_18) The elimination of genetic inheritance of disease. (a4speckly_7) Economic development through investment and research. (a4speckly_8) Economic disruption caused by the loss of traditional jobs. (a4speckly_9) Loss of personal privacy due to tiny new surveillance devices. (a4speckly_10) Pollution of the environment by nanomaterials. (a4speckly_11) Unforeseen side-effects from nanomedicines. (a4speckly_15) Loss of religious liberties (a4speckly_19) The widening of the gap between the rich and the poor. (a4speckly_16)					

Carry Forward Selected Choices from "**SPECIFIC RISKS & BENEFITS** -- How likely? As research in nanotechnology and biology develops, people say that some of the benefits and risks listed below might be possible. Meanwhile other risks and benefits are not very likely or possible. Before writing your final input, consider what YOU think about the following. Based on what you know now, how likely do you think it is that each of these potential benefits or risks will become a reality as a result of developments in nanobiological technologies?"

SPECIFIC RISKS & BENEFITS -- How valuable or important? As previously noted, the public's input is especially important when it comes to values. In a democracy, it is the public that is supposed to work together to determine what it values for society. Below, the potential risks and benefits are listed again. This time, please indicate your values, and how important the different outcomes are to try and achieve or avoid -- regardless of how possible you think the outcomes may be.

	Very important to AVOID (-3)	Moderately important to AVOID (- 2)	Slightly important to AVOID (-1)	NOT IMPORTANT to avoid or achieve (0)	Slightly important to ACHIEVE (1)	Moderately important to ACHIEVE (2)	Very important to ACHIEVE (3)
The extension of human life expectancy. (a4specimpt_1) Cheap and more universal healthcare. (a4specimpt_2) Higher rates of terminal illness survival (e.g., cancer survival). (a4specimpt_3) The ability to improve humans through genetic manipulation. (a4specimpt_4) The elimination of genetic inheritance of disease. (a4specimpt_5) Economic development through investment and research. (a4specimpt_6) Economic disruption caused by the loss of traditional jobs. (a4specimpt_7) Loss of personal privacy due to tiny new surveillance devices. (a4specimpt_8) Pollution of the environment by nanomaterials. (a4specimpt_9) Unforeseen side-effects from nanomedicines. (a4specimpt_10) Loss of religious liberties (a4specimpt_11) The widening of the gap between the rich and the poor. (a4specimpt_12)							

a4_t7 Timing

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- Page Submit (3)
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NOTE THAT PEOPLE WERE ASSIGNED EITHER THE A4FSCNINCR OR A4FSCNDECR SCENE (RANDOMLY)

The variable **a4scncond_incrdecr** indicates if people were assigned a4fscnincr (1) or a4fscndecr (0).

a4fscnincr In the Future... Imagine that thousands of people across America were invited to go through a process similar to that which you have just gone through, in order to give their input on the future of research and development in nano-biological technology. Specifically, they were: provided with background information and links to additional information given an assignment (very similar to the one you completed) to get a sense of their perceptions of the background information asked to respond to some "potential scenarios" involving possible future developments using nanotechnology, in the same way that you were asked to respond. and then were asked their opinions about the risks and benefits of nanogenomics and nanomedicine, and the types of regulations that should be imposed on research and development. Next, imagine that, based on this process, it seemed that the majority of U.S. citizens were extremely positive about the potential benefits of nano-biological research and development, and were in favor of increasing the pace with which that research and development was conducted. In general, it seemed that people wanted to be sure that there were just enough regulations in place to ensure basic safety issues, but they did not want those regulations to slow down innovation and development. In general, people believed that nano-biological research would make the U.S. a leader in the area and that the benefits would greatly outweigh the risks. Imagine that, based on these results, as well as input from experts in the field of nanotechnology, the U.S. government decided to increase its investment in and funding for nano-biological research and development. Furthermore, regulations on this research and development were fairly minimal and mostly involved attending to basic safety concerns, as is typical of most technologies, but without any special precautions specifically relating to the fact that it is "nanotechnology" per se. Given this scenario, please rate your agreement with the following statements.

a4fscndecr In the Future... Imagine that thousands of people across America were invited to go through a process similar to that which you have just gone through, in order to give their input on the future of research and development in nano-biological technology. Specifically, they were: provided with background information and links to additional information given an assignment (very similar to the one you completed) to get a sense of their perceptions of the background information asked to respond to some "potential scenarios" involving possible future developments using nanotechnology, in the same way that you were asked to respond. and then were asked their opinions about the risks and benefits of nanogenomics and nanomedicine, and the types of regulations that should be imposed on research and development. Next, imagine that, based on this process, it seemed that the majority of U.S. citizens were extremely negative about the potential benefits of nano-biological research and development, and were in favor of decreasing the pace with which that research and development was conducted. In general, it seemed that people wanted to be sure that there were plenty of regulations in place to ensure that the risks they perceived did not become reality, even if those regulations slowed down innovation and development. In general, people were very concerned about where nanomedicine and nanogenomic research would lead, and feared that the risks might greatly outweigh the benefits.

Imagine that, based on these results, as well as input from experts in the field of nanotechnology, the U.S. government decided to increase its regulation of nano-biological research and development and to primarily fund studies of the potential risks associated with research and development rather than innovative studies that might explore the frontiers of its development. Research attending to basic safety concerns was emphasized, and the government began to develop a number of special regulations relating to specific concerns that citizens had regarding nanotechnology. Given this scenario, please rate your agreement with the following statements.

	Strongly disagree (1)	Disagree (2)	Slightly disagree (3)	Slightly agree (4)	Agree (5)	Strongly agree (6)
The government should have used a different process to get public input about this issue. (a4scn_5) The process used by the government was a good one. (a4scn_7) The process used by the government to make decisions about this issue was fair. (a4scn_1) The government listened to the people it regulates. (a4scn_4) People influenced the government's choices. (a4scn_3) The government cares about the people it regulates. (a4scn_2) The government made its decisions in an INcompetent manner. (a4scn_6) I would resist this decision made by the government. (a4scn_8) I would support this decision made by the government. (a4scn_9) Because of the processes used, I would accept this decision made by the government. (a4scn_10)						

a4foragnt If the legislation above were really under consideration by the government...Would you be FOR or AGAINST such legislation?

- ☐ Strongly AGAINST (1)
- ☐ Moderately AGAINST (2)
- ☐ Slightly AGAINST (3)
- ☐ Slightly FOR (4)
- ☐ Moderately FOR (5)
- ☐ Strongly FOR (6)

Note that **A4scncond_match** indicates whether their response from the question above indicated the scenario matched their views (1) or not (0).

a4fscnexpl If you would like to comment on this scenario, or explain your ratings, please do so here.

a4_t8 Timing

First Click (1)

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Click Count (4)

a4_Q7 Nanoscientists Next, consider your perceptions of NANOSCIENTISTS -- that is, those who do the research and make the discoveries that you have been reading about and discussing.

a4_sconfNS To what extent do you have confidence in nanoscientists to...

	Not at all (1)	Just a little (2)	Some (3)	Quite a bit (4)	A great deal (5)
Do their jobs well. (a4_sconfNS_1)					
Meet their professional responsibilities. (a4_sconfNS_2)					
Make decisions about the most important directions for future development. (a4_sconfNS_3)					

A4trust_nano To what extent do you feel nanoscientists probably...

	Not at allprobable (1)	Just a littleprobable (2)	Somewhatprobable (3)	Quiteprobable (4)	Veryprobable (5)
Are trustworthy. (2)					
Are not to be trusted. (3)					
Will make decisions based on their care and concern for those they will impact. (4)					
Are generally caring people. (5)					
Generally do not care about those who they impact. (6)					
Don't really care about the long-term risks of their work (16)					
Are primarily motivated by what will benefit them personally. (17)					
Are very competent at their job(s). (7)					
Have the knowledge and skills needed to do their job(s). (8)					
Are incompetent. (9)					
Are persons of integrity. (10)					
They are honest in their dealings with others. (11)					
Have questionable morals. (12)					
Share my values. (13)					
Things that are important to me, are also important to them. (14)					
Do not share my values. (15)					

a4_t10 Timing

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a4_Q8 What do you know? Next, consider what you have learned and know about nanotechnology. The purpose of the next questions is to find out how much you feel you may have learned as a result of working on these assignments.

a4_famnano How familiar are you with nanotechnology?

- ☐ Not at all familiar (1)
- ☐ Slightly familiar (2)
- ☐ Somewhat familiar (3)
- ☐ Very familiar (4)
- ☐ Extremely familiar (5)

a4_fammed How familiar are you with how nanotechnology is used in medical research and development?

- ☐ Not at all familiar (1)
- ☐ Slightly familiar (2)
- ☐ Somewhat familiar (3)
- ☐ Very familiar (4)
- ☐ Extremely familiar (5)

a4_famgen How familiar are you with how nanotechnology is used in genetics research and development?

- ☐ Not at all familiar (1)
- ☐ Slightly familiar (2)
- ☐ Somewhat familiar (3)
- ☐ Very familiar (4)
- ☐ Extremely familiar (5)

a4_t13 Timing

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a4_Q9 The following questions are to see how much you have actually learned as a result of working on these assignments....So as usual, please don't Google the answers!

A4know2 What is genetic engineering?

- ☐ The changing of the structure of genetic material (1)
- ☐ The engineering of new organisms and life forms (2)
- ☐ The engineering of electronic devices using genetic materials (3)
- ☐ The method by which taxonomists edit transgenic traits (4)

A4know1 How many nanometers are in one meter?

- ☐ 1,000,000,000,000 (One trillion) (1)
- ☐ 1,000,000,000 (One billion) (2)
- ☐ 1,000,000 (One million) (3)
- ☐ .000001 (One millionth) (4)
- ☐ 10^{-9} (One billionth) (5)

A4know4 Which of the following is between 2 and 100 nanometers?

- ☐ DNA (1)
- ☐ The head of a pin (2)
- ☐ A human hair (3)
- ☐ DNA base-pairs (4)
- ☐ A hydrogen atom (5)

a4_know6 What are "second order effects" of technology?

- ☐ Social impacts, or changes in society that result indirectly from the new technology (1)
- ☐ Impacts of new technology on the offspring of the individual who was exposed to the technology (2)
- ☐ The increase in choices that are available as a result of new technologies (3)
- ☐ All of the above (4)
- ☐ None of the above (5)

a4_t14 Timing

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Click Count (4)

a4_Q10 What do you know?

a4TFABC_ Now, please indicate whether the following statements are true or false.

	True (1)	False (2)
Materials that are harmless at the macro-level could be harmful at the nano-level. (a4TFABC_1)	☐	☐
Researchers have used nanomedicine technologies to create biological weapons that have already fallen into the wrong hands and are currently being used by organized crime groups. (a4TFABC_2)	☐	☐
One outcome already identified as possible with nanotechnology is innovative diabetes treatments that stimulate insulin production from outside the body. (a4TFABC_3)	☐	☐
Biologics (biological medications) may be able to benefit from nanotechnology because nanotechnology may allow for a delivery system that can make smaller doses of biologics possible. (a4TFABC_4)	☐	☐
Nanotechnology has already been used to develop materials to improve products such as tennis rackets. (a4TFABC_5)	☐	☐
Liposomes have been used to house and deliver drugs in a way that organs and tissues that are otherwise hard to reach, like the brain, can be reached. (a4TFABC_6)	☐	☐
A good example of a nano-sized object is a red blood cell. (a4TFABC_7)	☐	☐
Nanomaterials in the environment can enter the body and certain nanoparticles have already been shown to interfere with normal bodily processes. (a4TFABC_8)	☐	☐
The term "human enhancement" includes advancements like curing diseases. (a4TFABC_9)	☐	☐
Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines. (a4TFABC_10)	☐	☐
Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research. (a4TFABC_11)	☐	☐
Due to the increased cost of surgical and diagnostic tools, nanotechnology will definitely increase the cost of health care. (a4TFABC_12)	☐	☐

The major risks associated with the use of nanomedicine have been identified. (a4TFABC_13)	☐	☐
Currently, it is really hard to predict the potential second order-effects of nano-technology. (a4TFABC_14)	☐	☐
Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems. (a4TFABC_15)	☐	☐
The government currently uses nano-scale devices to monitor people. (a4TFABC_16)	☐	☐
The “second order effects” of nanotechnology can be accurately predicted from “first order effects.” (a4TFABC_17)	☐	☐
Most traditional pollutant filters are able to catch and stop nanoparticles. (a4TFABC_18)	☐	☐

a4_t15 Timing

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- Last Click (2)
- Page Submit (3)
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a4_Q12 Consent - revisited (please read)Speaking of democracy, deliberation and public input...Remember...if you gave consent, your (anonymous) answers will become part of the public record regarding what people think should be the future of nanotechnology.At this time, we would like to give everyone a chance to change their consent if they would like. The reason we give this second opportunity is because when you gave your consent at the beginning of the semester you had not yet completed any assignments, and so did not know what all they entailed.On the next page is the official consent form, the same consent form that you saw in your first New Biology assignments. Please indicate again if you are willing to allow researchers to analyze your anonymous data. There are no benefits to you, and no one will know whether you said yes or no. If you do allow your data to be used, however, it will be used to improve the assignments and will become part of the public record concerning how people feel about the future of nanotechnology.

