

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, contact Lisa M. PytlikZillig at lpytlikz@nebraska.edu.

Study 4 Detailed Methods¹

1. Study Overview

Study 4, conducted in the spring of 2012, used experimental methods to examine the effects of (1) critical thinking prompts and (2) organization of information (both during reading activities), as well as (3) peer discussion during group discussion activities.

Study 4 built on Study 3 by altering the training of the moderators so that, during Assignment 3, they guided the discussion in a manner that was consistent with the condition that participants had been assigned during the reading. Thus, moderators who were facilitating discussion among students who were in the critical thinking group tried to prompt critical thinking using the prompts that students had seen during their reading. Moderators who were facilitating discussion among student who were in the control group asked for clarification and prompted additional contributions from group members but did not explicitly attempt to promote critical thinking. Likewise, A3 materials were somewhat customized to the conditions that students had been in A2. As in our other studies, we examined impacts of our manipulations on engagement, knowledge gains, and attitudes toward nanotechnology as well as toward deliberation. However, to see if we could encourage greater consideration of opposing views in student deliberation about their own views, students were explicitly asked to consider opposing views at pre and post.

2. Methods

2.1. Participants

Participants were 205 students (57.1% female) enrolled in a freshman-level introductory biology course at the University of Nebraska-Lincoln during the spring semester of 2012. The average age of participants was 19 (SD=2 years), with ages ranging from 17 to 36 years old. Participants included primarily first (60%) and second (27%) year students, and fewer students in their third (10%) or fourth

¹ Any statistics reported in this document can be reproduced using the Study 4 Methods SPSS syntax and Study 4 data set. The syntax generally follows the order of this report but may include additional analyses not reported here.

years (or beyond) (4%). The majority of students (79%) came from science-related majors, with Biological Science (23%) and Pre-Med (16%) having the most representation. Ten percent of the participants did not answer the political party question. Of those answering, the plurality of participants reported an affiliation with the Republican party (47%), while 28% reported an affiliation with the Democratic party and 26% identified as independent or other.

2.2. Participant Recruitment and Consent

All of the activities described here were part of course requirements. However, students could choose whether or not to allow researchers to use their data in the research. Prior to activities relevant to this study, at approximately mid-semester, students were informed that the researchers wished to examine different methods of engaging people with ethical, legal and social issues (ELSI) topics in 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 219/238 (92%) 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: 85% (191 of 226) of those present indicated their willingness to participate at that time, including 183 who had given consent at the beginning of the activities, and 6 additional persons who had not given consent in Assignment 1; but omitting 22 students who had given consent during Assignment 1 and retracted that consent during Assignment 4.² The final participants were 205 students out of an estimated 242 students in the course (85%). This included participants who gave consent to use their data in the last assignment ($n=191$), and those who were missing data at the last assignment but had given consent during the first assignment ($n=14$).

2.3. Research Design Overview

The study consisted of a series of four assignments completed over the course of four weeks, each of which 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 opportunities to offer opinions about hypothetical ethical scenarios involving application of nanobiological technologies. Repeated measures were used to assess student knowledge and attitudes throughout the exercises.

Assignments also included experimental manipulations of factors that commonly vary between different public engagement activities. The experimental design used in this study was very similar to that used in Study 3. Specifically, assignments 1 (A1) and 4 (A4) did not include any experimental manipulations. A1 was designed to measure a variety of existing attitudes, prior knowledge, and demographics. A4 was designed to measure a variety of post-engagement attitudes, knowledge, and outcomes. As with Study 3, Assignment 2 (A2) required students to complete an online assignment in which they read a background document pertaining to applications of nanotechnology with a focus on nanogenetics and nanomedicine. 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 (organization 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

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.

the information was presented in a format consistent with National Issues Forum procedures of presenting competing viewpoints or a more traditional newsletter approach (organization factor). The specific prompts and documents used varied slightly from those used in Study 3.

The main difference between Study 3 and this Study 4 was that, in Assignment 3 (A3), prompts were added to accentuate the A2 conditions. As in Study 3, students were asked to consider hypothetical future scenarios involving the ethical implications of nanotechnology. Using a 2-group between-group design, students were randomly assigned either to complete this condition alone or to complete it as part of a small group of peers, with each peer group being homogenous in respect to the conditions used in Assignment 2. In addition, however, the A2 formatted materials were made available in hard copy and prompts were included in A3 to extend the cognitive manipulations.

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 online materials/surveys and measures used in each assignment are included as Appendix A. The procedures used in Study 4 were largely identical to those used in Study 3 except where noted below.

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

A1 was homework assigned in the middle of the semester which consisted of questions regarding their own demographic characteristics, their previous *experience* with and *knowledge* of issues related to ELSI and nanotechnology, their *attitudes* towards nanotechnology as well as the scientists who study it and the policymakers who regulate it, and a variety of individual traits such as *need for cognition*, *dispositional trust* and *deliberative values*.

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

A2 was assigned one week after A1. This second assignment presented a background document on nanotechnology and ELSI issues in science. The materials concerning nanotechnology included peer-reviewed information suggested by the nanoscientists consulted for the project as well as information from other resources. Also included were numerous links to sources of additional information. 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 (organization 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 organized in a “dueling perspectives” or topical manner (organization factor). 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.

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 (in addition to providing two of the four possible versions of A3 in Appendix A, we extracted the two types of prompts and the two versions

of the reading material, and present these in Appendix B). Note that, for those students that received these prompts in Assignment 2, prompts were also provided during the hypothetical scenario exercises in Assignment 3, as discussed next.

Information organization factor. Students were randomly assigned to either a “traditional” or “National Issues Forum” (NIF) format of the portion of the background reading concerning ELSI. Those who were assigned a traditional format read a list of potential ELSI concerns such as “unforeseen risks” and the “right to autonomy,” which included descriptions of arguments for why these may or may not be an issue for future nanotechnology research. Those in the NIF condition read the same information presented as two conflicting perspectives: the “Human Enhancement as ‘Human Progress’” approach and the “Human Enhancement as ‘Unnecessary Risk’” approach. As previously noted, these two versions of the reading material are extracted from the Appendix A versions of A2, and presented in Appendix B for easy finding.

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.)

2.4.3. Assignment 3 (A3): Consideration of Ethical Scenarios (2x2 design).

Note that the procedures for A3 were very similar to Study 3, with a few exceptions. First, two additional scenarios were added to be considered (students read through as many scenarios as they had time for). Also, the Biofinity online forum was dropped in Study 4, and so all students participated in A3 in-person during class. Specifically, a week after receiving the reading assignment, students were asked to consider a series of hypothetical future ethical scenarios during their normal recitation period. The two experimental conditions employed during this assignment concerned whether students completed the assignment alone or as part of a small group, and a continuation of the critical thinking manipulation from A2.

Social context conditions. Students were randomly assigned to work on Assignment 3 either alone or in a group of three to six of their peers, with each group led by an outside moderator trained by the research team. In the small groups, the moderators asked students to briefly discuss their reactions to each scenario. The moderator introduced each of the four hypothetical future scenarios one at a time. After discussing each scenario with their peers, students were asked a series of questions to assess their thoughts about the ELSI concerns that were raised and their use of various sources of background information. The moderators also completed questions about group processes after discussion of each topic (see Appendix C for form).

Critical thinking conditions. In addition, those who had been randomly assigned to be in the critical thinking condition in A2, continued to be in that condition in A3. A3 moderator training and

assignment materials were customized to use condition appropriate critical thinking or control prompts. Whereas in Study 3 students in the critical thinking condition were given tip sheets for critical thinking, in this study the tips were embedded into the online assignment. For example, the A3 instructions preceding the ethical scenarios in the critical thinking condition included instructions to “remember to evaluate the evidence of different points of view. Is the evidence relevant or strong enough? Is there enough evidence? Keep an eye out for bias. Are some points of view more driven by values than others? Also try to think of any details relevant from when you read the background document, and incorporate those into your responses.” These instructions were not included in the A3 control (non-critical thinking) condition (see Appendix C for A3 materials).

Other procedures. In all conditions, students considered various ethical scenarios related to nanotechnology. Some of the scenarios presented were taken from prior research efforts. In all conditions, the scenarios were introduced with the following instructions:

The following are FICTIONAL potential FUTURE scenarios. Please write your responses to the scenarios.

IMPORTANT NOTE: Some of the scenarios include things commonly said by people reacting to nanotechnology. These are NOT necessarily FACTS. It is your job, as you reflect on what the fictional people say, to determine if it is likely true or false, and the extent to which you agree with it. Use your background document that was provided to you, and any additional materials or your own research, to make these determinations.

Besides the “improving human memory development” and “cystic fibrosis” scenarios from Study 3, students also considered a scenario, titled “barless prisons,” in which they were asked to consider a hypothetical drug containing nanoparticles that can be activated using radio controls to control imprisoned criminals. This was always the first scenario considered. Another scenario, titled “healthy chip,” described smart nanodevices that work as a network to monitor the body and deliver medicines (e.g., insulin) as needed. This scenario was considered after the cystic fibrosis scenario and before the memory development scenario (see Appendix C for complete scenarios and moderator guidance.)

After they were finished considering the scenarios, 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, if they were in small groups, their assessment of overall *group dynamics*.

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

Assignment 4: 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. 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

The next sections present descriptions of all of the measures included throughout this study. A full set of the materials and measures used in each assignment are included as Appendix A.

2.5.1. Knowledge and Experience

Subjective knowledge. At four time points, in Assignments 1, 2 (pre and post), and 4, three questions were asked and averaged ($\alpha = .89-.92$) to assess participants' subjective knowledge regarding nanotechnology. 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."

Subjective learning. Students were also asked to assess whether and how much they learned about nanotechnology from completing A2. They were asked: "How much do you feel you learned about nanotechnology as a result of working on this assignment?" with a scale of five responses ranging from "nothing that I didn't know before" to "a great deal." In A4, they were asked a similar question accompanied by the same response scale: "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?"

Objective knowledge. A series of objective knowledge questions were used to measure knowledge and learning throughout the study. 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. As described next, certain questions were answered multiple times (e.g. at A1 and A4, or pre and post A2). (See Appendix A, Assignment 1, for all items; see also Appendix A Compiled measures.)