a4_t18 Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
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a4_Q13 Identification of Project: Developing a Social-Cognitive, Multilevel, Empirically-Based Model of Public Engagement for the Shaping of Science and Innovation Policy Purpose of the Research: “Public participation” can refer to many different ways in which residents engage with, consider, discuss, or give input on matters of public policy. This research will compare the processes and outcomes associated with different methods of participation relating to the consideration of ethical, legal, and social issues (ELSI) associated with topics in “New Biology,” a topic you will discuss in your biology course. You must be 14 years of age or older to participate. You are invited to participate because you are an undergraduate student enrolled in a science-related course at the University of Nebraska—Lincoln that will be incorporating consideration of New Biology ELSI as part of the coursework. Procedures: Participation in this study includes assessments and analyses of activities that will be required as part of your participation in your science course. During the semester, as part of your course content, you will be instructed in some of the ethical, legal, and social issues (ELSI) associated with New Biology, and in strategies for approaching (e.g., learning more about and/or thinking critically about) these issues. The present research seeks your permission to allow researchers to analyze the work products and activities relating to the New Biology assignments that you will be completing as part of your science coursework. For example, as part of your regular course activities, you will complete a 30-40 minute pre-survey comprised of multiple-choice and rating questions assessing your prior knowledge and opinions (e.g., about biology in general, “New Biology” and trust in government to regulate scientific breakthroughs). You will complete course-related assignments which may include surveys, worksheets, group discussions (including focus groups), and writing assignments about New Biology topics. At the end of the semester, you will also complete a 30-40 minute post-survey comprised of questions similar to those in the pre-survey. If you give your consent to participate in this research, researchers will simply analyze your contributions to the activities listed above. In addition, you may be invited to participate in additional optional research-related activities that are not part of your coursework. For example, we may ask your permission to videotape the discussion of a group in which you are involved as part of your coursework. No individual group will be videotaped, however, unless all members in the group give their permission. In addition, a limited number of students will be asked to volunteer to be interviewed regarding their experiences in the New Biology-related activities. If you agree to participate, you would participate in a 30-minute interview held outside of class, at a time and place convenient to you. This interview may be video or audio taped with your explicit permission. Risks and/or Discomforts: There are no known risks or discomforts associated with this research. In the event of problems resulting from participation in the study, psychological treatment is available on a sliding fee scale at the UNL Psychological Consultation Center, telephone (402) 472-2351. Benefits: Most of the research simply involves an analysis of activities that you will already be doing as part of your coursework. Thus, allowing researchers to analyze your data does not result in any additional benefits to you personally. You may, however, enjoy knowing that the use of your data will help to advance the understanding of public views on New Biology, and the understanding of different public participation methods. If you decide to participate in the interview, you may also enjoy having

your views heard regarding the activities relating to New Biology issues. Confidentiality: Any information obtained during this study which could identify you will be kept strictly confidential. Unique, study specific alphanumeric user IDs will be used instead of names to identify and collate data. During the study the electronic data and the master list that connects participants to their study IDs will be stored on a physically secure server. Paper data will be kept in a locked cabinet or data storage room. The study ID-participant master list will be destroyed as soon as all data collection and checking procedures are complete. Electronic or paper data will only be seen by approved project researchers. The study data (without names or identifying information) will be kept for at least three years after the study is complete. The information obtained in this study may be published in scientific journals or presented at scientific meetings as aggregated data. No interview, audio or video data will be obtained as part of this study, under the online version of this consent form. If you were to participate in interview, audio or videotaped activities, you would be provided with an additional, separate, paper copy of this consent form, for you to sign to indicate your consent at the time of the interview or taping. Audio and video data will be held confidential and be kept for no longer than three years after project completion. Audio and video tapes will be stored in a locked filing cabinet and any digital audio and video files will be stored on a secure server at the Public Policy Center that is password protected. Only approved research personnel will have access to the tapes and files. Compensation: There will be no compensation for allowing researchers to use your course data and analyze your activities. However, because the interviews take place outside of class and are not part of the regular course work, a \$10 gift card will be offered to interviewees as an incentive. Opportunity to Ask Questions: You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may call the investigators at any time, at the numbers listed below. If you have questions concerning your rights as a research subject that have not been answered by the investigator or to report any concerns about the study, you may contact the University of Nebraska-Lincoln Institutional Review Board, telephone (402) 472-6965. Freedom to Withdraw: Though your involvement in many study-related activities is required as part of course requirements, you are not required to allow researchers to analyze or assess your data from these course-related activities. Though you take part in the activities as part of the course, you are free to decide not to allow the researchers to use your data in their study of public participation. You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators, the University of Nebraska-Lincoln, or your course instructors. Your decision will not result in any loss or benefits to which you are otherwise entitled. Consent, Right to Receive a Copy: You are voluntarily making a decision to give your permission for researchers to analyze the work products and activities relating to New Biology that you will be completing as part of your science coursework. By indicating your consent, you certify that you have decided to participate having read and understood the information presented. You may print a copy of this consent form to keep from your browser now. Copies will also be available on the Blackboard website for your course. Name and Phone number of investigator(s): Lisa PytlikZillig, Ph.D., Principal Investigator Office: (402) 472-6877, lpytlikz@nebraska.edu Alan Tomkins, J.D., Ph.D., Secondary Investigator Office (402) 472-5688, atomkins@nebraska.edu

a4_consent Do you consent to participate in the research by allowing us to use your coursework-related data as indicated above?

- ☐ Yes (1)
- ☐ No (2)

a4_t19 Timing

First Click (1)
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a4_Q5 Final Input These are the final Questions before you write your open-ended input...You've seen these questions before. You may answer them the same as before, or differently if you changed your mind.

a4_riskben 1. Based on what you know right now: Do you think the risks of nanobiological research and development outweigh the benefits? Alternatively, do you think that the benefits outweigh the risks?

- ☐ The risks greatly outweigh the benefits (1)
- ☐ The risks somewhat outweigh the benefits (2)
- ☐ The risks slightly outweigh the benefits (3)
- ☐ The risks and benefits are equal (4)
- ☐ The benefits slightly outweigh the risks (5)
- ☐ The benefits somewhat outweigh the risks (6)
- ☐ The benefits greatly outweigh the risks (7)

a4_rbchgm Overall, from the time you began these exercises, until now, to what extent did you change your mind about the risk/benefits question above?

- ☐ Not at all (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a4_regslid 2. In your opinion, how much regulation is needed with respect to nanobiological research

and development? Slide the slider to reflect your view. Zero means that you believe there should be NO regulation of nanobiological developments. 100 means that you believe EVERY ASPECT of nanobiological research and development should be HIGHLY regulated.

_____ None at all (1)

a4_regchgm Overall, from the time you began these exercises, until now, to what extent did you change your mind about the regulation question above?

- ☐ Not at all (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a4_enhance Human enhancement can refer very generally to anything designed to “enhance” human capabilities. In modern society, this can include activities ranging from higher education and athletic training, to plastic surgery and prosthetic limbs. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing cancer or eliminating genetic diseases to choosing a baby's eye color. It may even involve the enhancement of normal capabilities to be extraordinary. There are many conflicting views on whether and how much human enhancement should be allowed, or whether some methods of human enhancement are allowable and others not. 3. In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement? Move the slider to reflect your view. Use the following guidelines regarding the meaning of different levels. 0 = NEVER, that is, you believe that no amount of nanotechnology-supported human enhancement should be allowed, not even for life-threatening illnesses or medical purposes. 25 = RARELY, that is, you believe that nanotechnology-supported human enhancement should only be allowed RARELY, and only under a small set of situations. For example, you may approve of it to cure life-threatening illnesses and disabilities. 50 = SOMETIMES, that is, you believe that nanotechnology-supported human enhancement should be allowed SOMETIMES, but not too often. For example, you may approve of it to treat medical conditions, including those that are not life-threatening, but perhaps not for enhancing appearance. 75 = USUALLY, that is, you believe that nanotechnology-supported human enhancement USUALLY should be allowed, but perhaps with some specific restrictions. For example, you may feel its use is ok for many or most non-medical purposes, but maybe not to create “super humans” or modify one’s children. 100 = ALWAYS, that is, you believe human enhancement should ALWAYS be allowed in all cases. For example, uses could include superficial and “superhuman” purposes, and may include enhancing yourself or others (e.g., your children).

_____ To what extent should nanotechnologically-supported human enhancement be allowed? (1)

a4_enhchgmn Overall, from the time you began these exercises, until now, to what extent did you change your mind about the human enhancement question above?

- ☐ Not at all (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a4_inflnce_ To what extent did the following influence the final views that you gave about nano-biological technologies and human enhancement?

	Not at all (1)	Just a little (2)	Some (3)	Quite a bit (4)	A great deal (5)
Talking about the issue with others. (a4_inflnce_1)					
The background information that I read about the topics. (a4_inflnce_2)					
Learning about new arguments that I'd not thought of before. (a4_inflnce_3)					
My own research on the issue. (a4_inflnce_4)					
Views of other people that I discussed with. (a4_inflnce_5)					
The additional resources provided by the background documents. (a4_inflnce_6)					
My study and knowledge of biology in this course. (a4_inflnce_7)					

a4_chgexp If you would like....Please explain briefly why you did or did not change your mind about any of the questions regarding nanobiological research for human enhancement, and what sorts of factors influenced your input.

a4_Q4 Final Analysis: Where Do You Stand? Finally, based on all you learned, and the issues that you just considered, please give your final policy recommendations. Refer to your work from prior assignments (e.g., the law you wrote, and your justification; your prior first draft of this, and your answers to the risks & benefits questions in this assignment) as you write. This is the PRIMARY answer that you will be graded on for this assignment.

a4_input_text (1) Future development: What developments should be prioritized or avoided? As you consider your answers this question, consider the questions below, indicate why you feel the way you do, and do your best to look for and provide evidence for the statements you make. In your opinion, what should the future of nano-biological technology development look like, especially when it comes to human enhancement applications? What should it not look like? That is, should any developments be avoided? Why do you feel that way? Is there evidence to support your views? What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the development of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why? (2) Regulation of Nanotechnology: What regulations should be in place or are needed? As you answer this question, please consider the questions below, indicate why you feel the way you do, and do your best to provide evidence for the statements you make. In your opinion, given current developments in nano-biological technologies and the various developments that are possible in the future, what social policies, rules, limits and regulations should be in place? What regulations should not be in place or should be avoided? Why do you feel that way? Is there evidence to support your views? What ethical, legal and social issues (ELSI) need to be considered and resolved when making decisions about the regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these "ELSI" issues be resolved, and why? Write a final draft of your policy input below.

a4_regchng Overall, from the time you began these exercises, until now, to what extent did you change your mind about the question above?

- ☐ Not at all (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

A4_newbio_eva How well did the New Biology assignments prepare you to write the final input above?

- ☐ Not at all well (1)
- ☐ Just a little (2)
- ☐ Somewhat well (3)

- ☐ Quite well (4)
- ☐ Extremely well (5)

A4_exp_cit Some people feel that the government should primarily rely on expert opinions, not citizen opinions when making policy decisions. What do you think? In your opinion, how much weight should government give to citizen opinions (like you wrote above) when making decisions about the future of Nanotechnological development and regulation?

- ☐ None! The government shouldn't be considering opinions of everyday people like me (1)
- ☐ Just a little weight (2)
- ☐ Some weight, but not too much (3)
- ☐ Quite a bit of weight (4)
- ☐ A lot of weight! The government should take opinions like mine very seriously (5)

A4_exp_cit_com If you would like to explain your answer, please do so here:

a4_t3 Timing

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a4_Q14 Finally, on this last page of the assignment, please provide us with some feedback as to your work and experience with the assignment.

a4_IrnELSI What do you think? In your opinion, how important is it that science students--including beginning science students such as you and your classmates--learn how to think about the ethical, legal and social issues (ELSI) pertaining to science? In 2-3 sentences, give your answer and a brief explanation of why you think as you do.

a4_ppben Overall, to what extent was the public participation module a beneficial part of your learning in this course?

- ☐ Not at all (1)

- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a4_learn How much do you feel you learned about nanobiological research for human enhancement as a result of working on the public engagement module last week and this week?

- ☐ Nothing I didn't know before (1)
- ☐ Just a little (2)
- ☐ Some (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a4dataqual Did you give your honest answers in this assignment? (You will not be penalized for your answer. Your instructors will not know how you answered this question.)

- ☐ Yes, my answers reflect my honest answers to the questions in the assignment (1)
- ☐ No, I answered the questions randomly (2)
- ☐ No, I felt like I should answer in a certain way, so I gave those answers instead of my honest responses (3)
- ☐ Other (Please explain) (4) _____

a4finlfdbk Final Feedback? As you know, the New Biology assignments are being evaluated by your instructor with the help of researchers from the Public Policy Center. So, if you have any feedback, comments, or questions about the New Biology Assignments, please write them below. These comments WILL be seen by your instructor, so do not write anything that you do not intend your instructor to see. However, your name and identity will not be associated in any way with the comment unless you choose to put your name within the comment.

a4_t17 Timing

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a4_Q15 THANK YOU! PLEASE PRINT THIS PAGE! THEN....Click continue to submit your assignment. After submitting, a copy of your work will be emailed to you if you entered an email address. If you would like, you can also print a copy of your answers from THIS window to have for your records. Your Final Input on Nano development and Regulation:
[[q://QID293/ChoiceTextEntryValue]]

a4email To receive your work on this assignment via email, please put your email below.

Email to which to send a copy of your work --> (1)

a4_t21 Timing

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4.1.5. Compiled Measures and Scales

Assignment 1

Demographics.

- What is your age?
- What is your gender?
- What is your year in school?
- What is your major?
 - Biochemistry, Biological science, Biological Science Engineering, Chemistry, Pre-Med, Pre-Vet, Psychology, or Other (Please specify)
- On average, would you say you are an A, B, C or D student?

Experience with ELSI. (2 items, averaged after z-scoring)

- About how much previous academic work have you done that covered ethics (human, animal, environmental?)
 - None, a little, some, a moderate amount, a great deal
- How many course have you taken in the past that touched on ethics (human, animal, environmental?)
 - 0, 1, 2, 3, 4, 5, more than 5 courses

Subjective knowledge. (3 items) Answers on a five point scale from “Not at all familiar” to “Extremely familiar.”

- How familiar are you with nanotechnology?

- How familiar are you with how nanotechnology is used in medical research and development?
- How familiar are you with how nanotechnology is used in genetics research and development?