In A1, knowledge questions included four questions with a multiple choice format and five with a true/false format. Furthermore, each knowledge question was followed by a measure of confidence in one's answer (e.g., "Please indicate how confident you are in your answer..." or "I am _____ confident in my answer"; 1=not at all, 2=a little bit, 3=moderately, 4=mostly, 5=completely). Examples of multiple choice questions include "What is genetic engineering?" and "How many nanometers are in one meter?" Examples of true/false questions included statements such as "Materials are harmless at the macro-level could be harmful at the nano-level" (true) and "All nanoscale materials can conduct electricity because their extremely small size" (false). The true/false questions were presented in a randomized order.

In A2, prior to reading the background document on nanotechnology, students were randomly assigned to one of two sets (set A or set B) of eight true/false questions. Examples of these items include "Breakthroughs in nanogenomics already allow very wealthy parents to manipulate the intelligence of their children" (false) and "The 'second order' effects of nanotechnology can be accurately predicted from 'first order effects'" (false). Once again, each knowledge question was followed by a measure of confidence in one's answer as was the case in A1.

At the end of A2, students were asked to revisit the four multiple choice questions from Assignment 1 (plus one additional question original to this assignment) as well as the same eight questions they completed before reading the background document (i.e., set A or set B). Once again,

each knowledge question was followed by a measure of confidence in one's answer as was the case in A1.

In A4, students were asked to revisit the five multiple choice questions used at the end of A2. They were then asked a set of 25 true/false questions, including the five introduced in A1 and those introduced during A2 (*both* set A and set B), as well as some new questions that none of the students had seen before (set D). Once again, each knowledge question was followed by a measure of confidence in one's answer.

Note that because a randomly selected half the students saw "set A" true and false questions only in A4 but saw "set B" multiple times; and the other half the students saw "set B" true and false questions only in A4 but saw "set A" multiple times our design makes it possible to gauge the extent to which additional knowledge gains come from seeing a question multiple times rather than only after information is presented.

2.5.2. Attitudes toward Nanotechnology and Attitude Change

Repeated single item measures. Two attitude questions were asked in Assignment 1, and then repeated in Assignments 2, 3 and 4. The first question asked students, "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?" Students selected responses from a seven-point scale ranging from "the risks greatly outweigh the benefits" to "the benefits greatly 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).

The second item asked students "In your opinion, how much regulation is needed with respect to nano-biological research and development?" Students 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.

Self-reports of opinion change and likelihood of opinion change. In Assignment 1, after each of the two repeated attitude items (relating to the risk-to-benefit ratio, and to the need for regulation), students were asked to assess "In your estimation, as you become more knowledgeable about nano-biological technologies, how likely are you to change your views about the development and regulations of those technologies?" Responses were recorded on a seven-point scale ranging from "very unlikely" to "very likely."

Also after each of the two attitude items (risk/benefits and need for regulation) were repeated in Assignments 2 and 4, students were asked "During this assignment" (A2) or "Overall, from the time you began these exercises, until now" (A4), to what extent did you change your mind..." (e.g., "about the risk/benefits question above?").

Finally, in A3, students were asked to consider both of the attitude items at once and to rate: "Overall, from the time you began these exercises, until now, to what extent did strengthen your original opinions about the questions above?" and "Overall, from the time you began these exercises, until now, to what extent did you change your mind about the questions above?" For these items, the five point response scale ranged from "not at all" to "a great deal."

During A4, students were also asked about the extent to which they changed their attitudes toward policy makers and the extent to which they changed their attitudes toward nanoscientists. For these items, the five point response scale ranged from "not at all" to "a great deal."

Also during A4, students were asked, after each of the two contrasting perspective essay questions "Overall, from the time you began these exercises, until now, to what extent did you change your mind about the... question above?" Again, the five point response scale ranged from "not at all" to

“a great deal.”

General attitudes toward nanotechnology. In Assignments 1 and 4, students were presented with six general goals of nano-biological research and development and asked to assess each on a five-point scale ranging from “unimportant” to “extremely important.” Examples of these items included the statements “minimizing potential risks for humans,” “minimizing potential environmental risks,” and “studying the social and ethical impacts and implications of future developments and regulations.” Factor analyses suggested the items comprised one factor at A1 and two factors at A4. If the items were combined into a single scale, the reliability of the scale also reduced from A1 to A4 ($\alpha = .72$ to $.65$).

After these rating items, students were then asked to consider the finite resources that are available for such goals, and asked to ascribe to each some percentage of resources dedicated to nanotechnology regulation and development to each goal (with the sum of all goals equaling 100%). They were instructed to give their top priorities the largest share of resources.

In Assignment 1 only, students were asked whether they agreed or disagreed with eight statements concerning nanotechnology research and regulation. These items were obtained or adapted from prior research (Hamlett & Cobb, 2006; Scheufele & Lewenstein, 2005). These were divided into two subscales. Responses fell on a seven-point Likert scale ranging from “strongly disagree” to “strongly agree.” To create the *Risks/Concerns subscale*, three items were averaged to measure the extent to which students felt the risks associated with nanotechnology were significant ($\alpha = .71$). These included “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;” and “Due to the fact that some have expressed strong concern about nanotechnology's risks, we should have a world ban on new nanotechnology products.” To create the *support/pro-nanotechnology subscale*, two items were averaged to measure the extent to which students felt the benefits associated with nanotechnology were more significant than potential risks ($\alpha = .61$). These included “We should develop nanotechnology at full speed despite its possible risks, in order to keep the U.S. from falling behind other countries” and “There are serious ethical problems associated with not quickly developing nanotechnologies.”

Two items were not included in the subscales above and assessed the extent to which students trusted certain authorities to effectively manage the risks and promote the benefits associated with nanotechnology. These included “The government will effectively manage any risks associated with nanotechnology” and “Scientists working with nano-biological technologies will develop them in directions that are positive for society.” These items did not appear to make a reliable scale.

Likelihood/Importance of specific risks and benefits. In Assignments 1 and 4, students 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 include “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.” The second, concerning importance, was a seven-point scale ranging from “very important to AVOID” to “very importance to ACHIEVE,” with “NOT IMPORTANT to avoid or achieve” representing the midpoint (coded as -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). These items were then composited by multiplying the scores for likelihood and importance, and then averaged to create two sub-scales. One scale comprised of 6 items ($\alpha = .74, .79$ for A1 and A4 respectively) reflecting the *importance of various benefits of*

nanotechnology (disease cures and economic benefits). The second scale included 6 items (α s = .74, .79 for A1 and A4 respectively) reflecting [low] avoidance of various risks (e.g., economic disruption, widened gap between the rich and the poor).³

2.5.3. Familiarity with and Trust and Confidence in Nanoscientists and Policymakers.

Familiarity with nanoscientists. In A1 and A4, students were asked three questions designed to assess their familiarity with nanoscientists (A1, α = .70; A4, α = .70). Examples of these items include “How much do you know about nanoscientists?”; “To what extent have you had experiences or interactions with nanoscientists?” and “To what extent do you feel certain in your views about nanoscientists?” Responses were recorded on a five-point scale ranging from “not at all” to “a great deal.”

Familiarity with policymakers. In A1 and A4, students were asked three questions designed to assess their familiarity with policymakers (A1, α = .77; A4, α = .78). These questions included “How much do you know about policy makers who regulate nanotechnology?”; “To what extent have you had more experiences or interactions with policy makers?” and “To what extent do you feel certain in your views about these policy makers?” Responses were recorded on a five-point scale ranging from “not at all” to “a great deal.”

Confidence and perceived trustworthiness/distrustworthiness of nanoscientists. In A1, students were asked a series of 11 questions to determine their level of confidence in nanoscientists as a group. In A4, students completed a short scale comprised of only three of the original 11 items. These items were created based on prior reviews of trust and confidence measures (PytlikZillig et al., 2016). These items were then averaged to create a scale of *confidence in nanoscientists to do their jobs* (A1 all items, α = .93; A1 repeated items, α = .85; A4 repeated, α = .86). Each question began with the phrase “To what extent do you have confidence in nanoscientists to...” Examples of these items include “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.”

In A4, students were also asked a series of six questions to determine their perception of nanoscientists’ trustworthiness or distrustworthiness. The stem for these items was “To what extent do you feel nanoscientists probably...” Responses were recorded on a five-point scale ranging from “not at all probable” to “very probable.” Three items were averaged to measure the level of *perceived trustworthiness* of nanoscientists (α = .81). Examples of these items include the statements “...are trustworthy” and “...are fair.” Three items were averaged to measure the level of *distrustworthiness* students perceived in nanoscientists (α = .61). These included the statements “...are primarily motivated by what will benefit them personally,” “...don’t really care about the long-term risks of their decisions” and “...are dishonest.”

Confidence in policymakers. In A1, students were randomly assigned one of two groups of questions to determine their level of confidence in policymakers as a group. In set A, each of 11 questions began with the phrase “To what extent do you have confidence in policy makers who help regulate nanotechnology to...” and included “...do their jobs well?” “...meet their professional responsibilities?” and “...make decisions about the most important directions for future development [of nanotechnology].” These items contained content more specifically relevant to the regulation of

³ In some of the studies, the item concerning human enhancement was kept as a separate single-item measure. In this study we made it part of the benefits scale.

nanotechnology. In set B, 10 more general items were used, and the stem was “To what extent do you feel policy makers who help regulate nanotechnology...” e.g., “are trustworthy” or “are fair” or “...are primarily motivated by what will benefit them personally,” “...don’t really care about the long-term risks of their decisions” and “...are dishonest.” For both sets, responses fell on a five-point scale ranging from “not at all” to “a great deal.” In A4, all students completed only a subset of the original items, including three of original items from set A and six of the items from set B.⁴

2.5.4. Process and policy acceptance

To assess acceptability of policies resulting from experimentally varied public engagement procedures, in A4, students were randomly assigned to read 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, the *pro-nanotechnology* scenario, it was reported that most Americans involved in a public engagement identical to the one the students had engaged in were enthusiastic about nanotechnology, and the government decided to dramatically increase its investment in related research and development. In the second, the *pro-regulation* scenario, it was reported that 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.

Students were then asked after each scenario whether they agreed or disagreed with five statements evaluating the government’s decision-making process (5 items with negative items reversed scored, $\alpha = .86$). Examples of these items include the statements “The process used by the government to make decisions about this issue was fair,” “The government should have used a different process to get public input about this issue” (reversed) and “The government made the right choices with regard to this issue.” Responses fell on a six-point scale ranging from “strongly disagree” to “strongly agree.”

Finally, so that we would know whether the randomly assigned policy/decision scenario was consistent with their preferences or not, participants were asked whether they would favor or be opposed one of two randomly assigned specific policies related to nanotechnology. Use of two similar but different questions was designed to help assess how question wording might be impacting participant responses. The first read “If legislation were being considered that would slow down nanogenomics research and development in the area of human enhancement by decreasing funding and increasing restrictions...” and the second read “If legislation were being considered that would speed up nanogenomics research and development in the area of human enhancement by increasing funding and decreasing restrictions...” After each, students were asked “Would you be FOR or AGAINST such legislation?” Responses fell on a six-point scale ranging from “strongly AGAINST” to “strongly FOR.”

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. Students were also asked to identify whether, on average, they consider themselves an “A, B, C, or D” student, and were asked the highest level of education achieved by both their mother and father.

⁴ Note that a variety of different configurations of scales are given in the syntax file that is paired with this methods section.

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 in Assignment 1 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)?”

A variety of scales were used to assess student individual differences and personality characteristics during A1. Unless otherwise noted, items were accompanied by a six-point Likert scale ranging from “strongly disagree” to “strongly agree.” Each measure is described in greater detail below (for a full list of items contained in each, see Appendix A). In A4, students were asked to complete short versions of several of the scales.

Need for cognition. In A1, a set of seven items were averaged to measure the extent to which students were inclined to invest effort in cognitive activities ($\alpha = .78$). 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 ($\alpha = .68$). These included 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 were averaged to measure a student’s general inclination to trust others ($\alpha = .82$). These items include “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 from the National Opinion Research Center (1994) and the Trust scale included in the International Personality Identity Pool (<http://ipip.ori.org>).

Political efficacy. In A1, a set of four items, and A4, a set of five items, was averaged to measure a student’s evaluation of their own ability to meaningfully participate in the political process ($\alpha = .71, .79$). 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 (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 items in A1 and three items in A4 were averaged to measure the extent to which a student felt motivated to be politically engaged by factors that are *intrinsic* to their concept of self (A1, A4, α s = .83, .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.” The extent to which a student felt motivated to be politically engaged by factors they had internalized from outside sources (*introjected motivation*) was assessed with one item in A1 and two items in A4 (A4 α = .80). These included items such as “I follow political and social issues because it bothers me when I don’t.” The extent to which a student felt motivated to be politically engaged by external factors (*extrinsic motivation*) was assessed with one item in A1 and two items in A4 (A4 α = .82).

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 (α s = .76, .87). These included 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).

2.6.3. Political and religious attitudes

The remainder of the individual difference variables were administered only in A1.

Interest in politics. Two items (α = .74 when averaged) were used to measure the extent of a student’s interest in political issues. 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).

Political ideology. Students 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” and averaged (α = .89). “Prefer not to answer” was also provided as a possible response and treated as missing. These items were based on similar self-assessments used in Rosenstone, Behr, and Lazarus (1996).

Political affiliation. Students 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).

Religiosity. Students 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.

Religious affiliation. Students 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, a scale was generated to measure student engagement during the background reading exercise. This consisted of 34 statements beginning with the phrase “During the assignment, I...” and including, for example, “gave careful consideration to all of the options presented” and “felt open-minded.” Students were asked to indicate the extent to which they agreed with each statement on a five-point scale ranging from “not at all” to “a great deal.” Engagement items are discussed in more detail in PytlikZillig et al. (2013). The items were divided into eight subscales using the method described in that paper. Specific items were given in random order by the survey program, so that items for each of the different forms of engagement were intermixed. The subscales are described in greater detail below. These items were presented at the end of Assignments 2 and 3.

Conscientious engagement. A subscale of four items was used to measure the extent to which students were effortful, careful and thorough in completing the assignment (A2, $\alpha = .79$; A3, $\alpha = .81$). These included the statements “felt focused” and “gave careful consideration to all of the options presented.”

Open-minded engagement. A subscale of three items was used to measure the extent to which students felt open to changing their opinions while completing the assignment (A2, $\alpha = .73$; A3, $\alpha = .78$). 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 used to measure the extent to which students actively engaged with the learning process, as opposed to becoming passive recipients of information (A2, $\alpha = .73$; A3, $\alpha = .75$). 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 used to measure the extent to which students engaged with others about the assignment (A2, $\alpha = .85$; A3, $\alpha = .95$). 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 used to measure the extent to which students attempted to approach the assignment creatively (A2, $\alpha = .84$; A3, $\alpha = .80$). Examples of these items include the statements “used my imagination” and “felt inspired.”

Disinterested engagement. A subscale of six items was used to measure disinterest as a form of disengagement in the learning process (A2, $\alpha = .89$; A3, $\alpha = .90$). 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 five items was used to measure the extent to which students felt angry while completing the assignment (A2, $\alpha = .91$; A3, $\alpha = .92$). Examples of these items include the statements “felt angry” and “found it aggravating.”

Close-minded engagement. A subscale of three items was used to measure the extent to which students felt unwilling to changing their opinions while completing the assignment (A2, $\alpha = .84$; A3, $\alpha = .83$). Examples of these items include the statements “felt like my mind was already made up,” “know 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 the background reading, but before finishing

the items related to engagement and activity evaluations, students were asked to estimate the total time spent on A2 by first estimating the amount of time in minutes spent on reading and exploring information as well as the time spent answering questions and then adding these two estimates together.

A3 resource exploration. After completing the exercises associated with each of the hypothetical scenarios in A3, students were asked “To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question?” (response options ranged from “not at all” to “a great deal”).

2.7.2. Evaluation measures

Background document evaluation. After completing this background reading in A2, 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 ($\alpha = .80$). 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 ($\alpha = .85$). 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 ($\alpha = .71$).

Assignment evaluation. Students were asked to consider the quality of the A2 assignment as a whole, including both the background reading and the subsequent exercises. Specifically, students 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 to...” These included “more clearly articulate my own perspective” and “think critically about the evidence.” Responses were recorded on a five-point scale ranging from “not at all” to “a great deal.” In addition, they were asked to rate “Overall, how useful was this assignment for helping you to think more about nanogenomics and nanomedicine and preparing you to answer the two overarching questions?” and “How much do you feel you learned about nanotechnology as a result of working on this assignment?” with five-point ordinal response scales respectively ranging from “not at all” to “extremely” and “nothing I didn’t know before” to “a great deal.” These 11 items were then averaged to create a single scale ($\alpha = .92$).

Evaluation of A3 resources. After completing the exercises associated with each of the hypothetical scenarios in A3, students were asked about the resources they consulted to guide the response to these scenarios. These items included “To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario?” and “To what extent do you feel like the background document that you were provided with in Assignment 2, before you came to reci) was helpful as you responded to this scenario?” Response options ranged along a five-point scale from “not helpful at all” to “extremely helpful.”

Satisfaction with process. In A4, students were asked three questions designed to assess their

level of satisfaction with all four assignments as a module. Specifically, they were asked “To what extent did you change your mind about the [importance of ELSI in science] over this semester?” and “Overall, to what extent was the public participation module a beneficial part of your learning in this course?” with responses to both on a five-point scale ranging from “not at all” to “a great deal.”

2.7.3. Group Processes

Influence of group identities. After completing the ethical scenario activities in A3, students were asked to respond to a series of eight questions regarding the importance of various forms of identity in informing their answers. Examples of these items include “my identity as an individual” and “my identity as a UNL student.” Responses fell on a five-point scale ranging from “not at all important” to “extremely important.”

A3 group dynamics reported by participants. After completing A3, students who were assigned to the group condition were asked a series of questions intended to reflect their attitudes toward group members and level of agreement within the group.

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

Students were also asked to report on perceptions of consensus within their group by rating “How much disagreement was there within your group?” (five response options ranging from “no disagreement at all” to “total disagreement”), “How much consensus was there within your group?” (five response options ranging from “no consensus at all” to “total consensus”), and “During the discussion, my group reached a consensus as to the answers to the ethical scenarios” (seven response options ranging from “strongly disagree” to “strongly agree”).

As another measure of consensus, participants also rated the extent to which their group interaction felt like, “one group,” “two or more subgroups within a larger group,” or “separate individuals” (see Gaertner et al. 1989; Gaertner et al. 1990). For each item there were five response options ranging from “not at all” to “extremely.”

In addition, students who were assigned to the group condition were asked to list the members of their group and then answer a series of four questions about each group member. Specifically, they were asked, “*Before today’s discussion:* How familiar would you say you were with [group member]?” and “To what extent did you agree with the opinions expressed by each person during the discussion?” and “regarding the ethical scenarios you just discussed, how similar do you think each person’s opinions are to your opinions?” In addition, they were asked to “please indicate whether each person is a member of your recitation small group.”

Finally, six statements were relevant to positive experience and identification with the group ($\alpha = .77$). Examples of these items include “I felt strong ties with my group” and “My ideas were not respected by other group members,” reverse coded. Responses were on a seven-point scale ranging from “strongly disagree” to “strongly agree.”

A3 group dynamics reported by moderators. The trained group moderators were also asked to report their observations of group processes including rating the extent to which each topical discussion (i.e., about a specific ethical scenario) stayed on topic (5-point scale ranging from not at all to all of the time). The rest of the items used a 5-point scale ranging from not at all to very/extremely and included questions about how interested/engaged the students seemed to be, how much disagreement there was within the group, the extent to which students gave evidence for their views, the extent to which students evaluated or challenged the evidence available, the extent to which students explicitly talked

about bias, the extent to which students acknowledged different perspectives, and the extent to which students appeared to reach consensus by the end of the discussion. In addition, for each scenario discussed, the moderators rated the extent to which certain topics were discussed and the extent to which students appeared to disagree about certain topics. They also were asked to report if the students appeared to have any misconceptions about the topics and to report how long the students discussed and wrote responses to the ethical scenario. Finally, as a manipulation check, they were asked to report whether or not they used the correct prompts for the condition assigned to their group. The guiding scripts and forms used to rate the discussions by the moderators are given in Appendix C.

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.