Objective knowledge: multiple choice. (4 items, answers are given in bold)

- What is genetic engineering?
 - **The changing of the structure of genetic material**; the engineering of new organisms and life forms; the engineering of electronic devices using genetic materials; the method by which taxonomists edit transgenic traits.
- Which of the following is between 2 and 100 nanometers wide?
 - **DNA**; the head of a pin; a human hair; DNA base-pairs; a hydrogen atom.
- How many nanometers are in one meter?
 - 1,000,000,000,000 (one trillion); **1,000,000,000 (one billion)**; 1,000,000 (one million); .000001 (one millionth); 10^{-9} (one billionth)
- What are the “second order effects” of technology?
 - **Social impacts, or changes in society that result indirectly from the new technology**; impacts of new technology on the offspring of the individual who was exposed to the technology; the increase in choices that are available as a result of new technologies; all of the above; none of the above.

Objective knowledge: true/false. (18 items, correct answers are indicated in parens)

- (T) Materials that are harmless at the macro-level could be harmful at the nano-level.
- (F) Researchers have used nanomedicine technologies to create biological weapons that have already fallen into the wrong hands and are currently being used by organized crime groups.
- (F) One outcome already identifies as possible with nanotechnology is innovative diabetes treatments that stimulate insulin production from outside the body.
- (T) Biologics (biological medications) may be able to benefit from nanotechnology because nanotechnology may allow for a delivery system that can make smaller doses of biologics possible.
- (T) Nanotechnology has already been used to develop materials to improve products such as tennis rackets.
- (T) Liposomes have been used to house and deliver drugs in a way that organs and tissues that are otherwise hard to reach, like the brain, can be reached.
- (F) A good example of a nano-sized object is a red blood cell.
- (T) Nanomaterials in the environment can enter the body and certain nanoparticles have already been shown to interfere with normal bodily processes.
- (T) The term “human enhancement” includes advancements like curing diseases.
- (T) Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines.
- (F) Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research.
- (F) Due to the increased cost of surgical and diagnostic tools, nanotechnology will definitely increase the cost of health care.
- (F) The major risks associated with the use of nanomedicine have been identified.
- (T) Currently, it is really hard to predict the potential second order-effects of nano-technology.
- (T) Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems.
- (F) The government currently uses nano-scale devices to monitor people.

- (F) The “second order effects” of nanotechnology can be accurately predicted from “first order effects.”
- (F) Most traditional pollutant filters are able to catch and stop nanoparticles.

Attitudes towards nanotechnology. (3 items, analyzed individually)

- Based on what you know right now: Do you think the risks of nano-biological research and development outweigh the benefits? Alternatively, do you think that the benefits outweigh the risks?
 - The risks greatly outweigh the benefits, the risks somewhat outweigh the benefits, the risks slightly outweigh the benefits, the risks and benefits are equal, the benefits slightly outweigh the risks, the benefits somewhat outweigh the risks, the benefits greatly outweigh the risks
- In your opinion, how much regulation is needed with respect to nano-biological research and development?
 - Move the slider to reflect your view. 0 means that you believe there should be NO regulation of nano-biological developments. 100 means that you believe EVERY ASPECT of nano-biological research and development should be HIGHLY regulated.
- In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement?
 - Move the slider to reflect your view. Use the following guidelines regarding the meaning of different levels.
 - 0 = NEVER, that is, you believe that no amount of nanotechnology-supported human enhancement should be allowed, not even for life-threatening illnesses or medical purposes.
 - 25 = RARELY, that is, you believe that nanotechnology-supported human enhancement should only be allowed RARELY, and only under a small set of situations. For example, you may approve of it to cure life-threatening illnesses and disabilities.
 - 50 = SOMETIMES, that is, you believe that nanotechnology-supported human enhancement should be allowed SOMETIMES, but not too often. For example, you may approve of it to treat medical conditions, including those that are not life-threatening, but perhaps not for enhancing appearance.
 - 75 = USUALLY, that is, you believe that nanotechnology-supported human enhancement USUALLY should be allowed, but perhaps with some specific restrictions. For example, you may feel its use is ok for many or most non-medical purposes, but maybe not to create “super humans” or modify one’s children.
 - 100 = ALWAYS, that is, you believe human enhancement should ALWAYS be allowed in all cases. For example, uses could include superficial and “superhuman” purposes, and may include enhancing yourself or others (e.g., your children).

Individual differences. Answers for all items were on a six point scale ranging from “strongly disagree” to “strongly agree.” Negative items need to be reverse scored.

Disposition to trust (3 items)

- I believe that others have good intentions.

- I trust what people say.
- I believe most people try to be fair.

Need for cognition. (7 items)

- The notion of thinking abstractly is appealing to me.
- I like to have the responsibility of handling a situation that requires a lot of thinking.
- Thinking is not my idea of fun. (r)
- I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something. (r)
- I really enjoy a task that involves coming up with new solutions to problems.
- Learning new ways to think doesn't excite me very much. (r)
- I usually end up deliberating about issues even when they do not affect me personally.

Deliberative values (4 items)

- A good citizen should listen to people who disagree with them politically.
- A good citizen should allow others to challenge their political beliefs.
- A good citizen should be willing to justify their political views.
- If a citizen is dissatisfied with the policies of government, he or she has a duty to do something about it.

Intrinsic political motivation (2 items)

- I follow political and social issues because I want to learn more things.
- I follow political and social issues because I think it's important.

Introjected political motivation

- I follow political and social issues because it bothers me when I don't.

Extrinsic political motivation

- I follow political and social issues because that's what I'm supposed to do.

Political efficacy (4 items)

- Sometimes politics and government seem so complicated that a person like me can't really understand what's going on. (r)
- I consider myself well-qualified to participate in politics.
- I think that I am better informed about political and social issues than other students.
- I feel I have a pretty good understanding of current political and social issues facing my world.

Trait openness (4 items)

- I have a vivid imagination.
- I enjoy hearing new ideas.
- I do not like art. (r)
- I am not interested in abstract ideas. (r)

Cultural cognition

Individualism (6 items)

- The government interferes far too much in our everyday lives.

- It's not the government's business to try to protect people from themselves.
- The government should stop telling people how to live their lives.
- Sometimes government needs to make laws that keep people from hurting themselves. (r)
- The government should do more to advance society's goals, even if that means limiting the freedom and choice of individuals. (r)
- Government should put limits on the choices individuals can make so they don't get in the way of what's good for society. (r)

Hierarchy (6 items)

- We have gone too far in pushing equal rights in this country.
- Our society would be better off if the distribution of wealth was more equal. (r)
- We need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women. (r)
- Discrimination against minorities is still a very serious problem in our society. (r)
- It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.
- Society as a whole has become too soft and feminine.

Trait conscientiousness (10 items)

- I am always prepared.
- I pay attention to details.
- I get chores done right away.
- I carry out my plans.
- I make plans and stick to them.
- I waste my time. (r)
- I find it difficult to get down to work. (r)
- I do just enough work to get by. (r)
- I don't see things through. (r)
- I shirk my duties. (r)

Interest in politics. (2 items) Seven point scale from "Not Interested" (0) to "Extremely Interested" (6)

- How interested are you in *national* politics and *national* affairs?
- Thinking about your community, how interested are you in *local* community politics and *local* community affairs?

Political ideology. (3 items) Seven point scale from "Strongly Liberal" to "Strongly Conservative." "Prefer not to answer" also provided.

- Overall.
- When it comes to ECONOMIC issues.
- When it comes to SOCIAL issues.

Political affiliation.

- In politics today, do you consider yourself a Republican, Democrat, or Independent/Other?
 - Seven point scale ranging from "Strong Democrat" to "Strong Republican," with "Independent/Other" in the middle.

Religiosity.

- With regard to religion, which of the following best describes you?
 - Not at all religious, a little bit religious, moderately religious, very religious, prefer not to answer.

Religious affiliation

- With regard to religion, which of the following most closely describes you?
 - Mainline Protestant, Evangelical Protestant, Black Protestant, Roman Catholic, Jewish, Muslim, Agnostic, Atheist, Other (please specify), Prefer not to answer

Quality check.

- If you are reading each item as you answer, choose strongly agree (within the personality trait items)
- Did you read the questions and answer the questions in this assignment honestly? (You will **not** be penalized for your answer. Your instructors will not know how you answers.)
 - Yes, my answers reflect my honest answers;
 - No, I answered the questions randomly;
 - No, I felt I should answer in a certain way, so I gave those answers instead of my honest responses;
 - No, I did not even read the questions as I answered them;
 - Other (Please explain).

Assignment 2.

Background document evaluation. Answers for all on a six point scale ranging from “strongly disagree” to “strongly agree.” Items began with the stem: “The information presented in this assignment was...”

- *Background document evaluation: biased.*
 - A biased portrayal of the issues.
 - A neutral portrayal of the issues. (r)
 - Not always fair in its presentation of the issues.
 - Fair in its presentation of the issues. (r)
 - Balanced. (r)
 - Unbalanced.
 - Written to try to persuade people of a certain viewpoint.
 - Written to allow people to make up their own minds on the issues. (r)
 - A good resource for understanding multiple perspectives on the issues.
 - Not very good for understanding multiple perspectives on the issues. (r)
- *Background document evaluation: not trustworthy.*
 - Trustworthy. (r)
 - Untrustworthy.
 - Inaccurate.
 - Not always accurate in its characterization of the facts.
 - Pretty accurate in its characterization of the facts. (r)
 - Thorough. (r)
 - Not thorough enough.
 - A high quality source of information. (r)

- o Well-written. (r)
- *Background document evaluation: not clear.*
 - o Clear and easy to understand.
 - o Unclear and difficult to understand.

Attitudes towards nanotechnology. All three questions were repeated from Assignment 1, but the third question was changed to a 9-point (instead of a 100-point) scale.

- Based on what you know right now: Do you think the risks of nano-biological research and development outweigh the benefits? Alternatively, do you think that the benefits outweigh the risks?
 - o The risks greatly outweigh the benefits, the risks somewhat outweigh the benefits, the risks slightly outweigh the benefits, the risks and benefits are equal, the benefits slightly outweigh the risks, the benefits somewhat outweigh the risks, the benefits greatly outweigh the risks
- In your opinion, when, or to what extent should it be legal to use nanotechnologies for human enhancement? Choose a level below to reflect your view. Use the following guidelines regarding the meaning of different levels. 0% of the time = NEVER, that is, you believe that no amount of nanotechnology-supported human enhancement should be allowed, not even for life-threatening illnesses or medical purposes. 25% of the time = RARELY, that is, you believe that nanotechnology-supported human enhancement should only be allowed RARELY, and only under a small set of situations. For example, you may approve of it to cure life-threatening illnesses and disabilities. 50% of the time = SOMETIMES, that is, you believe that nanotechnology-supported human enhancement should be allowed SOMETIMES, but not too often. For example, you may approve of it to treat medical conditions, including those that are not life-threatening, but perhaps not for enhancing appearance. 75% of the time = USUALLY, that is, you believe that nanotechnology-supported human enhancement USUALLY should be allowed, but perhaps with some specific restrictions. For example, you may feel its use is ok for many or most non-medical purposes, but maybe not to create “super humans” or modify one’s children. 100% of the time = ALWAYS, that is, you believe human enhancement should ALWAYS be allowed in all cases. For example, uses could include superficial and “superhuman” purposes, and may include enhancing yourself or others (e.g., your children).
 - o NEVER 0% of the time (1)
 - o ALMOST NEVER 12% (2)
 - o RARELY 25% (3)
 - o NOT TOO OFTEN 37% (4)
 - o SOMETIMES 50% (5)
 - o A LOT OF THE TIME 63% (6)
 - o USUALLY 75% (7)
 - o ALMOST ALWAYS 88% (8)
 - o ALWAYS 100% of the time (9)

Mind changed by assignment. Each of the 3 questions above was followed by the additional question below. Thus, the question below was administered 3 times and then averaged into a scale.

- How much did this assignment influence you answer to the [risk/benefits, etc.] question above?
 - o Not at all, just a little, some, quite a bit, a great deal

Objective knowledge: multiple choice. Two questions repeated from Assignment 1.

- What is genetic engineering?
 - o **The changing of the structure of genetic material**; the engineering of new organisms and life forms; the engineering of electronic devices using genetic materials; the method by which taxonomists edit transgenic traits.
- How many nanometers are in one meter?
 - o 1,000,000,000,000 (one trillion); **1,000,000,000 (one billion)**; 1,000,000 (one million); .000001 (one millionth); 10^{-9} (one billionth)

Objective knowledge: true/false. Five questions repeated from Assignment 1.

- (F) A good example of a nano-sized object is a red blood cell.
- (F) Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research.
- (F) Due to the increased cost of surgical and diagnostic tools, nanotechnology will definitely increase the cost of health care.
- (T) Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems.
- (F) The government currently uses nano-scale devices to monitor people.

Engagement. Answers on a five point scale from “Not at all” to “A great deal.” Subscales are noted below.

- During the assignment, I...
 - o Conscientious engagement (4 items)
 - Gave careful consideration to all of the options presented.
 - Thought it was important to be thorough in my consideration of the issues.
 - Felt focused.
 - Carefully evaluated the relevance of various arguments.
 - o Open-minded engagement (3 items)
 - Felt open to hearing new ideas about the topics.
 - Tried hard to understand perspectives that were different from mine.
 - Felt open-minded.
 - o Active learning/Metacognitive engagement (5 items)
 - Tried to find answers to my questions about the topics.
 - Explored topics related to the issues in order to satisfy my own curiosity.
 - Checked myself to see how well I understood the issues related to the topics I was learning about.
 - Identified questions I still had about the topics.
 - Thought about how the topics related to other things I know.
 - o Social engagement (4 items)
 - Discussed my ideas about the topics with others.
 - Talked to others about the topics to get their opinions.
 - Asked others what they thought about the topics and issues.
 - Listened to what others thought about the issues.
 - o Creative engagement (4 items)
 - Used my imagination.
 - Felt inspired.

- Worked to think of novel or inventive issues related to the topic.
- Tried to be innovative in my ideas.
- o Disinterested engagement (4 items)
 - Was impatient to get this over.
 - Wished I were doing something else.
 - Felt bored.
 - Was uninterested in the task I was asked to do.
- o Angry engagement (4 items)
 - Felt angry.
 - Found it aggravating.
 - Felt frustrated.
 - Became irritated.
- o Close-minded engagement (3 items)
 - Felt like my mind was already made up.
 - Knew how I would feel about the topic even before doing the task.
 - Felt like new information would not change my opinions.