Open-ended expression of nanotechnology attitudes: contrasting perspectives. In Assignments 1, 2, 3 and 4 students were asked to write two short essays outlining their perspective on nanotechnology application. The first essay focused on the students' own perspective, and asked "What *developments* should be prioritized and what *regulations* are needed?" The second essay considered alternatives to the students' own perspective, and asked "What do you think someone who disagrees with you would say, and how would you answer them?"

ELSI attitudes. In both A1 and A4, students were asked to respond to the following prompt: "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."

"Who are you?" At the end of A1, students were asked to write two or three sentences in response to the following questions: "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 different than you?"

Change of mind. In A1, following a close-ended assessment of "how likely are you to change your views about the development and regulation of those technologies" students 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? 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."

In addition, in A1, after students were asked the close-ended question "In your estimation, as you learn more about nano-biological technologies, how likely is it that you may change your feelings and attitudes about the following... The overall risk to benefit ratio of nano-biological developments.... The extent to which nano-biological development needs to be regulated," they were asked to "Write at least one or two sentences explaining the answers that you gave above. Why might you change your feelings about these items? Note: 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."

In A4 after rating the extent to which they felt their minds had changed and the factors that

influenced their change of mind, students were asked, “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.”

Feedback and critical thinking prompts. During A2, students were asked to reflect on what they were reading by responding either to prompts for feedback on the materials (e.g., “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!”) or prompts for critical thinking (e.g., “Below, give 1-2 examples 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.”) See Appendix A Study 4 Assignment 2 for the full context of these questions.

Critical thinking scenario. After completing the background reading in A2, students were asked to write a short paragraph responding to the following hypothetical future scenario: “Doug was recently diagnosed with a degenerative genetic disease. Scared about his future, Doug did some research and was convinced that his doctors should use nanotechnology to “fix” the genetic abnormality. Arguing that if the technology exists to manipulate genes with the help of nanotechnology, Doug believes failure to cure him of his disease constitutes malpractice. Doug’s girlfriend Dianne, however, urges Doug to seek counseling in order to come to terms with his disease. Citing Doug’s religious beliefs and a series of fears for the future, Dianne argues that it is not Doug’s or his doctor’s right to do something as dangerous and unethical as mess with his genetics.”

Responses to A3 scenarios. After each of the A3 scenarios, participants were asked to write about their reactions and recommendations. Control group participants were additionally asked to report any questions they would have liked to have had answered in order to be able to write a better response to the scenario. Critical thinking participants were asked to consider and write about a potential viewpoint that might disagree with their view. In the critical thinking condition only, the question about reactions and recommendations included prompts for use of evidence, evaluation, avoidance of bias, and so on (see Appendix A, Assignment 3).

2.9. Data Quality Measures

We also included in our measures two questions related to data quality. In 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, 95% and 92%, of respondents to A2 and A4 respectively indicated giving honest answers.

On the A1 measure of potential negative or positive outcomes of nanotechnology, 15 persons (about 7%) did not classify two or more of six negative outcomes as expected (e.g., not classifying pollution as a negative rather than as a positive outcome). On the A4 measure of potential negative or positive outcomes of nanotechnology, 6 persons (about 3%) did not classify two or more of five negative outcomes as expected.

We created a variable that counted the number of data quality checks missed by a given participant. A total of 84% of participants missed 0, and 97% missed 0-4 checks. Seven 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 – All Assignments

APPENDIX A: Study 4 Survey Questions and materials

4.1.1. Study 4 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_t2 Timing

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

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

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a1_Q5 Are changes needed in biology education? To ensure that biology majors are equipped to work across traditional subdisciplinary boundaries? To provide biology curricula that equip physical scientists and engineers to take advantage of advances in biological science? And to provide nonscientists with a level of biological understanding that gives them an informed voice regarding relevant policy proposals? --From "A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution" One purpose of a university education is to create well-informed community members (i.e., citizens) who can advise government on the direction that society should move and public policies. While "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" divorced from society. Science developed apart from a consideration of its role in society may not be utilized or utilized correctly.

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.

a1_t4 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a1_Q6 The goals of the New Biology assignments used in this course are to provide you with the opportunity to practice applying your biological knowledge across and within different science 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 a couple of weeks you will have a reading assignment about Nanotechnology and hear a guest lecture on Ethical, Legal and Social Issues in science. 3. Issue Deliberation. Following the reading, in recitation, you will consider some ethical scenarios pertaining to nanotechnology and biology, and deliberate about the best courses of action in light of those scenarios. 4. Your Input. The final step in the process is for you to give your input on the issues. Based on what you learned, at the end of the semester, you will write down 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

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

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.

Age

What is your age? (1)

Male

What is your gender?

- ☐ Male (1)
☐ Female (0)

Year What is your year in school?

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

Major What is your major?

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

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

a1_momedu What is the highest level of education of your mother?

- ☐ I don't know (9)
- ☐ Did not complete high school (1)
- ☐ Completed high school (2)
- ☐ Completed some post-secondary education, but no degree (3)
- ☐ Received a 2-year degree, e.g., associate's degree (4)
- ☐ Received a 4-year college degree, e.g., B.A., B.S., etc. (5)
- ☐ Completed some post-graduate courses, but no additional degree (6)
- ☐ Received a 2-year post-graduate degree (e.g., M.A., M.S., etc) (7)
- ☐ Received a 4-year post-graduate degree (e.g., Phd, D.Ed, etc) (8)

a1_dadedu What is the highest level of education of your father?

- ☐ I don't know (9)
- ☐ Did not complete high school (1)
- ☐ Completed high school (2)
- ☐ Completed some post-secondary education, but no degree (3)
- ☐ Received a 2-year degree, e.g., associate's degree (4)
- ☐ Received a 4-year college degree, e.g., B.A., B.S., etc. (5)
- ☐ Completed some post-graduate courses, but no additional degree (6)
- ☐ Received a 2-year post-graduate degree (e.g., M.A., M.S., etc) (7)
- ☐ Received a 4-year post-graduate degree (e.g., Phd, D.Ed, etc) (8)

a1_t6 Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
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a1_Q8 Where do you start? The spirit of this assignment is to simply get you to reflect on your current knowledge and opinions. So please don't spend any time "googling" or researching the topics. (You will be doing that later!). Ok! Let's get started with "Step 1: Opening Reflections." Many of you may never have even heard of nanotechnology before now, so you will want more information to help you form your opinions. You'll be provided with that information in other New Biology activities. For now, however, consider the questions below and write a paragraph describing what comes to mind as possible preliminary answers to the below questions. These are the two questions you will be asked, at the end of the New Biology activities, to give your final input on.

a1_inputself (1) Your Perspective: What developments should be prioritized and what regulations are needed? As you answer this question, please consider the questions below, indicate why do you feel the way you do, and do your best to provide evidence for 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? 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? What ethical, legal and social issues need to be considered and resolved when making decisions about the development and regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these issues be resolved, and why? 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. What comes to your mind as possible preliminary answers to these questions? Write your paragraph reflection below.

a1_inputothr (2) Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? As you answer this question, please consider the questions below, indicate why do you feel the way you do, and do your best to provide evidence for statements you make. How might others differ from you? What might they want the future of nano-biological technology development to look like in terms of human enhancement applications? What different social policies, rules, limits, and regulations might they want in place? And what ethical, legal, and social issues would they prioritize in their consideration of nano-biological technologies? Why do you think they would have their opinions? What evidence or reasons would they have for their views? How would you answer a person or persons who disagree(s) with you and holds such views? 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. What comes to your mind as possible preliminary answers to these questions? Write your paragraph reflection below.

a1_t7 Timing

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

a1_Q9 What do you know? Next, you will reflect on how your "starting point" is impacted by what you currently know and don't know, your attitudes and values, and by the trust you have or don't have in people who produce science or regulate new technologies.

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)
- Last Click (2)
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- Click Count (4)

a1_Q10 What do you know? The "New Biology" issues that you think about later in the 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. See if you can answer the following questions. Please don't "Google" the answers! (You will learn more about these things in later assignments.)

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_know2c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

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_know4c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (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_know1c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (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_know6c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

a1_t9 Timing

First Click (1)

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a1_ktfConf Please indicate whether the following statements are True or False:

	This statement is: (1)		I am _____ confident in my answer: (2)				
	True (1)	False (2)	Not at all (1)	A little bit (2)	Moderately (3)	Mostly (4)	Completely (5)

Materials that are harmless at the macro-level could be harmful at the nano-level. (a1_ktfConf_1_1 and a1_ktfConf_2_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. (a1_ktfConf_1_2 and a1_ktfConf_2_2)

All nanoscale materials can conduct electricity because of their extremely small size. (a1_ktfConf_1_3 and a1_ktfConf_2_3)

Nanoparticles exist naturally in the environment. (a1_ktfConf_1_4 and a1_ktfConf_2_4)

A limitation of nanoparticles is they cannot penetrate into the brain. (a1_ktfConf_1_5 and a1_ktfConf_2_5)

a1_t10 Timing

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a1_Q11 What do you know?

a1_Q12 When you were asked what comes to mind when you think about the development and regulation of nano-biological technologies, you wrote the following paragraph:

"xxxxq://QID336/ChoiceTextEntryValuexx"

a1_chng 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_chngexp 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

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

a1_Q13 What do you think?

a1_Q14 Now that you have thought about what comes to mind when you think of nanotechnology development and regulation, and considered what you know, take a moment to reflect on any attitudes you may be bringing to your consideration of the issues. For example, do you approach the idea of new technologies with suspicion, fear, doubt and distrust? Or with excitement, interest and hopes for a brighter future? Or perhaps a bit of both? Or neither? How might you answer the following attitude questions? Again, 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? Slide the slider to reflect your view. Zero 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)

a1_genrate_ When it comes to nano-biological technologies, how important are the following general goals?

	Unimportant (1)	Slightly important (2)	Important (3)	Very important (4)	Extremely important (5)
--	-----------------	------------------------	---------------	--------------------	-------------------------

- Minimizing potential risks for humans. (a1_genrate_1)
- Minimizing potential environmental risks. (a1_genrate_2)
- Making decisions about the most important directions for future development. (a1_genrate_3)
- Studying the social and ethical impacts and implications of future developments and regulations. (a1_genrate_4)
- Maximizing potential benefits for human enhancement. (a1_genrate_5)
- Maximizing potential environmental benefits. (a1_genrate_6)

a1_gensum There are, of course, only a limited number of resources (time, effort, money) that can be spent on each of the things that you rated above. So, please consider what percentage of the U.S. resources (i.e., total time, effort, and money) should be spent on each. Make sure that your percentages sum to 100%, and make sure that you give the items you rated the most important the greatest percentage of resources. What percentage of resources would you assign to each category?