Assignment evaluation. The following items assessed the quality of the assignment.

Answers to the first list of items are on a five point scale from “Not at all” to “A great deal.”

- Overall, to what extent did this assignment help me to...
 - o Understand nanotechnology.
 - o Learn about nanotechnology.
 - o More clearly articulate my own perspective.
 - o Compare the positives and negatives related to nanogenomics.
 - o See the issues from multiple perspectives.
 - o Formulate my arguments better.
 - o Think critically about evidence.
 - o Better understand what it means to think critically.
 - o Motivate me to look at the evidence for different claims, rather than just accepting the claims.
 - o If you are reading this question, please mark ‘not at all’ as your answer. (This item was included with the other items during administration, but not included in scale. It was used as a data quality check instead).
- Overall, how useful was this assignment for helping you to think more about nanogenomics and nanomedicine and preparing you to form opinions and policy input related to nanotechnology development and regulations relating to human enhancement?
 - o Not at all, slightly, somewhat, quite, extremely
- How much do you feel you learned about nanotechnology as a result of working on this assignment?
 - o Nothing I didn’t know before; Just a little; Some; Quite a bit; A great deal

Subjective knowledge.

- Now that you’ve done some reading... How familiar do you feel with regard to nanotechnology and its biological applications?
 - o Not at all familiar; Slightly familiar; Somewhat familiar; Very familiar; Extremely familiar

Assignment 3.

Attitudes towards nanotechnology. All three questions were repeated from Assignment 1 along with the three follow-up questions from Assignment 2.

Assignment evaluation. All questions repeated from Assignment 2.

Group identification. (6 items) Answers for all on a six point scale ranging from “strongly disagree” to “strongly agree.”

- I felt strong ties with my group.
- I felt like a member of my group during the discussion.
- I identified with my group during the discussion.
- I “liked” or had positive feelings toward my group.
- I felt like an “outside” member of my group.
- I “disliked” or had negative feelings toward my group.

Perceived group consensus

- How much disagreement was there within your group AT THE BEGINNING of the discussion?
 - No disagreement at all; Slight disagreement; Some disagreement; A lot of disagreement; Total disagreement
- How much consensus was there within your group AT THE BEGINNING of the discussion?
 - No consensus at all; Little consensus; Some consensus; A lot of consensus; Total consensus
- How much disagreement was there within your group AT THE END of the discussion?
 - No disagreement at all; Slight disagreement; Some disagreement; A lot of disagreement; Total disagreement
- How much consensus was there within your group AT THE END of the discussion?
 - No consensus at all; Little consensus; Some consensus; A lot of consensus; Total consensus

Group assessment items.

- How satisfied were you with your small group discussion in class today?
 - Not at all satisfied; Slightly satisfied; Somewhat satisfied; Quite satisfied; Extremely satisfied
- Overall, how do you feel about the other people in your group?
 - Very negative; Somewhat negative; Slightly negative; Neither negative nor positive; Slightly positive; Somewhat positive; Very positive

Group member ratings. Participants were asked to identify each of their group members by first name and last initial. The following questions were asked in regards to each group member.

- *Before today's discussion:* How familiar would you say you were with “_____”
 - Not at all familiar; Slightly familiar; Somewhat familiar; Quite familiar; Extremely familiar
- Regarding the ethical scenarios you just discussed, how similar do you think each person's opinions are to your opinions?
 - Not at all similar; A little similar; Somewhat similar; Extremely similar

Perceptions of active moderator. (6 items) Answers for all on a six point scale ranging from “strongly disagree” to “strongly agree.”

- The MODERATOR of our group...
 - Was very active in leading our group discussion.
 - Summarized what he/she heard the group saying.
 - Made the group discussion more productive.
 - Encouraged our group to think more deeply about the topics under discussion.
 - Was helpful.
 - Encouraged group members to actively engage in the discussion.
 - *Was unbiased while leading the group.
 - *Mostly let the students lead the discussion
- *Starred items not included in final scale.

Assignment 4.

Individual differences. The following scales were repeated from Assignment 1. Answers for all items were on a six point scale ranging from “strongly disagree” to “strongly agree.” Negative items need to be reverse-scored.

Deliberative values (4 items)

- A good citizen should listen to people who disagree with them politically.
- A good citizen should allow others to challenge their political beliefs.
- A good citizen should be willing to justify their political views.
- If a citizen is dissatisfied with the policies of government, he or she has a duty to do something about it.

Intrinsic political motivation (3 items)

- I follow political and social issues because I want to learn more things.
- I follow political and social issues because I think it’s important.
- Being politically and socially conscious is important to who I am. (Item not in A1)

Introjected political motivation (2 items)

- I follow political and social issues because it bothers me when I don’t.
- I follow political and social issues because I will feel bad about myself if I don't. (Item not in A1)

Extrinsic political motivation (2 items)

- I follow political and social issues because that’s what I’m supposed to do.
- I follow political and social issues because that's what I'm expected to do. (Item not in A1)

Political efficacy (5 items)

- People like me don't have any say about what the government does. (r) (Item not in A1)
- Sometimes politics and government seem so complicated that a person like me can’t really understand what’s going on. (r)
- I consider myself well-qualified to participate in politics.
- I consider myself well qualified to provide input on political and social issues. (Item not in A1)
- I think that I am better informed about political and social issues than other students.
- I feel I have a pretty good understanding of current political and social issues facing my world.

Nanotechnology attitudes: specific issues. (Items were z-scored and combined with general goals items to form scales subsequently described.) Answers for all on a six point scale ranging from “strongly disagree” to “strongly agree.”

- Nanotechnology is one of the more important issues confronting government today.
- The risk of nanotechnology directly affecting physical things like human health, wildlife or the environment in general is currently too high.
- The risk of nanotechnology affecting social systems like the economy, trade and sustainable food supply is currently too high.
- The government will effectively manage any risks associated with nanotechnology.
- Scientists working with nano-biological technologies will develop them in directions that are positive for society.
- We should develop nanotechnology at full speed despite its possible risks, in order to keep the US from falling behind other countries.
- There are serious ethical problems associated with *not* quickly developing nanotechnologies.
- Due to the fact that some have expressed strong concern about nanotechnology’s risks, we should have a world ban on new nanotechnology products.

Nanotechnology attitudes: general goals. (6 items, z-scored and combined with general goals items to form scales subsequently described.) Answers for all on a five point scale ranging from “unimportant” to “extremely important.”

- When it comes to nanobiological technologies, how important are the following general goals?
 - Minimizing potential risks for humans.
 - Minimizing potential environmental risks.
 - Making decisions about the most important directions for future development.
 - Studying the social and ethical impacts and implications of future developments and regulations.
 - Maximizing potential benefits for human enhancement.
 - Maximizing potential environmental benefits.

The two sets of items above were z-scored at the item level then combined into the following scales:

- *General perceptions of importance of maximizing benefits and minimizing risks* (5 items)
 - Minimizing potential risks for humans.
 - Minimizing potential environmental risks.
 - Making decisions about the most important directions for future development.
 - Studying the social and ethical impacts and implications of future developments and regulations.
 - Maximizing potential environmental benefits.
- *General perceptions of [low] risks* (3 items)
 - The risk of nanotechnology directly affecting physical things like human health, wildlife or the environment in general is currently too high
 - The risk of nanotechnology affecting social systems like the economy, trade and sustainable food supply is currently too high
 - Due to the fact that some have expressed strong concern about nanotechnology's risks, we should have a world ban on new nanotechnology products.

- *General perceptions of high benefits* (3 items)
 - There are serious ethical problems associated with not quickly developing nanotechnologies.
 - Maximizing potential benefits for human enhancement.
 - We should develop nanotechnology at full speed despite its possible risks, in order to keep the US from falling behind other countries.
- Three items were not included in the scales
 - The government will effectively manage any risks associated with nanotechnology.
 - Scientists working with nano-biological technologies will develop them in directions that are positive for society.
 - Nanotechnology is one of the more important issues confronting government today.

Likelihood of specific risks and benefits. (12 items) Answers for all on a five point scale ranging from “not at all likely” to “extremely likely.”

- Based on what you know now, how *likely* do you think it is that each of the potential benefits or risks will become a reality as a result of developments in nanobiological technologies?
 - The extension of human life expectancy.
 - Cheap and more universal healthcare.
 - Higher rates of terminal illness survival (e.g. cancer survival).
 - The ability to improve humans through genetic manipulation.
 - The elimination of genetic inheritance of disease.
 - Economic development through investment and research.
 - Economic disruption caused by the loss of traditional jobs.
 - Loss of personal privacy due to tiny new surveillance devices.
 - Pollution of the environment by nanomaterials.
 - Unforeseen side-effects from nanomedicines.
 - Loss of religious liberties.
 - The widening of the gap between the rich and the poor.

Importance of specific risks and benefits. (12 items) Answers for all on a seven point scale ranging from “very important to AVOID” to “very important to ACHIEVE,” with “NOT IMPORTANT to avoid or achieve” in the middle.

- The extension of human life expectancy.
- Cheap and more universal healthcare.
- Higher rates of terminal illness survival (e.g. cancer survival).
- The ability to improve humans through genetic manipulation.
- The elimination of genetic inheritance of disease.
- Economic development through investment and research.
- Economic disruption caused by the loss of traditional jobs.
- Loss of personal privacy due to tiny new surveillance devices.
- Pollution of the environment by nanomaterials.
- Unforeseen side-effects from nanomedicines.
- Loss of religious liberties.
- The widening of the gap between the rich and the poor.

The pairs of likelihood x importance items were multiplied together and then multiplied items were

averaged to create the following scales:

Importance of approaching of benefits of nanotechnology

- The extension of human life expectancy.
- Cheap and more universal healthcare.
- Higher rates of terminal illness survival (e.g. cancer survival).
- Economic development through investment and research.
- The elimination of genetic inheritance of disease.

Importance of avoiding various risks of nanotechnology (but is reversed because negative numbers indicate avoidance)

- Loss of religious liberties.
- The widening of the gap between the rich and the poor.
- Economic disruption caused by the loss of traditional jobs.
- Loss of personal privacy due to tiny new surveillance devices.
- Pollution of the environment by nanomaterials.
- Unforeseen side-effects from nanomedicines.

Assessment of public engagement activities. (11 items)

- A hypothetical scenario is introduced involving a public engagement exercise used by the government to establish new nanotechnology regulations. Participants are asked to assess the exercise employed in this scenario. Answers for all on a six point scale ranging from “strongly disagree” to “strongly agree.”
 - The government should have used a different process to get public input about this issue.
 - The process used by the government was a good one.
 - The process used by the government to make decisions about this issue was fair.
 - The government listened to the people it regulates.
 - People influenced the government’s choices.
 - The government cares about the people it regulates.
 - The government made its decisions in an INcompetent manner.
 - I would resist this decision made by the government.
 - I would support this decision made by the government.
 - Because of the processes used, I would accept this decision made by the government.
- If the legislation above were really under consideration by the government, would you be FOR or AGAINST such legislation?
 - Strongly AGAINST; moderately AGAINST; slightly AGAINST; slightly FOR; moderately FOR; strongly FOR

Confidence in nanoscientists. (3 items) Answers for all on a five point scale ranging from “not at all” to “a great deal.”

- To what extent do you have confidence in nanoscientists to...
 - Do their jobs well.
 - Meet their professional responsibilities.
 - Make decisions about the most important directions for future development.

Trust in nanoscientists. (7 items) Answers for all on a five point Likert scale ranging from “not at all probable” to “very probable.”

- To what extent do you feel nanoscientists probably...
 - Are trustworthy.
 - Will make decisions based on their care and concern for those they will impact.
 - Are generally caring people.
 - Are persons of integrity.
 - Are honest in their dealings with others.
 - Share my values.
 - Things that are important to me, are also important to them.

Distrust in nanoscientists. (5 items) Answers for all on a five point Likert scale ranging from “not at all probable” to “very probable.”

- To what extent do you feel nanoscientists probably...
 - Are not to be trusted.
 - Generally do not care about those who they impact.
 - Don't really care about the long-term risks of their work.
 - Are primarily motivated by what will benefit them personally.
 - Have questionable morals.
 - Do not share my values.

Perceived competence of nanoscientists (3 items) Answers for all on a five point Likert scale ranging from “not at all probable” to “very probable.”

- To what extent do you feel nanoscientists probably...
 - Are very competent at their job(s).
 - Have the knowledge and skills needed to do their job(s).
 - Are incompetent.

Subjective knowledge. All questions repeated from Assignment 1.

Objective knowledge: true/false. All questions repeated from Assignment 1.

Objective knowledge: multiple choice. All questions repeated from Assignment 1.

Attitudes towards nanotechnology. All three questions repeated from Assignment 1 along with the three follow-up questions from Assignment 2.

Activity evaluation.

- Overall, to what extent was the public participation module a beneficial part of your learning in this course?
 - Not at all; just a little; some; quite a bit; a great deal
- How much do you feel you learned about nanobiological research for human enhancement as a result of working on the public engagement module last week and this week?
 - Nothing I didn't know before; just a little; some; quite a bit; a great deal

Quality check. Question repeated from Assignment 1.

4.2. Appendix B – Assignment 2 Materials

4.2.1. *Background documents: Varied in quality*

Students were randomly assigned to see one of two versions of the ELSI portion of the background reading: A weaker or stronger version (higher or lower quality information) of the document. The differences between the documents are outlined in the next pages.

STUDY 5

Comparison of Weaker and Stronger Background Texts

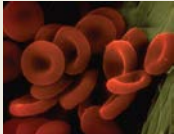
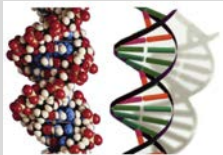
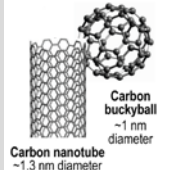
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Introduction: Working at the Nano Scale

Note:
Throughout this document, you can visit links to more information

Nanotechnology refers to a variety of scientific and technological developments that involve the very precise manipulation of matter at the *nanoscale*. One nanometer (nm) equals one-billionth of a meter. Nanoparticles are typically between 1 and 100 nanometers in length or width. As illustrated in Figure 1, DNA and silver nanoparticles are examples of "nano"-sized materials, red blood cells are bigger and considered to be "micro"-sized, and objects we can see easily are "macro"-sized. Powerful microscopes are needed to visualize objects at the nanoscale.

Figure 1. From the Macro-scale to the Nano-scale, the Natural and the Manufactured

	Natural	Manufactured
Macro 0.1mm and up (millimeters) or 100 μm and up 1 mm = one thousandth of a meter	<i>Most people can easily see objects at the macro level.</i>  Ant 4-5 mm long	 Head of a pin 1-2 mm wide
Micro 0.1-100 μm (micrometers) 1 μm = one millionth of a meter	<i>We start to need to magnify objects to see them well at the micro level.</i>  Red blood cells 2-6 μm wide	 MicroElectroMechanical (MEM) Devices 10-100 μm wide
Nano 2-100 nm (nanometers) 1nm= one billionth of a meter	<i>Very powerful microscopes are needed to see objects at the nano level.</i>  DNA 2-12 nm wide	 Carbon nanostructures 1-100 nm

Note: Figure based on a U.S. Dept of Energy (DOE) graphic. See DOE's illustrative examples [here](#).

An important feature of nanoscale materials is how their properties differ from macroscale materials. Everyday common materials take on [new and different properties](#) when reduced to nano-sized objects. For example, substances may change color and how they react to other substances. In fact, scientists have found that they can manipulate carbon atoms and molecules to create nanosized carbon tubes and

fibers with unique properties. Although normal-scale carbon does not conduct electricity, carbon nanotubes are effective electrical conductors, as well as extremely hard and durable and yet very light. The changes in properties at the nanoscale can be beneficial (as in the case of carbon) or negative--because some materials that are harmless at their normal size could be dangerous at the nanoscales.

The discovery of the changing properties of nano-sized materials has resulted in the creation of a number of revolutionary technologies that are already impacting our lives. For example, some [nanocomposites](#) and [nanocrystals](#) are more scratch-resistant, light-weight, rust-proof, stronger, or longer-lasting than traditional materials, leading to their use in tennis rackets, tennis balls, and display screens. Because of their [water dispersion properties](#), nanoparticles are also being incorporated into things like exterior paints, adhesives, paper, textiles, and even [stain-resistant clothing](#). Certain nanoparticles are extremely effective in absorbing light and are being used in cosmetics and sunscreens. Aluminum and copper nanoparticles are being used to create rocket propellants that burn at double the rate of traditional propellants and automotive lubricants that reduce engine wear. Additionally, nanofilters are being used to sterilize water much more efficiently than any other means discovered to date.

These developments are having broad impacts on society as a whole. For example, a company in China has licensed nanocatalyst technology that will enable it to liquefy coal and turn it into gas, which may make the company much more competitive on a global scale. Similarly, the automotive industry is adopting the use of nanocatalysts in its [catalytic converters](#), thus making certain chemical reactions more efficient and resource-saving, which have various [industrial implications](#). Additionally, the United States stands to gain from nanotechnological developments related to renewable energy. This is especially important because many believe the U.S. is [falling behind](#) in its use of “green” energy.

On the other hand, many people are concerned about the potential risks of these developments. [Sandler and Bosso \(2007\)](#) argue that more attention needs to be directed at the social context of nanotechnology, including who has access to resources, social and political power, individual rights, and justice in general. Sandler and Bosso also criticize U.S. federal regulatory organizations as often being too slow in reacting to technological breakthroughs that require regulatory oversight, and recommend that caution be used in pursuing advances in nanotechnology.

[Hoet et al. \(2004\)](#) discuss some specific known risks of nanotechnology. Such risks include the ability of nanomaterials to enter the body through various ports, most likely via the lungs, and pass to other vital organs via the bloodstream. Given that human skin, lungs and the intestinal tract are always in direct contact with the environment, there are many ways in which nanomaterials can enter the body. This is

of concern because nanoparticles have been shown to be active at the cellular level. For example, carbon black nanoparticles have been implicated in interfering with cell signaling and causing inflammation and even tumors in the lungs. Experiments on laboratory animals also have shown that carbon nanotubes, used in many applications due to their unique properties, can damage the lungs of rats and mice.

Beyond harm to humans, a report from the Health Council of the Netherlands explains how the ability of nanomaterials to cross barriers, as well as the high reactivity and toxicity of some, can make them hazardous to both humans *and* the environment. Although nanoparticles exist naturally in the environment, fossil-fuel combustion has substantially increased their volume in the air. Some research has shown that iron nanoparticles are capable of travelling with groundwater twenty meters into the soil and can remain reactive for four to eight weeks. These reactive nanomaterials can make their way into soil-eating organisms, accumulate in the fatty tissue of those organisms, and move up the food chain to humans. In addition, “free form” nanoparticles can be released into the air or water during the process of manufacturing nanomaterials and most traditional pollutant filters are unable to catch nano-sized particles. **TEXT IN RED OMITTED FROM WEAK VERSION**

Biology Meets Nanotechnology

Two technologies that exist at the interface of nanotechnology and biology are *nanomedicine* and *nanogenomics*. Both technologies have shown potential for use in **human enhancement** applications. **Human enhancement** refers very generally to anything designed to “enhance” human capabilities. In modern society, methods for human enhancement include common activities ranging from higher education and athletic training, to less common methods such as plastic surgery and the development and use of prosthetic limbs. Thus, human enhancement includes both removal of negative human characteristics (e.g., curing diseases and disabilities) as well as the enhancement of positive capabilities. Nanotechnology may one day push the boundaries of human enhancement to include everything from curing genetic diseases to choosing a baby's eye color. Some think it may even involve the enhancement of normal capabilities to be extraordinary. We'll next talk a bit more in detail about human enhancement developments specific to nanomedicine and nanogenomics.

To watch a short lecture about what the future holds in human enhancement, including benefits and risks, see [this video.](#)

Nanomedicine

Nanomedicine refers to the application of nanotechnology to medical work, such as health diagnoses and treatments. Doctors use nanotechnology in a variety of ways, including research with liposomal nanoparticles, in order to find new and better ways to treat various diseases. **Liposomes** are man-made,

sphere-shaped cell organelles (a type of vesicle), only 100 nanometers in diameter, that are generally used to house and deliver drugs. For example, liposomes have been used to administer highly potent anticancer chemotherapy drugs in a way that delivers a higher proportion of the drug to the target and less to the rest of the body, possibly minimizing serious side-effects (LaVan, McGuire, & Langer, 2003). Liposomes have also been used to deliver drugs to organs and tissues that are otherwise hard to reach, such as the brain. This is important because roughly 90% of drugs showing therapeutic benefits for treating diseases like Alzheimer's, Multiple Sclerosis and brain tumors cannot reach the brain in sufficient concentrations to be effective without assistance from nanotechnology (Freitas, 2005). Only with the aid of liposome delivery systems are these medicines able to penetrate the blood-brain barrier, which normally prevents the passage of large polar molecules. Additionally, there is a newer class of "biological medications" (called biologics), which are destroyed in the stomach and thus cannot be taken as traditional tablets. Biologics are much more expensive than traditional medications, so some scientists hope that the smaller doses that are made possible by nanotechnology-enabled delivery systems could make these drugs cheaper and thus accessible to more people (Freitas, 2005). Also, nanoparticles are being incorporated for their water dispersion properties into certain vitamins and pharmaceuticals that have precursors that are insoluble in water.

REMOVED LINKS AND REFERENCES FROM RED TEXT BUT LEFT TEXT

In addition to drug delivery, EVERYONE KNOWS THAT nanomedicine has been used for cutting-edge diagnostic purposes. For example, injecting iron oxide nanoparticles into the bloodstream prior to an MRI (magnetic resonance imaging) significantly enhances the MRI's ability to detect the spread of cancer from its point of origin to lymph nodes in the body (Cavalcanti et al., 2007). Further diagnostic techniques that utilize nanotechnology are being studied for their potential to detect early signs of skin cancer, Alzheimer's disease and other cell diseases. REMOVED REFERENCE

Currently, researchers are also working to develop a variety of novel AND IMPORTANT medical treatments. Some research involves using mice to test the internal use of engineered nanosized gold-coated silica particles. These nanoshells accumulate in tumor tissues and can be selectively heated when illuminated from outside the body with near infrared light. The heat then destroys the tumor tissue (Nanoscale Informal Science Education, 2007). Clusters of heated, magnetic nanoparticles have been used to control ion channels in cell membranes. DOESN'T IT SEEM LIKELY that such techniques will someday result in new treatments for cancer, diabetes and some neurological disorders? MANY Doctors are ALSO hopeful that this research will one day allow us to target and treat tumors more efficiently and with fewer side effects than traditional treatments. ALSO REMOVED LINK TO REFERENCE

Nanogenomics

Nanogenomics is an area of study within both genetics and nanotechnology. The term "nanogenomics" implies the use of nanotechnology to aid in the study of the genes of cells at microscopic levels (DNA, mRNA and protein). Sometimes the term "nanogenetics" is used to refer to the study of how

nanotechnologies might be applied to change single genes within the genetic code. Here, however, we are using the term nanogenetics or nanogenomics broadly to refer to any research and development involving both nanotechnology and genetics. For example, since 2003, researchers have been able to use nanotechnology to manufacture mechanical devices that are DNA-based, including DNA “scaffolds,” which have the same double helix shape, that can help scientists build smaller-than-ever computer chips ([Seeman, 2003](#); [Kershner, 2009](#)). Though this line of research focuses on the technology industry, its concepts are rooted in biology, through the architectural design of DNA. IT SEEMS PRETTY LIKELY THAT This technology could SOMEDAY allow computer chips to be made that are faster, more energy efficient and less expensive than they were before.

Other developments in nanogenomics overlap with nanomedicine. For example, some nanogenomic medicines consist of a manufactured strand of RNA that can be delivered to a set of cells to reduce the expression of, or target the destruction of, a specific gene. This technique, called RNA interference (or RNAi) is being explored for its potential to treat diseases such as cancer ([Wang et al., 2008](#)) and inflammatory bowel disease ([Wilson, 2010](#)). OF COURSE, AS ALWAYS some PEOPLE debate the likelihood of THE eventual success OF THIS IMPORTANT WORK (e.g., see [Ledford, 2010](#)). REMOVED REFERENCES AND LINKS in red text.

RNA Interference

A short, informative video about RNA interference can be found [here](#).

Nanotechnology is also currently being used in the area of genetics to investigate new means for mapping the human genome (referred to as “nano-sequencing” of DNA) and to provide new methods for transforming genetic code or genetic expression and, thus, for genetic engineering (defined as the changing of the structure of genetic material). In general, genetic engineering techniques can be used to modify products such as the stress resistance of agricultural crops ([Moeller & Wang, 2008](#)) and for tissue engineering ([Ernest & Shetty, 2005](#)), in which new tissues are created outside the body and then surgically placed in the body.

Approaches & Perspectives: An Overview

So far this background document has focused on describing current developments at the interface of nanotechnology and biology. As with any issue that holds significant implications for society, however, there exist many opinions about the role of nanotechnology in today’s world—and what *future* development and regulation should look like. In this section, we review two major approaches or perspectives on the ethical, legal and social issues pertaining to these topics, in order to provide you with a starting point for exploring your own opinion.

Note: In the online version of this document, the blue headings below were clickable expandable links that opened up additional information and explanation. You will find that additional information immediately following this overview, on page 8.

Approach 1: Human Enhancement as "Human Progress"	Approach 2: Human Enhancement as "Unnecessary Risk"
Summary According to the <i>Human Progress</i> perspective, the benefits of nanogenomic and nanomedical research that have already been discovered (as reviewed above), as well as those potentially available in the future, far outweigh the risks that might accompany such research. Those with this opinion argue that it is our nature as humans to progress, and we should take advantage of new technology as it is developed. We have the potential to save many lives, and the longer we wait, the more lives go unsaved. The costs of slowing down research and development can be measured in numbers of lives lost while waiting for the research.	Summary According to the <i>Unnecessary Risk</i> perspective, the risks of nanogenomic and nanomedical research are <i>too great</i>, especially if human enhancement is the goal. For example, it is often suggested that there could be unforeseen side effects of nanomedicines and nanogenomic treatments. Alternatively, using such technology could interfere with the nature of the human body and have devastating consequences. People in this approach wonder if there could be severe, negative biological and social implications that would stem from such rapid changes to the human genome and human biology.
Action Implications: The major implication of the <i>Human Progress</i> perspective is that we should keep regulation of nanogenomic and nanomedical research to a minimum, and fund such research aggressively.	Action Implications: The major implication of the <i>Unnecessary Risk</i> perspective is that nanogenomic and nanomedical research should be extremely regulated, if allowed (and if funded) at all. Very limited amounts of funding should only be used for clearly beneficial research.