- Minimizing potential risks for humans. (a1_gensum_x1)
- Minimizing potential environmental risks. (a1_gensum_x2)
- Making decisions about the most important directions for future development. (a1_gensum_x3)
- Studying the social and ethical impacts and implications of future developments and regulations. (a1_gensum_x4)
- Maximizing potential benefits for human enhancement. (a1_gensum_x5)
- Maximizing potential environmental benefits. (a1_gensum_x6)

a1_t12 Timing

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a1_Q15 What do you think?

a1_rblkly_ 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. However, some of these are more likely than others. Based on what you know right 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 nano-biological technologies? You should guess based on your other knowledge of science even if you don't know anything about nano-biological technologies.

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

- The extension of human life expectancy. (a1_rblkly_1)
- Cheap and more universal healthcare. (a1_rblkly_2)
- Higher rates of terminal illness survival (e.g., cancer survival). (a1_rblkly_4)
- The ability to improve humans through genetic manipulation. (a1_rblkly_8)
- The elimination of genetic inheritance of disease. (a1_rblkly_13)
- Economic development through investment and research. (a1_rblkly_14)
- Economic disruption caused by the loss of traditional jobs. (a1_rblkly_18)
- Loss of personal privacy to tiny new surveillance devices. (a1_rblkly_19)
- Pollution of the environment by nanomaterials. (a1_rblkly_23)
- Unforeseen side-effects from nanomedicines. (a1_rblkly_26)
- Loss of religious liberties. (a1_rblkly_31)
- The widening of the gap between the rich and the poor. (a1_rblkly_29)

a1_t13 Timing

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a1_rbimpt SPECIFIC RISKS & BENEFITS -- How valuable or important? 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. (a1_rbimpt_x1)
- Cheap and more universal healthcare. (a1_rbimpt_x 2)
- Higher rates of terminal illness survival (e.g., cancer survival). (a1_rbimpt_x 4)
- The ability to improve humans through genetic manipulation. (a1_rbimpt_x 8)
- The elimination of genetic inheritance of disease. (a1_rbimpt_x 13)
- Economic development through investment and research. (a1_rbimpt_x 14)
- Economic disruption caused by the loss of traditional jobs. (a1_rbimpt_x 18)
- Loss of personal privacy to tiny new surveillance devices. (a1_rbimpt_x 19)
- Pollution of the environment by nanomaterials. (a1_rbimpt_x 23)
- Unforeseen side-effects from nanomedicines. (a1_rbimpt_x 26)
- Loss of religious liberties. (a1_rbimpt_x 31)
- The widening of the gap between the rich and the poor. (a1_rbimpt_x 29)

a1_t14 Timing

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Click Count (4)

a1ATTPRE04_ Finally, read each of the following statements, and then indicate to what degree you agree or disagree. Do your best to answer -- it's OK if you feel uncertain about your answers, because you will have a chance to change your mind later.

	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)

a1_attchng_ How Do You Feel: Question for Reflection In your estimation, as you learn more about nano-biological technologies, how likely is it that you may change your feelings and attitudes about the following:

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

- The overall risk to benefit ratio of nano-biological developments. (a1_attchng_5)
- The extent to which nano-biological development needs to be regulated. (a1_attchng_6)

a1_chgrefl Write at least one or two sentences explaining the answers that you gave above. Why might you change your feelings about these items? Note: 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_t15 Timing

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a1_Q16 Who Do you Trust?

a1_Q17 To some extent, your "starting point" with regard to your feelings about nano-biological technologies might be impacted by your trust or faith in the people who are developing or regulating new technologies. Nanoscientists are generally seen as responsible for the development of nanotechnologies, as their expertise and interests will impact that development. However, policy makers also make decisions about which technologies to provide funding for, and also how much to regulate new technologies. Such funding and regulations can, in turn, influence decisions scientists make about future developments. Next, you will reflect on the extent to which you generally trust the scientists developing new nano-biological technologies, and policy makers who influence decisions about funding for and regulations of such technologies.

a1_knowNS_ NANOSCIENTISTS First, consider what you know about the nanoscientists responsible for researching and making discoveries involving nanotechnology.

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

- How much do you know about nanoscientists? (a1_knowNS_1)
- To what extent have you had experiences or interactions with nanoscientists? (a1_knowNS_2)
- To what extent do you feel certain in your views about nanoscientists? (a1_knowNS_3)

a1_Q18 Next, please make the following judgments based on whatever knowledge or experience you have right now. Don't worry if you don't have much knowledge and experience yet, just indicate your gut-level feelings and impressions. It's ok if you have to guess -- you'll have a chance to indicate if you have changed your mind at the end of the assignments.

a1_sconfNS Right now, 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. (a1_sconfNS 1)
- Meet their professional responsibilities. (a1_sconfNS 2)
- Meet their ethical responsibilities. (a1_sconfNS 3)
- Go above and beyond what is expected of them professionally in order to better society. (a1_sconfNS 4)
- Go above and beyond what is expected of them professionally in order to protect society from risks. (a1_sconfNS 5)
- Minimize potential risks for humans. (a1_sconfNS 6)
- Minimize potential environmental risks. (a1_sconfNS 7)
- Make decisions about the most important directions for future development. (a1_sconfNS 8)
- Study the social and ethical impacts and implications of future developments and regulations. (a1_sconfNS 9)
- Maximize potential benefits for human enhancement. (a1_sconfNS 10)
- Maximize potential environmental benefits. (a1_sconfNS 11)

a1_t16 Timing

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Click Count (4)

a1_Q19 Who Do you Trust?

a1_knowPM_ POLICY MAKERS Next, consider what you know about the policy makers responsible for making decisions about funding and regulations involving nanotechnology.

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

- How much do you know about policy makers who regulate nanotechnology? (a1_knowPM_1)
- To what extent have you had experiences or interactions with these policy makers? (a1_knowPM_2)
- To what extent do you feel certain in your views about these policy makers? (a1_knowPM_3)

a1_Q20 Please make the following judgments based on whatever knowledge or experience you have right now. Don't worry if you don't have much knowledge and experience yet, just indicate your gut-level feelings and impressions. It's ok if you have to guess -- you'll have a chance to indicate if you have changed your mind at the end of the assignments.

[Note participants completed only one of the following two sets of questions. The set completed was randomly assigned.]

a1_sconfPM_ To what extent do you have confidence in policy makers who help regulate nanotechnology to...

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

- Do their jobs well. (a1_sconfPM_1)
- Meet their professional responsibilities. (a1_sconfPM_2)
- Meet their ethical responsibilities. (a1_sconfPM_3)
- Go above and beyond what is expected of them professionally in order to better society. (a1_sconfPM_4)
- Go above and beyond what is expected of them professionally in order to protect society from risks. (a1_sconfPM_5)
- Minimize potential risks for humans. (a1_sconfPM_6)
- Minimize potential environmental risks. (a1_sconfPM_7)
- Make decisions about the most important directions for future development. (a1_sconfPM_8)
- Study the social and ethical impacts and implications of future developments and regulations. (a1_sconfPM_9)
- Maximize potential benefits for human enhancement. (a1_sconfPM_10)
- Maximize potential environmental benefits. (a1_sconfPM_11)

a1_gconfPM_ To what extent do you feel policy makers who help regulate nanotechnology...

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

- Are trustworthy. (a1_gconfPM_1)
- Are fair. (a1_gconfPM_6)
- Care about people like you, your friends, and your family. (a1_gconfPM_19)
- Are motivated to "do the right thing." (a1_gconfPM_23)
- Are competent to do their jobs. (a1_gconfPM_7)
- Have the knowledge needed to do their jobs well. (a1_gconfPM_9)
- Have the training needed to do their jobs well. (a1_gconfPM_11)

- Are dishonest. (a1_gconfPM_5)
- Are primarily motivated by what will benefit them personally. (a1_gconfPM_29)
- Don't really care about the long-term risks of their decisions. (a1_gconfPM_31)

a1_t17 Timing

First Click (1)

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Click Count (4)

a1_Q21 Who are you?

a1_Q22 So far, you've considered: Where do you start? What do you know? What do you think? and Who do you trust? Last but not least, think about who you are -- your traits, your attitudes about related topics, your beliefs, and your place in larger 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)

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 (a1_ideolog_1)
- When it comes to ECONOMIC issues (a1_ideolog_2)
- When it comes to SOCIAL issues (a1_ideolog_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)

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: xxx Recitation: q://QID82/ChoiceGroup/AllChoicesTextEntry Your Starting Point Your paragraph reflecting on your "starting point" regarding the development and regulation of nanotechnology: q://QID336/ChoiceTextEntryValue Your paragraph reflecting on what you think someone who disagrees with you would say and how you would answer them: " xxxq://QID337/ChoiceTextEntryValue " 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? q://QID258/ChoiceTextEntryValue How do you feel? q://QID257/ChoiceTextEntryValue Who are you? q://QID327/ChoiceTextEntryValue

a1_Q26 The End!

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 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 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 4 Assignment 2

In the 2x2 design, this is the assignment including information organization resembling that used by the national issues forum and NO use of critical thinking prompts. See Appendix B for Manipulations of

these conditions.

a2_Q1 This assignment will take approximately 60-90 minutes to complete. 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 is worth 7 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)

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)

a2_Q3 At the beginning of the semester, you began a specific method of public engagement that has been developed by the University of Nebraska Public Policy Center. The public engagement process includes the following steps: 1. Opening reflections: You did this a couple weeks ago. 2. Information Investigation & Exploration: <-- You are doing this NOW! This step includes a reading assignment about Nanotechnology and a guest lecture on Ethical, Legal and Social Issues in science. The last two steps you will do next week: 3. Issue Deliberation: In this step, you will consider some ethical scenarios and deliberate about the best courses of action. 4. Public Input: Finally, you will give your input on developments that you think nano-biological scientists should pursue, and how nanotechnology should be regulated. 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.

a2_time2 Timing

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

a2_Q4 Where Are You Starting From? Before getting started, please indicate what you think right NOW about the following questions. Don't worry if you do not know much about nanotechnology and human enhancement yet--just make your "best guess." The assignment may change your opinions, and you can indicate this later.

a2_fnanopr How familiar are you with nanotechnology?