Support: In support of the <i>Human Progress</i> perspective, many proponents argue points such as the following: Quality of life: With nanobiological technologies, we may be able to increase the <i>quantity and quality of life</i>.	Support: In support of the <i>Unnecessary Risk</i> perspective, many proponents argue points such as the following: Over population: Overpopulation could result from increased life expectancy and new treatments of diseases.
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Approach 1: Human Enhancement as "Human Progress"	Approach 2: Human Enhancement as "Unnecessary Risk"
Universal healthcare: We may be able to provide <i>cheaper and more universal healthcare</i>. A stronger country: We could <i>make the country stronger</i> and more independent. This would include creating a <i>new industry</i> based on nanobiological research and human enhancement developments that could <i>produce jobs</i>. Human autonomy: Individuals have the <i>right to self-improvement</i>, if they want it.	Unacceptable risks: There could be unpredictable and unacceptable health and genetic-related problems. Second-order effects: Unexpected and unpredictable "second order" effects could occur. A genetics gap: A genetics gap might result, where people with "good genes" are significantly different than those with "bad genes." This could spark a new eugenics movement. Personal privacy: Personal privacy could be threatened. Rights of children: Children could be (and should not be) genetically altered subject to the desires of their parents.
Trade-offs: Even though the proponents of the <i>Human Progress</i> perspective may strongly believe the points above, they still tend to admit that rapid advances in nanobiological human enhancements would probably include the following likely trade-offs: Potential side effects: There could be some <i>side effects</i> of nanomedical and nanogenomic treatments. Traditional job loss: Some <i>traditional jobs might be lost</i>. Social Changes: There would be significant structural changes in society that could change how we think about many aspects of life, including our understanding of concepts like "disease" and "age". There would also be implications for how we think about "human nature." However, according to this approach, these tradeoffs are not severe enough to warrant heavy regulation.	Trade-offs: Even though the proponents of the <i>Unnecessary Risk</i> perspective may strongly believe the points above, they still tend to admit that overregulation of nanobiological human enhancements would probably include the following likely trade-offs: Admitted benefits: Some forms of nanotechnological research might be okay to fund, and some people might be helped that wouldn't be helped if there was heavy regulation. Varied risk likelihood: Some risks are somewhat unlikely. However, for those who oppose nanobiological research, these tradeoffs are not convincing enough to warrant a lack of regulation on nanogenomic and nanomedical research.
Opposition: Of course, a number of people oppose the <i>Human Progress</i> perspective, and offer the following opposing points: Unacceptable risks: There would be unpredictable (and unacceptable) risks, including potentially devastating biological and genetic problems.	Opposition: Of course, a number of people oppose the <i>Unnecessary Risk</i> perspective, and offer the following opposing points: Importance of benefits: The existence of risks does not mean you should completely refuse to fund this research.

Approach 1: Human Enhancement as "Human Progress"	Approach 2: Human Enhancement as "Unnecessary Risk"
Unrealistic promises: Many of the benefits and promises are unrealistic. Economic disruption: Economic disruption could result from the introduction of this new industry.	Each risk has a benefit: There are benefits that accompany and outweigh most risks. We must progress: We must progress as a society and as a race when we can, or we are lost.

Approaches & Perspectives: A [More Detailed!] Overview

Note: Below is the same information as above, but with the additional detail that was provided in the clickable links to more information, in the online version.

Approach 1: Human Enhancement as "Human Progress"

According to the *Human Progress* perspective, the benefits of nanogenomic and nanomedical research that have already been discovered (as reviewed above), as well as those potentially available in the future, far outweigh the risks that might accompany such research. Those with this opinion argue that it is our nature as humans to progress, and we should take advantage of new technology as it is developed. We have the potential to save many lives, and the longer we wait, the more lives go unsaved. The costs of slowing down research and development can be measured in numbers of lives lost while waiting for the research.

Action Implications:

The major implication of the *Human Progress* perspective is that we should keep regulation of nanogenomic and nanomedical research to a minimum, and fund such research aggressively.

Support:

In support of the *Human Progress* perspective, many proponents argue points such as the following:

Quality of life: With nanobiological technologies, we may be able to increase the *quantity and quality of life*.

Related to quality of life, advocates of the *Human Progress* perspective argue that it is possible that future developments in nanomedicine and nanogenomics toward human enhancement could increase life expectancy and the quality of life. Consistent with this viewpoint, new technologies in medicine have already allowed us to increase life expectancy at a substantial rate over the centuries.

Further enhancements in the quantity (life expectancy) and quality (health) of life could follow from a multitude of factors. For example, nanobiological developments could lead to [higher rates of survival for those with otherwise terminal illnesses](#) (e.g. cancer) as we develop new and better ways to treat and detect human diseases ([Holland et al. 2007](#)), as well as drastic reductions in the effects of aging due to technologies that can cosmetically repair tissues associated with aging ([Konovalenko, 2010](#)). It may also be possible to decrease the number of side effects of medicines because targeting the medicine right to specific cells that need it would require much less medicine. Over a longer time period, we may also be able to improve individuals' physical abilities and muscle function, and eventually, individuals' mental abilities and brain function ([Kurzweil and Grossman, 2004](#)).

In general, these examples address the capabilities to improve humans, as a whole, through genetic manipulation. Some *Human Progress* advocates also believe and value the idea that nanogenomic research and development may someday allow us to [choose the traits of our children](#) (e.g., gender, hair color, height, intelligence, and so on). Further, advocates of this perspective suggest that we would no longer have to worry about passing on genetic diseases, because nanotechnology might provide us with alternatives to "viral transfection," or [gene transfer](#), which would change and potentially improve us as a species by reforming how we treat inherited diseases ([Hassoun, 2008](#)).

Universal healthcare: We may be able to provide *cheaper and more universal healthcare*.

On a more economic note, some *Human Progress* advocates argue that *healthcare*, due to this new technology, could become cheaper and more universal. [Surgical and diagnostic tools](#) can be made more elegant and cheap because in a molecular manufacturing system, production costs are not influenced by the complexity of a product. This would lead to cheaper, longer lasting consumer products, not only in healthcare but also in related industries, such as materials that go into health care products.

A stronger country: We *could make the country stronger* and more independent. This would include creating a *new industry* based on nanobiological research and human enhancement developments that could *produce jobs*.

If we were the first country to make certain discoveries and developments, we might also experience [economic development through investment and research](#) in nanogenomics techniques and nanomedicines, especially those that could then be marketed internationally. Another economic

argument made by advocates of this perspective is that nanotechnological research could also allow the United States to become stronger and more independent as a nation by allowing us to utilize renewable energy more efficiently (see [this article](#) about how the U.S. is already falling behind in its use of “green” energy), as well as create new and better ways to [clean up and monitor the environment](#). We could also potentially increase our [national security and defense capabilities](#).

[Human autonomy](#): Individuals have the *right to self-improvement*, if they want it.

People who adhere to the *Human Progress* perspective also argue that use of nanotechnology for human enhancement is consistent with our inherent rights to autonomy. In the United States, we value individual freedom, part of which includes the right to make changes to ourselves and (to some extent) our children. Some proponents of the *Human Progress* perspective believe these rights apply to the manipulation of genetic codes through nanogenomics as well.

Trade-offs:

Even though the proponents of the *Human Progress* perspective may strongly believe the points above, they still tend to admit that rapid advances in nanobiological human enhancements would probably include the following likely trade-offs:

[Potential side effects](#): There could be some *side effects* of nanomedical and nanogenomic treatments.

Some note that there could, as with any new medicine, be some unforeseen side effects or problems that arise from nanomedicines or the use of nanogenomics to alter genetic code.

Autonomy:
Independence or
freedom, as of
the will or one's
actions.

[Traditional job loss](#): Some *traditional jobs might be lost*.

Some admit that traditional jobs might be lost due to a shift in medicine and technology away from traditional methods to nanotechnology, nanomedicine, and nanogenomics.

[Social Changes](#): There would be significant structural changes in society that could change how we think about many aspects of life, including our understanding of concepts like “disease” and “age”. There would also be implications for how we think about “human nature.”

If you take into account the potential of nanogenomic and nanomedical research to get rid of diseases, you might have to ask: “What exactly is a disease?” Maybe genes that alter phenotypes are disease-related. Or, perhaps a disease is any condition (physical, mental, or emotional) that is

undesirable ([Freitas, 1999](#)). By this definition, maybe *aging* is a disease. We already know that nanotechnology has the potential to address the effects of aging, but the implications of such change on our society (seeing aging as a disease) would be tremendous. There is also much discussion as to what the implications of such research would be for the concept of “human nature.” Some say that it is not in our nature as humans to be so resilient to death and illness, and rightfully so. We rely on a balance between our health and our environment. On the other hand, some argue that to progress with nanobiological research is perfectly “natural.” Technological advancements have done great things for society over time, and if we do not embrace these advancements, we are sacrificing many people to otherwise preventable illnesses and catastrophes.

However, according to this approach, these tradeoffs are not severe enough to warrant heavy regulation.

Opposition:

Of course, a number of people oppose the *Human Progress* perspective, and offer the following opposing points:

Unacceptable risks: There would be unpredictable (and unacceptable) risks, including potentially devastating biological and genetic problems.

Critics of this approach note that there are not only serious medical and biological implications to consider, but there are also many social, ethical, and economic issues that must be acknowledged in the conversation about nanogenomic and nanomedical research. The immediate health concerns might include side effects of new medications and treatments, but changes in the structure of the human genome may also have severe negative consequences.

Unrealistic promises: Many of the benefits and promises are unrealistic.

Many of the proposed benefits of the *Human Progress* approach aren’t even seen as generally foreseeable in the near future by many scientists. It is generally accepted that currently, the process of mapping one’s DNA sequence is very tedious, and to carry out this process on each individual would be very inefficient ([Kircher & Kelso, 2010](#)). It is also suggested that the practicality of passing on manipulated genes to offspring is quite slim (see [King](#) for more information).

Economic disruption: Economic disruption could result from the introduction of this new industry.

This would also have unpredictable ramifications for economic development and certain industries that would be significantly affected by the new industry of nanogenomics. [Employment patterns](#) would more than likely be disrupted, especially since nanotechnological manufacturing would allow for

extremely rapid change in manufacturing industries. Also, an abundance of cheap products can [put manufacturing companies out of business](#) as products are made faster and cheaper.

Approach 2: Human Enhancement as “Unnecessary Risk”

According to a second perspective, the risks of nanogenomic and nanomedical research are *too great*, especially if human enhancement is the goal. For example, it is often suggested that there could be unforeseen side effects of nanomedicines and nanogenomic treatments. Alternatively, using such technology could interfere with the nature of the human body and have devastating consequences. People in this approach wonder if there could be severe, negative biological and social implications that would stem from such rapid changes to the human genome and human biology.

Action Implications:

The major implication of the *Unnecessary Risk* perspective is that nanogenomic and nanomedical research should be extremely regulated, if allowed (and if funded) at all. Very limited amounts of funding should only be used for clearly beneficial research.

Support:

In support of the *Unnecessary Risk* perspective, many proponents argue points such as the following:

Over population: Overpopulation could result from increased life expectancy and new treatments of diseases.

One major potential problem of using nanogenomics and nanomedicine to increase life expectancy would be [overpopulation](#) due to the eradication of genetic inheritance of disease. With genetic illnesses gone or easily cured, population sizes would skyrocket, making resources (such as food, oil, medicine) extremely scarce and expensive.

Unacceptable risks: There could be unpredictable and unacceptable health and genetic-related problems.

New, previously nonexistent health problems could also arise due to the use of nanomedicine. This could be due to [breathing in tiny nano-sized particles](#) that may accumulate in your body, or unforeseen side-effects of nanomedicine. Due to the relatively new and unknown nature of nanobiological human enhancement (especially nanogenomics), there could be many side effects (both immediate and in the long-term) of manipulating human biology and the human genome. For example, through gene therapy,

specific types of viruses are used to treat diseases like cancer. However, these viruses may sometimes infect healthy cells as well as cancer cells, and may even [in some instances cause cancer](#). Also, some research has already shown increases in toxicity (specifically, oxidative stress and apoptosis) as a result of certain nanomedicines ([Moghimi et al., 2005](#)). Additionally, if there are harmful genetic modifications, they can be [passed down to future generations](#). This effect would be highly unpredictable. The [human gene pool could even become contaminated](#) as nanoparticles become part of human DNA and are passed on to future generations.

Second-order

effects: *Effects of technology that are extraneous to the purpose for which the technology was created, and often result from the different ways that people react to the technology as opposed to resulting directly from the technology.*

[Second-order effects:](#) Unexpected and unpredictable "second order" effects could occur.

People supporting the *Unnecessary Risk* perspective also have concerns with regard to the economy and the state of the nation in general. This addresses the idea of "second-order effects." **Second-order effects** refer to the ways in which technologies change society more indirectly. For example, a first order effect of the creation of cell phone technology is that people are able to communicate more easily in more locations and situations. Some of the second-order effects cell phone technology relate to how culture responded to the technology. Use of cell phones while driving or by students during classes could be seen as having negative second-order effects detrimental to safety and learning. In addition, use of cell phones has resulted in new social norms and social pressures that influence when people use or do not use their phones. For example, you may notice many signs at businesses asking people not to use their cell phones while paying for their purchases.

These second-order effects are not easy to predict and that is one reason why, during the development of new technologies, scientists and policy makers solicit the public's help in considering what sorts of second-order effects might occur. In general, this process is founded on the belief that it is easier to avoid the negative impacts of second-order effects if you think about them ahead of time than if you wait until they are a large part of the culture.

One example of a potential second-order effect would be that the loss of traditional jobs due to shifts in funding to nanogenomic and nanomedical research could cause a disruption in the economy. This could also lead to a siphoning of U.S. funds away from more important purposes. There is also the potential for environmental deterioration due to pollution by nanomaterials (see [Walker](#) for more details on the harmful effects of nanomaterials on the environment). More extremely, this sort of technology could lead to a [nanotechnology inspired arms race](#) between the U.S. and other nations.

[A genetics gap:](#) A genetics gap might result, where people with "good genes" are significantly different than those with "bad genes." This could spark a new eugenics movement.

Some of the major concerns, however, of people who agree with the *Unnecessary Risk* perspective, lay in the potential ethical and moral consequences nanogenomic and nanomedical research could have. One possible moral implication of nanogenomics is the start of a new eugenics movement in the United States. During the start of the twentieth century, certain lines of thought (usually associated with the Nazi movement) lead to a social and political movement that supported sterilization of people who had what some deemed to be genetic deficiencies. If the gap between those with "good" genes and those with "bad" genes expands, many fear that a eugenics movement will be powerfully resurrected. This "genetic gap" could also lead to [greater deficiencies between the rich and the poor](#), since human enhancement and genetic manipulation using nanogenomics could be very expensive. This could lead to an increase in prejudice and discrimination in general, and even the loss of religious liberties, since the nanogenomics movement in society might be contradictory to some religious beliefs.

Personal privacy: Personal privacy could be threatened.

Eventually, even [personal privacy might be at stake](#) due to the development of tiny new surveillance devices. The extremely small scale of nanotechnological devices, combined with their ability to generate power, collect and store data, and share and process large sets of information may make developing nano-scale surveillance devices much easier and cheaper, as well as a very invasive form of surveillance. The increase in ease and cost-efficiency of production of these devices could easily lead to invasions of privacy.

Autonomy...of who?

Autonomy = Independence or freedom, as of the will or one's actions. But should parents or children decide?

Rights of children: Children could be (and should not be) genetically altered subject to the desires of their parents.

Like those in the *Human Progress* approach, people in the *Unnecessary Risk* approach also bring autonomy into the discussion. However, people in the *Unnecessary Risk* approach emphasize the rights of children who, under their parents' authority, might be subject to genetic alterations that they personally would not want. This perspective would argue that our offspring should not have to deal with the ramifications of genetic manipulation just so that they can become what their parents *intend* them to be, especially because nanogenomics is such a complex field and these ramifications may very well be negative.

Trade-offs:

Even though the proponents of the *Unnecessary Risk* perspective may strongly believe the points above, they still tend to admit that overregulation of nanobiological human enhancements would probably include the following likely trade-offs:

Admitted benefits: Some forms of nanotechnological research might be okay to fund, and some people might be helped that wouldn't be helped if there was heavy regulation.

Although the benefits are not worth the risk, nanotechnological research does hold some positive potential. Whereas human enhancement and genetic alteration might be too risky, smaller-scale research that uses nanotechnology to address diseases and has less risk involved might be acceptable to fund.

Also, there is the possibility that there are people that would have been helped by nanogenomic or nanomedical research but weren't because of regulations.

Varied risk likelihood: Some risks are somewhat unlikely.

Some of the potential risks of nanogenomic and nanomedical research would entail a multitude of other factors happening simultaneously in order to occur. For example, a new eugenics movement, although possible, would entail a broad, anti-democratic social movement to gain any substantial momentum. Also, the difference between eugenics through sterilization versus eugenics through gene selection is seen as hazy by some ([Leung, 2004](#)).

However, for those who oppose nanobiological research, these tradeoffs are not convincing enough to warrant a lack of regulation on nanogenomic and nanomedical research.

Opposition:

Of course, a number of people oppose the *Unnecessary Risk* perspective, and offer the following opposing points:

Importance of benefits: The existence of risks does not mean you should completely refuse to fund this research.

Critics note that just because there are risks involved with nanogenomic research does not mean that we should regulate it to the point of near nonexistence. Critics feel that it must be acknowledged that there are many benefits (both potential and immediate) of funding and promoting such research, and as such, we should do what we can to give nanogenomic scientists the tools they need to develop their research. Funding nanotechnological research also allows us to [maintain a competitive stature](#) among other countries that are developing these technologies.

Each risk has a benefit: There are benefits that accompany and outweigh most risks.

Some of the risks mentioned by those in the *Unnecessary Risk* approach could equally be countered by benefits of nanotechnology. For example, a loss of traditional jobs in the economy would be accompanied by [economic development due to investment in nanogenomic and nanomedical research](#). Additionally, the possible danger of nanomaterials to the environment would be accompanied by new and better ways to [clean and monitor the environment](#).

[We must progress](#): We must progress as a society and as a race when we can, or we are lost.

If we maintained an attitude of sacrificing progress to avoid risk in other aspects of life and society, we would remain stuck in a world with no improvement or hope of overcoming the challenges of today. We rely on ground-breaking research like the potential research in nanogenomics and nanomedicine to thrive and move forward as a society. If we really want to stand a chance against unknown catastrophes of the future and succeed as a society, we must embrace nanogenomic and nanomedical research.

Your Turn...

We've only pointed to a few of the existing and potential technologies and the corresponding ethical concerns of some people, and that may concern *you*. Hopefully this beginning will inspire you to think of other issues important to you. To explore these and other issues in more detail, see Box 1 for some additional resources.

In addition, you can see what other people think, and weigh in on the discussion of nanotechnology for human enhancement by visit the link to the online discussion given to you as part of your second online New Biology assignment. If you lost that link, email [name] to get it.

Box 1: Learn More about Nanotechnology and Ethics

[Allhoff, Lin, Moor, and Weckert \(2009\)](#) prepared a report for the National Science Foundation that covers a number of the ethical and moral issues and concerns specifically surrounding human enhancement.

Ethics of Human Enhancement:
25 Questions & Answers



In addition, [Understandingnano.com](#) lists some of the ethical questions surrounding nanotechnology in general. It also lists numerous organizations that are thinking about ethical issues related to nanotechnology, and which may serve as a resource for you as you think about the issues for yourself. A screen shot of some of that information is presented below.

Organizations Working on the Ethical Issues of Nanotechnology

Greater minds than mine are hard at work trying to address all the ethical challenges of nanotechnology. Here is a sampling of those groups and their mission statements:

The [Nanoethics Group](#) is a non-partisan organization that studies the ethical and societal implications of nanotechnology. They also engage the public as well as collaborate with nanotech ventures and research institutes on related issues and initiatives.

The [Center for Responsible Nanotechnology](#) (CRN) is a non-profit research and advocacy think tank concerned with the major societal and environmental implications of advanced nanotechnology.

[The International Council on Nanotechnology](#) is an international, multi-stakeholder organization whose mission is to develop and communicate information regarding potential environmental and health risks of nanotechnology, thereby fostering risk reduction while maximizing societal benefit.

[Latin American Nanotechnology and Society Network](#) (ReLANS) intends to create a forum for discussion and exchange of information that follows the process of nanotechnology development in Latin America. To that end, ReLANS will establish links and collaboration agreements with academic institutions, governments and society, intending to examine and evaluate the political, economic, social, legal, ethical and environmental implications of nanotechnologies that are domestically developed, and/or in collaboration with foreign centers and institutions, and imported goods that contain nanocomponents.

Works cited

Allhoff, F. et al. (2009). "Ethics of human enhancement: 25 questions and answers." National Science Foundation. Online at: http://www.humanenhance.com/NSF_report.pdf.

Center for Nanotechnology in Society. "Research and Ideas Highlights." Online at: <http://cns.asu.edu/cns-library/highlights/>

Ernest, H. and Shetty, R." Impact of Nanotechnology on Biomedical Sciences: Review of Current Concepts on Convergence of Nanotechnology with Biology". Online at: <http://www.ece.udel.edu/~baloo/Nanoimpact.pdf>

Foresight Institute. "Human Enhancement and Nanotechnology: A Foresight Institute Policy Brief." Online at: <http://www.foresight.org/policy/brief2.html>

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National Citizen's Technology Forum. "Human Enhancement, Identity and Biology." Online at: <http://www4.ncsu.edu/~pwhmds/BackgroundMaterials.pdf>.

People Daily. "China Develops Artificial Bone with Nanotechnology." March 29, 2003. Online at: http://english.peopledaily.com.cn/200303/29/eng20030329_114210.shtml

The Project on Emerging Nanotechnologies. "Perspectives." Online at: <http://www.nanotechproject.org/topics/perspectives/>

Seeman, N. C. (2003). "DNA in a material world." *Nature*, 421, 427-431. Online at: <http://tinyurl.com/28msqfk>

Wilson, D. S. (2010). "Orally delivered thioketal nanoparticles loaded with TNF- α -siRNA target inflammation and inhibit gene expression in the intestines." *Nature Materials*, Nature Materials Web site. Online at: <http://www.nature.com/nmat/journal/vaop/ncurrent/full/nmat2859.html>.

Videos

[Deepening Dialogue: Debating Nanotechnology's Responsible Development](#)

<http://www.youtube.com/watch?v=2AKUBwCWhiA>

[Nanotechnology, what's that?!](#)

http://www.sciencedaily.com/videos/2006/0611-nanotechnology_whats_that.htm

[Nanotechnology takes off](#)

www.kqed.org/quest/television/view/189

[To Upgrade is Human](#)

http://www.ted.com/talks/gregory_stock_to_upgrade_is_human.html

Web pages

[National Nanotechnology Initiative](#)

<http://www.nano.gov/>

[Understanding Nanotechnology: Ethics and Technology](#)

www.understandingnano.com/nanotechnology-ethics.html

[Human Enhancement and Nanotechnology](#)

<http://www.foresight.org/policy/brief2.html>

[Nanotech Now: Your Gateway to Everything Nanotech](#)

www.nanotech-now.co

4.2.2. Prompting engagement

Some students were randomly assigned to view prompts designed to stimulate critical thinking throughout Assignment 2. These prompts, and the corresponding instructions from the non-critical thinking condition, are reproduced below.

Critical Thinking Condition Prompts

The following prompts were included throughout Assignment 2 for those students randomly assigned to the Critical Thinking condition.

Prompt 1. Put on your Thinking Cap!

Because nanotechnology is a relatively new area and many people do not know much about it, we've prepared a brief introduction.

But don't let the background information that you are about to read limit or replace your own critical thinking about nanotechnology and human enhancement. When it comes to providing useful answers to questions about the future of nanotechnology, the more critically you have analyzed the various options, the better.

Critical thinking is one of the challenges of public engagements, because it requires a lot of hard mental work. Throughout this document, watch for links to additional information that you may want to consider as you weigh the options, and "Tips for Critical Thinking" to help you practice critical thinking skills as you read.

Prompt 2. TIP for Critical Thinking: Detecting Bias

Your goal is to provide useful input on the future of nanotechnology. To provide useful input on the future of nanotechnology, you need to be able detect and see past biased presentation of information.

As you read about nanotechnology—especially as you visit the links to additional information that are provided—look for signs of bias. Signs of bias include:

- Selective use of adjectives and examples

- Strong, persuasive language

- Presentation of only one perspective on an issue

If mostly positive or negative adjectives are used, or if mostly (or exclusively!) positive or negative examples are given, then ask yourself how someone with a different viewpoint might describe the same "facts." Although such examples do not guarantee bias, they do suggest the possibility the author is giving a one-sided perspective on something that may be less clear-cut. You may want to do some of your own research to see how others are describing the same topics.

Below, give one example of bias that you see in the background information so far -- or in links that you visited -- and indicate the changes that would be needed to make the information or source less biased.

Prompt 3. TIP for Critical Thinking: Consider the Quantity and Quality of Evidence

In the above text (and links you visit), consider the claims that are made. Ask yourself: What is the evidence for the claims that are being made?

Keep in mind that good evidence:

- Will be relevant. For example, if one claims that something is expensive, one needs to give evidence of

its price, not refer to the numbers of people who use it (which would instead support a claim about wide use, not cost of use).

Will be accurate. For example, it will be typical evidence--there will not be a lot of other evidence that would contradict the evidence presented. A short cut for looking for accurate information is to look for a credible source.

Will be sufficient. Is there sufficient evidence that the claim is true? Or are the claims made based on only a little evidence?

Below, give one example of a claim made above (in the text or a link that you explore) that you think is poorly supported, OR one example of a claim that is well-supported.

For the claim, explain why the evidence for the claim is good, or not very good.

For example, is the evidence relevant? Accurate? Typical? And/or sufficient?

Prompt 4. TIP for Critical Thinking: Consider the Bases of Arguments

Next week you will take what you've learned about nanotechnology, and use it to think about some potential ethical scenarios. One problem with ethical scenarios is that they typically involve shades of grey and controversy. Understanding the bases of different arguments can help you sort through the controversy, gain a clearer understanding of why people disagree, and form your own perspective and clearly articulate why you hold it.

Consider the claims that are made by different perspectives above and especially the points of disagreement. If two perspectives disagree, do they disagree because they disagree on

The facts? This is a disagreement over whether certain claims are accurate.

Or values? This is often a disagreement over which claims are most important.

Examine the issues and arguments above and describe one place where people seem to disagree on the facts and one place where they seem to disagree on values.

Describe the disagreements and what facts or values they disagree on. Then describe your opinion.

Which facts do you think are true and why? What values match your values?

Non-Critical Thinking Condition Prompts

The following prompts were included throughout Assignment 2 for those students randomly assigned to the Non-Critical Thinking condition.

Prompt 1. Get Ready to Explore!

Because nanotechnology is a relatively new area and many people do not know much about it, we've prepared a brief introduction.

But don't let the background information that you are about to read limit or replace your own exploration of nanotechnology and human enhancement. When it comes to providing useful answers to questions about the future of nanotechnology, the more you can learn about the topic, the better.

Prompt 2. Explore and Reflect

Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links.

You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!

Prompt 3. Explore and Reflect

Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links.

You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!

Prompt 4. Explore and Reflect

Below, give 1-2 interesting or surprising things that you learned by reading the information above or by visiting the links.

You can also help us improve these assignments by giving us suggestions for interesting ideas that you think should be included or excluded from the main text. All suggestions are welcome!

4.2.3. Lecture Outline

Note: The lecture was approximately the same each semester of the study.

Science and Regulation: History

Presented by Alan Tomkins

I. Opening Question:

- Many scientists believe government has no role in overseeing the scientific enterprise. It would stymie innovation and retard advancement. Agree?

Interactive Question#1

Many scientists believe government has no role in overseeing the scientific enterprise. It would stymie innovation and retard advancement.

- a. *Agree*
- b. *Disagree*
- c. *No opinion*

II. Survival studies

- Nazi survival study

Interactive Question#2

What do YOU think of the survival study? Choose the item that BEST reflects your view.

- a. *Although the study was unethical, the benefits of what was learned outweighed the harm to the few participants of the study.*
- b. *It is always unethical to collect data that would harm participants in this way, and such studies should not be done regardless of the benefits that could be accrued.*
- c. *This was an unethical study, primarily because the participants were forced to partake in the study and did not give their consent.*

III. Science is a reflection of society, not something apart from it.

A lesson learned well from the research of the 19th century (Mismeasure of Man, Stephen Jay Gould).

- Plessy v. Ferguson
- Eugenics Science: The idea that one can improve the human race by careful selection of those who mate and produce offspring

IV. Should science be regulated?

A Parade of horrors in US

- Tuskegee syphilis studies
- Milgram
- Willowbrook

V. If science should be regulated, how should it be?

Congress in the 1970s asked for a thoughtful examination. Result: Belmont Report.