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

a2_fmmedpre 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)

a2_fggenpre 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)

a2_Q5 You may feel like you do not have enough information to answer the next two questions -- Please try to answer them anyway. We will give you a chance to change your answer later, after you have more

information.

A2pre_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)

A2pre_regslide In your opinion, how much regulation is needed with respect to nano-biological research and development? Slide the slider to reflect your view. Zero 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.

_____ No regulation at all (1)

a2_time3 Timing

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

Answer If A2know_cond Is Equal to A

a2_knowA Current Knowledge How much do you already know about nanotechnology? See if you can answer the questions below. If you don't know an answer, just make your best guess. Note: You are not expected to know these yet! So please don't "Google" the answers!! Indicate whether the following statements are true or false. Also rate how confident you are in your answer to the true/false question.

This statement is: (TF)		I am _____ confident in my answer: (Conf)					
True (1)	False (2)	Not at all	A little bit	Moderately	Mostly (4)	Completely	

			(1)	(2)	(3)		(5)
--	--	--	-----	-----	-----	--	-----

- Nanotechnology is already being used to map the human genome. (a2_knowA_1__TF and a2_knowA_1__Conf)
- Breakthroughs in nanogenomics already allow very wealthy parents to manipulate the intelligence of their children. ((a2_knowA_2__TF and a2_knowA_2__Conf))
- A good example of a nano-sized object is a red blood cell. (a2_knowA_3__TF and a2_knowA_3__Conf)
- Nanomaterials in the environment can enter the body and certain nanoparticles have already been shown to interfere with normal bodily processes. (a2_knowA_4__TF and a2_knowA_4__Conf)
- The term "human enhancement" includes advancements like curing diseases. (a2_knowA_5__TF and a2_knowA_5__Conf)
- Liposomes have been used to house and deliver drugs in a way that gets a higher proportion of the drug to the target and less to the rest of the body. (a2_knowA_6__TF and a2_knowA_6__Conf)
- Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines. (a2_knowA_7__TF and a2_knowA_7__Conf)
- Research at the interface of nanotechnology and biology has been used for seemingly non-biological applications such as the creation of faster computer chips. (a2_knowA_8__TF and a2_knowA_8__Conf)

Answer If A2know_cond Is Equal to B

a2_knowB Current Knowledge How much do you already know about nanotechnology? See if you can answer the questions below. If you don't know an answer, just make your best guess. Note: You are not expected to know these yet! So please don't "Google" the answers!! Indicate whether the following statements are true or false. Also rate how confident you are in your answer to the true/false question.

	This statement is:		I am _____ confident in my answer:				
	True (1)	False (2)	Not at all (1)	A little bit (2)	Moderately (3)	Mostly (4)	Completely (5)

- (a2_KnowB_1__TF, a2_KnowB_1__Conf) Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research.
- (a2_KnowB_2__TF, a2_KnowB_2__Conf) Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems.
- (a2_KnowB_3__TF, a2_KnowB_3__Conf) The government currently uses nano-scale devices to monitor people.

- (a2_KnowB_4__TF, a2_KnowB_4__Conf) The “second order effects” of nanotechnology can be accurately predicted from “first order effects.”
- (a2_KnowB_5__TF, a2_KnowB_5__Conf) Most traditional pollutant filters are able to catch and stop nanoparticles.
- (a2_KnowB_6__TF, a2_KnowB_6__Conf) One outcome already identified as possible with nanotechnology is innovative diabetes treatments that stimulate insulin production from outside the body.
- (a2_KnowB_7__TF, a2_KnowB_7__Conf) 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.
- (a2_KnowB_8__TF, a2_KnowB_8__Conf) Nanotechnology has already been used to develop materials to improve products such as tennis rackets.

a2_time4 Timing

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a2_Q6 One purpose of the “New Biology” assignments is to help students to begin thinking about the social implications of scientific discoveries and methods. Another reason for this assignment is that... 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: 24px xx --> The Government Wants to Know <-- (click on the text above to see something neat) Nanotechnology is an up-and-coming hot topic--it is at the cutting edge of scientific developments. It is revolutionizing everything from tennis balls to cancer treatments. However, the general public knows very little about it. The U.S. government, therefore, has mandated that funds be spent on telling the public (that's you!) about nanotechnology and finding out what they (you again!) think should be the future of nanotechnology. (Isn't that neat? Note that throughout this document, more information will appear when you click on blue bold underlined text!) Two questions in need of public input are below. Read the two questions below carefully. You will be asked to answer these questions later in the assignment, so you may want to take notes on them as you read. Nanotechnology, Biology, and Human Enhancement Overarching Questions (1) Your Perspective: What developments should be prioritized and what regulations are needed? 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? 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? What ethical, legal and social issues need to be considered and resolved when making decisions about the

development and regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these issues be resolved, and why? (2) Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? How might others differ from you? What might they want the future of nano-biological technology development to look like in terms of human enhancement applications? What different social policies, rules, limits, and regulations might they want in place? And what ethical, legal, and social issues would they prioritize in their consideration of nano-biological technologies? Why do you think they would have their opinions? What evidence or reasons would they have for their views? How would you answer a person or persons who disagree(s) with you and holds such views?

a2_time5 Timing

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[Participants received only one of the 2 instructions, depending on their condition.]

a2_Q7FB 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 document. 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.

a2_Q7CT 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 document. 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.

a2_time6 Timing

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Click Count (4)

[Example information: Participants received information that varied in organization, depending on their condition. See Appendix B for how information differed]

a2_Q8 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.

a2_Q9 Figure 1- Source: BPDNB (2010) 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 long. As illustrated in Figure 1, DNA and silver nanoparticles are examples of "nano"-sized materials, red blood cells are bigger "micro"-sized, and objects we can see easily are "macro"-sized. At the nanoscale, only the most powerful microscopes are able to actually see objects. An important feature of nanoscale materials is how their properties differ from normal-scaled materials. Everyday common materials can have new and different properties when reduced to nano-sized objects. For example, elements may change color and materials that would normally not conduct electricity may do so when made into nano-sized objects. In fact, scientists have found that they can manipulate carbon atoms and molecules to create nano-sized 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. This has been a concern for some scientists because some materials that are harmless at their normal size could be dangerous at the nano-level. 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, and 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. Meanwhile, certain nanoparticles are extremely effective in absorbing light and are being used in cosmetics and sunscreens. As for developments in science industries, 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 thus far. These developments are having broad impacts on many levels of society. For example, the economies of several nations have been influenced by nanotechnological development. 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 automotive catalytic converters, thus making certain chemical reactions more efficient and resource-saving, which have industrial implications. Additionally, the United States stands to potentially gain from nanotechnological development by using it to more efficiently utilize renewable energy (especially because the U.S. has

been said to be falling behind in its use of “green” energy). On the other hand, many people are concerned about the potential risks of these developments. According to Sandler and Bosso (2007) from the National Academy of Sciences, the social context of nanotechnology must be acknowledged because it affects aspects of society like access to resources, social and political power, individual rights, and justice in general. Sandler and Bosso argue that the reactions of U.S. federal regulatory organizations have not traditionally acted in ways “optimal for the promotion and protection of the public good,” but have rather been somewhat delayed in reacting to technological developments that necessitate regulatory oversight. Thus, they recommend that caution be used in pursuing advances in nanotechnology.

Hoet et al. (2004) talk about some of the known risks of nanotechnology that should be considered seriously. They explain how nanomaterials can 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. Nanoparticles have been shown to be active at the cellular level, where 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 nano-sized carbon nanotubes, which can be used for their unique properties, can damage the lungs of rats and mice. 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 remaining 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 (Health Council). “Free form” nanoparticles can be released in the air or water via manufacturing nanomaterials, but they can also make their way into the environment via most traditional pollutant filters’ inability to catch nano-sized particles.

[Critical thinking and control students were prompted differently]

Control:

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!

Critical thinking:

TIP for Critical Thinking: Detecting Bias

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, but it does 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.

a2_biasex Below, give 1-2 examples 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.

a2_time7 Timing

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[Example information: Participants received information that varied in organization, depending on their condition. See Appendix B for how information differed]

a2_Q11 New Biology: Biology Meets Technology 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 to anything designed to improve or augment human capabilities. Human enhancement does not necessarily refer to extreme examples—such as altering average human beings to have special powers. Instead, human enhancement mainly includes common activities such as higher education and athletic training, as well as plastic surgery and the creation and use of artificial prostheses. Human enhancement can include both curing diseases and disabilities and 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 deliver highly potent anticancer chemotherapy drugs in a way that gets 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 non-nanotechnologically-delivered 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 (Freitas, 2005). 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 more 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, diagnostic techniques that involve injecting nano-sized particles into the bloodstream prior to an MRI (magnetic resonance imaging) have been developed. The presence of the iron oxide nanoparticles serves to significantly enhance 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 researched for the 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 internal use of engineered nanosized gold-coated silica particles. These nanoshells, which are being tested in mice, collect in tumor tissues. The nanoshells can be selectively heated when illuminated from outside the body with near infrared light. The heat 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 this technique will someday result in new treatments for cancer, diabetes and some neurological disorders. If this research and development continues to be successful, as doctors hope, we will be able to target and treat tumors more efficiently and with fewer side effects than with 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 using nanotechnologies that might be applied to change single genes within the genetic code. Here, we are using the term nanogenetics or nanogenomics broadly to refer to any research and development involving both nanotechnology and genetics. Nanogenomics has some 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.

[Critical thinking and control students were prompted differently]

Control:

a2cntrlex2 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!

Critical thinking:

a2_Q12CT 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?

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?

a2_supplex Below, give one example of a claim made above (in the text or a link that you explore) that you think is poorly supported, and one example of a claim that is well-supported.

For each 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?

a2_time8 Timing

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[Example information: Participants received information that varied in organization, depending on their condition. See Appendix B for how information differed]

a2_Q13 (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, as promised: What developments and regulations do YOU think should be prioritized? What

developments and regulations do you think OTHERS would prioritize? 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.