- Science not to take place without oversight.
- IRB, to include
 - Peer review
 - Public input
 - Usually clergy, but sometimes ethicist, member of the public advocate
 - Scientific concern, but ultimate acceptance of IRB

VI. Science is part of society

- What about public role in overseeing? Answer from the 1970s on is “Yes”. For example...
 - Health/Sexuality
 - Birth control and abortion
 - Use of fetuses
- Fast moving science: Balance advances versus the interest of societal oversight
 - Genome Project
 - Political and public concerns
 - ELSI (Francis Collins, now NIH head)
 - Big Success: One aspect of the success, public involvement

Interactive Question#3

What do you think of genetically modifying salmon by combining the genes of salmon with the genes of humans?

- a. Agree
- b. Disagree
- c. No opinion

Interactive Question#4

What about genetically modifying crops to make them drought tolerant or able to withstand pests?

- a. Agree*
- b. Disagree*
- c. No opinion*

VII. The Case of Nanotechnology

- Congressional mandate for ELSI
- Specific call for public involvement
 - Q: Types of Involvement?
 - A: New forms
- What works & why?
 - Our research and students' role in it: Learning about features of PP
- What else might it mean?
 - Substantive information about NT
 - Learning about providing public input
 - Contribute to our work
 - Asking attitude and knowledge Qs

Interactive Question#5

Define eugenics:

- a. The idea that one can improve the human race by careful selection of those who mate and produce offspring.*
- b. You-tube videos of genetics lectures*
- c. The study of European gene lines*

4.3. Appendix C—Assignment 3 Materials

APPENDIX C:

STUDY 5

SCENARIOS AND MODERATOR SCRIPT/FORM

[Due to formatting constraints, document begins on next page]

GROUP EXERCISES:

1. Please open up the assignment at URL (each group moderator will have a URL to give and should know what the small group number is) and put in your information (name, reci, small group number, group leader/moderator)
2. Give purpose and overview:
 - a. “The purpose of the discussion today is to help you shape your own attitudes towards human enhancement and articulate those attitudes as a proposed law. In the past, many students have found it helpful to hear what their classmates think about these issues.”
3. Your role:
 - a. FOR NOTE-TAKERS: My role is to introduce a few scenarios for you to consider and take notes during the discussion.
 - b. FOR ACTIVE MODERATORS: My role is to help guide today’s discussion. To that end, I will be introducing a few scenarios for you to consider and discuss.
4. TASK 1: Write the Law
 - a. On your printout for Assignment 2 that you brought today, you have record of what you said was your opinion about “when, or to what extent should it be legal to use nanotechnologies for human enhancement?” (e.g., you may have said, never, always, or somewhere in between). Our first task is to type out one or two sentences that describe what kind of law (or laws) you think should be passed in regards to human enhancement? A law describes under what specific situations such enhancement should be allowed and restricted.”
 - b. (Give only 2 min to write the law)
 - c. Please press “next” at the bottom of the assignment page when you are done.
 - d. Did everyone go to the next page? (PLEASE DO ask this and get a “yes”... otherwise they may not go on.
5. As you can see on the next page of your assignment, the law you wrote is there. Next, we are going to discuss these – please do feel free to edit the law you wrote – expand it, change it, add to it and so on, during the discussion.
6. Share
 - a. Ok, next, please go around and share both the rating that you gave on the always to never scale in Assignment 2, and the law that you wrote.

7. Discuss

- a. Now that you've heard each others' laws, what are your reactions?

ASSESSMENT:

Which of the following topics came up?

☐ Autonomy	☐ Tech. Comp.	☐ Morals	☐ Reg. Limit
☐ Econ Ben	☐ Econ Risk	☐ Env. Ben	☐ Env. Risk
☐ Superppl ben	☐ Superppl risk	☐ Health Ben	☐ Health Risk
☐ Defense Ben	☐ Defense Risk	☐ Uneql access	☐ Genetics Gap
☐ Abuse	☐ Overpop	☐ Privacy	

NOTE-TAKERS SELF CHECK:

8. *As needed, introduce the following hypotheticals to keep discussion moving forward. Students should consider whether each scenario changes their opinion regarding the appropriate human enhancement law. It is not necessary to get through all of the scenarios. Only move on to a new scenario if discussion seems to peter out on the last.*

"Now we're going to consider a few hypothetical future scenarios and whether these would have any effect on how you would write your law."

ACTIVE MODERATORS

I. BRAINSTORMING

- o Does anyone have a different view?
- o Does anyone want to suggest other considerations?
- o What are some concerns people might consider in deciding what ought to be done with this technology?
- o [Summarize]

II. ANALYSIS

- o What are some of the pros and cons that might be associated with this technology?
- o What if you were personally involved with these issues? How might your perspective change?
- o What would someone who disagrees with you say?
- o What are some potential second-order effects from this technology?
- o [Summarize]

III. SYNTHESIS

- o It might be helpful now to try to get a broad picture of what people agree on and disagree and why. Would anyone be willing to try to summarize what they see as the agreements and disagreements?
- o Are there any trade-offs that we need to consider? If we do [insert suggestion from the group here], will that prevent us from doing something else that we might consider desirable later on?
- o [Summarize]

SCENARIO 1: “Assume that scientists have developed a way to improve human memory. This discovery has the potential to cure Alzheimer’s. It may also enable some people to develop a super-human memory. Under what circumstances, if any, should this technology be restricted?”

ASSESSMENT:

Which of the following topics came up?

☐ Autonomy	☐ Tech. Comp.	☐ Morals	☐ Reg. Limit
☐ Econ Ben	☐ Econ Risk	☐ Env. Ben	☐ Env. Risk
☐ Superppl ben	☐ Superppl risk	☐ Health Ben	☐ Health Risk
☐ Defense Ben	☐ Defense Risk	☐ Uneql access	☐ Genetics Gap
☐ Abuse	☐ Overpop	☐ Privacy	

NOTE-TAKERS SELF CHECK:

ACTIVE MODERATORS

I. BRAINSTORMING

- o Does anyone have a different view?
- o Does anyone want to suggest other considerations?
- o What are some concerns people might consider in deciding what ought to be done with this technology?
- o [Summarize]

II. ANALYSIS

- o What are some of the pros and cons that might be associated with this technology?
- o What if you were personally involved with these issues? How might your perspective change?
- o What would someone who disagrees with you say?
- o What are some potential second-order effects from this technology?
- o [Summarize]

III. SYNTHESIS

- o It might be helpful now to try to get a broad picture of what people agree on and disagree and why. Would anyone be willing to try to summarize what they see as the agreements and disagreements?
- o Are there any trade-offs that we need to consider? If we do [insert suggestion from the group here], will that prevent us from doing something else that we might consider desirable later on?
- o [Summarize]

SCENARIO 2: “Assume that, sometime in the future, Mr. and Mrs. Vanderbilt decide they would like to have a baby. Both parents have the genetic markers for Cystic Fibrosis. Their doctor informs them that for \$250,000 he can, through the use of nanogenetics, ensure that their baby is born without Cystic Fibrosis. The Vanderbilts can afford this, but can’t agree on whether they should. Mrs. Vanderbilt favors any kind of intervention that may keep their future children healthy. ‘Protecting our children from suffering is a moral obligation,’ she argues. Mr. Vanderbilt, however, opposes any technology that can manipulate human genetics. He worries that while this technology might help his child, it will eventually be misused so that parents can engineer their children for superficial reasons. What do you think about this scenario? How should the law treat this technology?”

ASSESSMENT:

Which of the following topics came up?

☐ Autonomy	☐ Tech. Comp.	☐ Morals	☐ Reg. Limit
☐ Econ Ben	☐ Econ Risk	☐ Env. Ben	☐ Env. Risk
☐ Superppl ben	☐ Superppl risk	☐ Health Ben	☐ Health Risk
☐ Defense Ben	☐ Defense Risk	☐ Uneql access	☐ Genetics Gap
☐ Abuse	☐ Overpop	☐ Privacy	

NOTE-TAKERS SELF CHECK:

I. BRAINSTORMING

- o Does anyone have a different view?
- o Does anyone want to suggest other considerations?
- o What are some concerns people might consider in deciding what ought to be done with this technology?
- o [Summarize]

II. ANALYSIS

- o What are some of the pros and cons that might be associated with this technology?
- o What if you were personally involved with these issues? How might your perspective change?
- o What would someone who disagrees with you say?
- o What are some potential second-order effects from this technology?
- o [Summarize]

III. SYNTHESIS

- o It might be helpful now to try to get a broad picture of what people agree on and disagree and why. Would anyone be willing to try to summarize what they see as the agreements and disagreements?
- o Are there any trade-offs that we need to consider? If we do [insert suggestion from the group here], will that prevent us from doing something else that we might consider desirable later on?
- o [Summarize]

SCENARIO 3: “Suppose that a panel of experts from the American Sports Medicine Association and a group of prominent university athletic directors signed a letter to Congress advocating the use of nanotechnology in creating a class of superior football players. These players would be less vulnerable to the type of head injuries that now affect many athletes. Many athletes and fans object to this idea, arguing that it represents the beginning of a slippery slope towards a new world of sports where athletes are manufactured rather than discovered and molded. Many experts respond that football has proven to be a dangerous and violent sport; and that it’s irresponsible not to take advantage of new technology that promises to enhance player safety. Would these arguments lead to any change in your proposed law?”

ASSESSMENT:

Which of the following topics came up?

☐ Autonomy	☐ Tech. Comp.	☐ Morals	☐ Reg. Limit
☐ Econ Ben	☐ Econ Risk	☐ Env. Ben	☐ Env. Risk
☐ Superppl ben	☐ Superppl risk	☐ Health Ben	☐ Health Risk
☐ Defense Ben	☐ Defense Risk	☐ Uneql access	☐ Genetics Gap
☐ Abuse	☐ Overpop	☐ Privacy	

NOTE-TAKERS SELF CHECK:

ACTIVE MODERATORS

I. BRAINSTORMING

- o Does anyone have a different view?
- o Does anyone want to suggest other considerations?
- o What are some concerns people might consider in deciding what ought to be done with this technology?
- o [Summarize]

II. ANALYSIS

- o What are some of the pros and cons that might be associated with this technology?
- o What if you were personally involved with these issues? How might your perspective change?
- o What would someone who disagrees with you say?
- o What are some potential second-order effects from this technology?
- o [Summarize]

III. SYNTHESIS

- o It might be helpful now to try to get a broad picture of what people agree on and disagree and why. Would anyone be willing to try to summarize what they see as the agreements and disagreements?
- o Are there any trade-offs that we need to consider? If we do [insert suggestion from the group here], will that prevent us from doing something else that we might consider desirable later on?
- o [Summarize]

SCENARIO 4: “Suppose that an international panel of experts gathered by the UN to study population growth endorsed a global ban on the use of human enhancement to cure life-threatening diseases. Their proposal suggests this development would produce such cheap and effective treatments that many countries would be overwhelmed by a population explosion. An opposing group of experts signs a letter objecting to these conclusions. They argue that the same case could have been made against any previous development in health care or sanitation, and that it’s a violation of basic human rights to deny people access to needed medical care. Would these arguments lead to any change in your proposed law?”

ASSESSMENT:

Which of the following topics came up?

☐ Autonomy	☐ Tech. Comp.	☐ Morals	☐ Reg. Limit
☐ Econ Ben	☐ Econ Risk	☐ Env. Ben	☐ Env. Risk
☐ Superppl ben	☐ Superppl risk	☐ Health Ben	☐ Health Risk
☐ Defense Ben	☐ Defense Risk	☐ Uneql access	☐ Genetics Gap
☐ Abuse	☐ Overpop	☐ Privacy	

NOTE-TAKERS SELF CHECK:

ACTIVE MODERATORS

I. BRAINSTORMING

- ☐ Does anyone have a different view?
- ☐ Does anyone want to suggest other considerations?
- ☐ What are some concerns people might consider in deciding what ought to be done with this technology?
- ☐ [Summarize]

II. ANALYSIS

- ☐ What are some of the pros and cons that might be associated with this technology?
- ☐ What if you were personally involved with these issues? How might your perspective change?
- ☐ What would someone who disagrees with you say?
- ☐ What are some potential second-order effects from this technology?
- ☐ [Summarize]

III. SYNTHESIS

- ☐ It might be helpful now to try to get a broad picture of what people agree on and disagree and why. Would anyone be willing to try to summarize what they see as the agreements and disagreements?
- ☐ Are there any trade-offs that we need to consider? If we do [insert suggestion from the group here], will that prevent us from doing something else that we might consider desirable later on?
- ☐ [Summarize]

9. "Discussion time is now up. Please use the space provided on your online survey to write a short essay containing your revised law and a discussion of any changes you decided to make. If you were influenced by anything you heard in this discussion, please make a note of that. If you found a particular argument interesting or challenging, but ultimately decided you disagreed with it, please take note of that as well. When you are finished writing your essay press 'Next' so that you can complete the final part of this assignment."

Group Discussion Data Entry

Initial Questions:

Group #: _____ Reci Instructor: _____

Your (Moderator) Name: _____ Reci #: _____

Date: _____ Day of week: *Tues Wed Thurs* Time Start _____

Discussion: _____

What "condition" is this group in? Circle one: Active Mod or Note Taker

First names and Last Initials of group members:

Number of Males: _____ Number of females: _____ Total number: _____

To what extent did the student discussion stay "on topic"?	Not at all	About a quarter of the time	About half the time	Most of the time	All of the time
How <u>interested/engaged</u> did they seem to be in or with the discussion?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
How <u>controversial</u> was the topic of discussion? That is, how much did it spark debate or disagreement?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
To what extent did students give <u>evidence</u> for their views? (e.g., because the background document said...)	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
To what extent did they <u>evaluate</u> the evidence available or challenge it? (e.g., its accuracy or relevance)	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
To what extent did students explicitly talk about <u>bias</u> ?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
To what extent did students seem to <u>acknowledge</u> different perspectives? (e.g., "I can understand that some people might think that....")	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely