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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.

a2_time9 Timing

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a2_Q14 Nano-biological Human Enhancement: Ethical, Legal and Social Issues (ELSI)

[Example information: Participants received information that varied in organization, depending on their condition. See Appendix B for how information differed]

a2_Q15_2NI 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: 14px xx a.rollover:hover 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. 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.
improvement, if they want it.

Human autonomy: Individuals have the right to self-

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.

a2_Q15_3NI 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 (Moghim 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.

[Critical thinking and control students were prompted differently]

Control:

a2cntrlex3 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!

Critical thinking:

a2_Q16CT 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.

a2_factex 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?

a2_time10 Timing

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a2_Q17

[Example information: Participants received information that varied in organization, depending on their condition. See Appendix B for how information differed]

a2_Q18nif Conclusion Of course, many people probably fall between these two perspectives. Many people probably agree that there are some risks that should be taken seriously, and that certain potential benefits should not be undermined. However, we shouldn't feel pressured to take a moderate stance, because some argue that there are drawbacks to such a position. For example, a moderate

stance on nanobiological research could lead to more spending of money than if there was no regulation at all. Similarly, frequent debates as to what the exact regulations on this research should be could cause political stalemates and lead to financial losses. Also, if you support nanobiological research, you might acknowledge that people who might otherwise be helped would suffer due to the slowing effects of regulation. On the other hand, if you oppose nanobiological research, the limited regulations of a moderate approach might not be able to prevent certain long-term consequences such as impacts on society because regulations are too focused merely on immediate risks. The question is, which risks are acceptable and which are unacceptable to you? Which directions for future research and development should be prioritized, and which should either not be prioritized, or perhaps forbidden? These are the questions that you need to consider next. One problem with reading background information like you have just read, however, is that it is very abstract. So, as a final exercise in thinking about these issues, please consider the scenario below.

a2_doug For Your Consideration! Doug's Dilemma Doug was recently diagnosed with a degenerative genetic disease. Scared about his future, Doug did some research and was convinced that his doctors should use nanotechnology to "fix" the genetic abnormality. Arguing that if the technology exists to manipulate genes with the help of nanotechnology, Doug believes failure to cure him of his disease constitutes malpractice. Doug's girlfriend Dianne, however, urges Doug to seek counseling in order to come to terms with his disease. Citing Doug's religious beliefs and a series of fears for the future, Dianne argues that it is not Doug's or his doctor's right to do something as dangerous and unethical as mess with his genetics. What do you think of Doug's situation in this scenario? Write a short paragraph with some advice to Doug. Be sure to explain your reactions. Need some inspiration? Click Here. If you are having trouble thinking of how to respond to this scenario, you could ask yourself questions like these: What are your thoughts about using nanotechnology to help reverse Doug's disease? Can you empathize with how Doug must feel? How do you feel about Dianne's advice for Doug to seek therapy? Have you ever experienced a similar situation where what you wanted conflicted with what your partner, parent, or friend, thought was best for you? How would you react if you were in Doug's position?

a2_time11 Timing

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a2_Q19 Now that you have read the background information and had a chance to think about it and explore some of the additional materials, please answer the following questions. NOTE: You may use

the "back" button to re-read information or to remind yourself how you answered the prior questions. You may also download the background information at the link below, or use any other resources you would like. Download a PDF of the Background Information [HERE](#)

a2_inputself (1) Your Perspective: What developments should be prioritized and what regulations are needed? 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? 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? What ethical, legal and social issues need to be considered and resolved when making decisions about the development and regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these issues be resolved, and why? Write one paragraph responding to this question in the box below.

a2_inputothr (2) Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? How might others differ from you? What might they want the future of nano-biological technology development to look like in terms of human enhancement applications? What different social policies, rules, limits, and regulations might they want in place? And what ethical, legal, and social issues would they prioritize in their consideration of nano-biological technologies? Why do you think they would have their opinions? What evidence or reasons would they have for their views? How would you answer a person or persons who disagree(s) with you and holds such views? Write one paragraph responding to this question.

a2_time12 Timing

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a2post_rskben 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_riskben During this assignment, 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)

a2post_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_chgmnd_reg During this assignment, 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)

a2_time13 Timing

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a2_Q20 The following questions are to see how much you have learned as a result of reading the background materials. Again, 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_know2c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

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_know1c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

a2_know4 Which of the following is between 1 and 100 nanometers?

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

a2_know4c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

a2_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)

a2_know6c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

a2_know7 Which of the following is not a known risk of nanotechnology?

- ☐ Nanomaterials have been shown to be active at the cellular level, which can cause inflammation and even tumors in the lungs. (1)
- ☐ The lungs of rats and mice have been damaged in experiments using nano-sized carbon nanotubes. (2)
- ☐ Nanomaterials have been shown to interact adversely with skin cells, which have already been shown to cause skin cancer in otherwise healthy humans. (3)
- ☐ Iron nanoparticles have been shown to be able to travel with groundwater into soil and remain active for weeks. (4)

a2_know7c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

a2_time14 Timing

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Answer If A2know_cond Is Equal to A

a2_knwApst Indicate whether the following statements are true or false. Also rate how confident you are in your answer to the true/false question.

	This statement is:		I am _____ confident in my answer:				
	True (1)	False (2)	Not at all (1)	A little bit (2)	Moderately (3)	Mostly (4)	Completely (5)

- Nanotechnology is already being used to map the human genome. (a2_knwApst_1__TF, a2_knwApst_1__Conf)
- Breakthroughs in nanogenomics already allow very wealthy parents to manipulate the intelligence of their children. (a2_knwApst_2__TF, a2_knwApst_2__Conf)
- A good example of a nano-sized object is a red blood cell. (a2_knwApst_3__TF, a2_knwApst_3__Conf)
- Nanomaterials in the environment can enter the body and certain nanoparticles have already been shown to interfere with normal bodily processes. (a2_knwApst_4__TF, a2_knwApst_4__Conf)
- The term “human enhancement” includes advancements like curing diseases. (a2_knwApst_5__TF, a2_knwApst_5__Conf)
- Liposomes have been used to house and deliver drugs in a way that gets a higher proportion of the drug to the target and less to the rest of the body. (a2_knwApst_6__TF, a2_knwApst_6__Conf)
- Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines. (a2_knwApst_7__TF, a2_knwApst_7__Conf)
- Research at the interface of nanotechnology and biology has been used for seemingly non-biological applications such as the creation of faster computer chips. (a2_knwApst_8__TF, a2_knwApst_8__Conf)

Answer If A2know_cond Is Equal to B

a2_knwBpst Indicate whether the following statements are true or false. Also rate how confident you are in your answer to the true/false question.

	This statement is:		I am _____ confident in my answer:				
	True (1)	False (2)	Not at all (1)	A little bit (2)	Moderately (3)	Mostly (4)	Completely (5)

- Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research. (a2_knwBpst_1__TF, a2_knwBpst_1__Conf)
- Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems. (a2_knwBpst_2__TF, a2_knwBpst_2__Conf)
- The government currently uses nano-scale devices to monitor people. (a2_knwBpst_3__TF, a2_knwBpst_3__Conf)
- The “second order effects” of nanotechnology can be accurately predicted from “first order effects.” (a2_knwBpst_4__TF, a2_knwBpst_4__Conf)
- Most traditional pollutant filters are able to catch and stop nanoparticles. (a2_knwBpst_5__TF, a2_knwBpst_5__Conf)
- One outcome already identified as possible with nanotechnology is innovative diabetes treatments that stimulate insulin production from outside the body. (a2_knwBpst_6__TF, a2_knwBpst_6__Conf)
- 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. (a2_knwBpst_7__TF, a2_knwBpst_7__Conf)
- Nanotechnology has already been used to develop materials to improve products such as tennis rackets. (a2_knwBpst_8__TF, a2_knwBpst_8__Conf)

a2_time15 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a2_Q21 Assignment Evaluation 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. 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 Estimated time spent completing this assignment (in *Minutes*). Please only include the time you spent actively working on the assignment. Do not include any breaks you took, interruptions that may have lengthened your time on the pages, or any time spent on web pages not relevant to the assignment.

Reading and exploring information (number of minutes) (a2_sptime_1_TEXT)

Writing your answers to questions (number of minutes) (a2_sptime_2_TEXT)

Total time (number of minutes) (a2_sptime_3_TEXT)

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)
- Felt distracted. (a2_engage_27)
- Was uninterested in the task I was asked to do. (a2_engage_28)
- Thought this process was not worth my time. (a2_engage_29)
- Felt angry. (a2_engage_32)
- Found it aggravating. (a2_engage_33)
- Was resentful. (a2_engage_34)
- 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

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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_5) • Compare the positives and negatives related to nanogenomics (a2_asseval_9) • See the issues from multiple perspectives (a2_asseval_10) • Formulate my arguments better (a2_asseval_13) • Think critically about evidence (a2_asseval_12) • Better understand what it means to think critically (a2_asseval_14) • Motivate me to look at the evidence for different claims, rather than just accepting the claims (a2_asseval_15)					

a2_bkgdevl_ What did you think of the background information? The information provided in the background materials was...

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
--	-----------------------	--------------	--------------------------------	-----------	--------------------

- 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_time17 Timing

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a2_prepare Overall, how useful was this assignment for helping you to think more about nanogenomics and nanomedicine and preparing you to answer the two overarching questions?

- ☐ 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 are you with nanotechnology?

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

a2_fmepst Now that you've done some reading....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)

a2_fgennst Now that you've done some reading....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)

a2_time18 Timing

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a2_Q22 Finally, answer the following question. The reason for the question below is to ensure the accurate evaluation of the assignments.

a2_honest Did you give an honest evaluation of this assignment? (You will not be penalized for your answer. You will receive credit for participation regardless of how you answer.)

- ☐ Yes, my answers reflect my honest evaluation of 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) _____

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

a2_time19 Timing

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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 if you would like a record of having completed this assignment. Your

Name:xxxxq://QID255/ChoiceTextEntryValue/1xx xxxxq://QID255/ChoiceTextEntryValue/2xxYour answers to the Open-ended Questions: 1. Question 1. xxxxq://QID366/ChoiceTextEntryValuexx 2.

Question 2. xxxxq://QID368/ChoiceTextEntryValuexx 3. Question

3: xxxxq://QID370/ChoiceTextEntryValuexx4. Response to Doug's

Dilemma. xxxxq://QID357/ChoiceTextEntryValuexx Your answers to the Overarching

Questions: (Note: These are the questions you will be revising in Step 4 -- Make sure you save a copy for yourself too) 1. Your Perspective:xxxxq://QID264/ChoiceTextEntryValuexx2. Other

Perspectives:xxxxq://QID116/ChoiceTextEntryValuexx

a2_email If you would also like this page emailed to you, 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

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4.1.3. Study 4 Assignment 3

Note that A3 varied between students working alone vs. in groups and students in the critical thinking vs. control conditions. Notations are provided throughout to indicated differences.

a3_Q1 ELSI Questions in Nano-biological Technology

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_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)

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[Instructions for critical thinking condition:]

a3_Q3 Instructions The following are FICTIONAL potential FUTURE scenarios.

Today, you will be reading some scenarios that have to do with some of the Ethical, Legal, and Social Issues related to the use of nanotechnology for human enhancement. Each scenario might bring up different issues, so we want to encourage you to think thoroughly about each issue as it comes to mind and write down any opinions or thoughts that you have.

Remember to evaluate the evidence of different points of view. Is the evidence relevant or strong enough? Is there enough evidence? Keep an eye out for bias. Are some points of view more driven by values than others? Also try to think of any details relevant from when you read the background document, and incorporate those into your responses. Please write your responses to the scenarios.

IMPORTANT NOTE: Some of the scenarios include things commonly said by people reacting to nanotechnology. These are NOT necessarily FACTS. It is your job, as you reflect on what the fictional people say, to determine if it is likely true or false, and the extent to which you agree with it. Use your background document that was provided to you, and any additional materials or your own research, to make these determinations.

[Instructions for control condition:]

a3_Q3 Instructions The following are FICTIONAL potential FUTURE scenarios. Please write your responses to the scenarios.

IMPORTANT NOTE: Some of the scenarios include things commonly said by people reacting to nanotechnology. These are NOT necessarily FACTS. It is your job, as you reflect on what the fictional people say, to determine if it is likely true or false, and the extent to which you agree with it. Use your background document that was provided to you, and any additional materials or your own research, to make these determinations.

a3_prsnesy Possible Scenario: Barless Prisons Imagine that sometime in the future, researchers develop a caged drug (a drug within a nano-sized capsule) that is injected into prisoners that becomes activated by radio control if prisoners cross designated boundaries. The following scenario reflects this possibility. Ever since the first true nanomedicine product came on the market, a caged cancer drug

that releases once bound to the cancer cell, researchers have been working towards utilizing these technologies for control purposes. This week it was announced that NanoCage, in collaboration with United Penitentiary Systems, have developed the first barless prison. Upon entry, inmates are injected with a cocktail of caged drugs that have a variety of effects when released via radio control. The base technology utilizes focused radio waves to target deep tissue tumors in places such as the abdominal cavity. The basis for security is a net of radio transmitters that surrounds the facility. As a prisoner crosses the perimeter threshold, the radio signals will cause the release of one type of caged drug. For instance, if the prisoner crosses an inner 'warning' perimeter, a drug will be released that causes extreme vertigo and mild nausea. If the prisoner continues, the next perimeter will signal the release of incapacitating sedatives, and if the next signal is reached it will trigger a fatal dose of narcotics. These perimeters are spaced far apart enough to prevent unintentional crossing of more than the first. The caged drug is connected to an antenna that upon receipt of a specific radio signal causes the physical break down of the carbon-nanotube-based cage. The package including the antenna is roughly half the size of a red blood cell. A coating of biocompatible molecules minimizes the physiological side effects from the caged drugs. There is, on very rare occasions, mild inflammatory responses that can be treated with over the counter anti-inflammatory drugs. Because some degradation of the caged drugs occurs naturally in the body, supplemental injections are advised every six weeks and always after drugs have been released. Guards in barless facilities will be equipped with radio transmitters that can be aimed at individual inmates or larger areas to quell local unrest. The transmitters used by the guards will be unable to access the frequencies that trigger the fatal dosages. NanoCage and United Penitentiary Systems claim this is the new model for working prisons, where inmate labor is unencumbered by restraints or monitoring devices and physical investment costs are not much more than traditional factories. The perimeter of these facilities need only be physically secured to keep people from trespassing on the grounds.

[For critical thinking condition:]

a3_prsnesy

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations. Be sure to use evidence that you found in the background resources or your own research, to support your claims and recommendations. Whenever possible cite where your information is coming from (e.g., National Geographic 2008, your own experience, understandingnano.com, etc). Pay attention to the quality of the information you use as evidence: Is it unbiased? Relevant? Accurate? Is the evidence typical and generalizable? Is it sufficient? The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations.

[for control condition:]

a3_prsnesy

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and

how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations.

[additional question for critical thinking condition:]

a3_prsnotr Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? Be sure to consider why they might feel as they do, that is the values and interests underlying their views, and indicate if you are in disagreement with their values or with their evidence/conclusions. Pay attention to the quality of evidence that they might use to support their view, and whether you agree that the evidence is strong or not. Be sure that your answer to them lines up with and acknowledges their perspective so that you are not just “talking past” their points. The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations, even if they disagree with you.

[additional question for control condition:]

a3_prsnqst What questions came up as you were answering this scenario, or would you like to have answered in order to be able to write a better response to the scenario above?

a3_prsnrvw To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question?

- ☐ Not at all (1)
- ☐ Slightly (2)
- ☐ Somewhat (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_prsninf To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario?

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

a3_prsnbgh To what extent do you feel like the background document that you were provided with in

Assignment 2 (the reading provided before you came to reci) was helpful as you responded to this scenario?

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

a3_t2 Timing

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a3_cysfesy Possible Scenario: Cystic Fibrosis Prevention Imagine that some time in the future nanotechnology has enabled doctors to be able to screen for and prevent many common genetic disorders. The following scenario reflects this possibility. Mr. and Mrs. Vanderbilt have decided they would like to have a baby. Both Mr. and Mrs. Vanderbilt have the genetic markers for Cystic Fibrosis. Their doctor informs them that for xx250,000, he can, through the use of nanogenetics, ensure that their baby is not born with Cystic Fibrosis. The Vanderbilt family can afford this, but wonder if they should. Mrs. Vanderbilt favors any kind of intervention that may keep their future children healthy, "we have a responsibility to our future children to keep them from suffering," she says. "If there is something that can be done to ensure that our son or daughter is born healthy, then how could we not take advantage of it and still call ourselves good parents?" Mr. Vanderbilt is against use of this technology. He thinks that technology that is applied to genetics is always wrong. Sure, this technology may benefit his child, but he worries that the same technology could be misused and that people will engineer children based on physical appearances. "This technology should be outlawed," he says. "It can only lead to no good. For example, people will start to create super-babies," he says, "and future generations will all end up looking and acting the same." "Furthermore," he worries, "what does this say about people alive now who have diseases and disabilities? Does this mean that we think that they are less worthy of life than others? And what if mistakes are made in messing with our human genetic code and these mistakes are passed down from generation to generation?"

[critical thinking]

a3_cysfesy

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations. Be sure to use evidence that you found in the background resources or your own research, to support your claims and recommendations. Whenever possible cite where your information is coming from (e.g., National Geographic 2008, your own experience, understandingnano.com, etc). Pay attention to the quality of the information you use as evidence: Is it unbiased? Relevant? Accurate? Is the evidence typical and generalizable? Is it sufficient? The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations.

[control]

a3_cysfesy

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations.

[critical thinking]

a3_cysfotr

Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? Be sure to consider why they might feel as they do, that is the values and interests underlying their views, and indicate if you are in disagreement with their values or with their evidence/conclusions. Pay attention to the quality of evidence that they might use to support their view, and whether you agree that the evidence is strong or not. Be sure that your answer to them lines up with and acknowledges their perspective so that you are not just “talking past” their points. The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations, even if they disagree with you.

[control]

a3_cysfqst

What questions came up as you were answering this scenario, or would you like to have answered in order to be able to write a better response to the scenario above?

a3_cysfrvw To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question?

☐ Not at all (1)

- ☐ Slightly (2)
- ☐ Somewhat (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_cysfinf To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario?

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

a3_cysfbgh To what extent do you feel like the background document that you were provided with in Assignment 2 (the reading provided before you came to reci) was helpful as you responded to this scenario?

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

a3_t3 Timing

- First Click (1)
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a3_hlcpesy Possible Scenario: Healthy Chip Imagine that sometime in the future, a new breed of smart nanodevices makes tedious, often inaccurate, disease monitoring and treatment processes a thing of the past. The following scenario reflects this possibility. The Healthychip Network System, available to patients through their doctors, can not only continuously monitor chemical deficiencies or saturations within the body, but can deliver medicine before the patient is even able to recognize any physical symptoms. Patients who have been diagnosed with a disease that can be monitored and regulated with the Healthychip Network System are injected with a large set of networked nanoscale electronic chips referred to as receptor chips. The receptor chips contain nanonowires that have attached to them

specially designed molecules. These specially designed molecules are able to bind to very specific chemicals within the bloodstream. When the chemical that is being monitored within the blood binds to one of these molecules on the nanowire, an electronic property of the nanowire changes, and the receptor chip is able to detect the chemical within the bloodstream. With many nanowires on each chip, the receptor chip calculates the concentration of that chemical in the bloodstream at its location by reading the changes in electronic properties of the many nanowires. Every few seconds, each of these electronic receptor chips uses a wireless signal to send the data regarding chemical concentrations to a central computer chip implanted beneath the skin. This central chip takes in the data from all of the chips located throughout the body, and calculates whether or not to release medication needed to regain, or maintain, healthy chemical levels in the bloodstream. This chip, equipped with a medication reservoir, is then able to release the required amount of medicine within the body. In the case of diabetes, the central chip can choose to release insulin or a sugar derivative depending upon sugar levels within the blood. This centralized chip can be refilled when the medicine within it runs out, or removed when a disease is cured. Once a disease has been diagnosed and a chemical treatment plan ascertained, doctors can choose the correct Healthy Chip Network System. The receptor chips are then injected into the blood stream through an IV. The central chip is calibrated prior to insertion, to make sure that it is working correctly with the receptor chips. Finally, the central chip with corresponding medicine is inserted beneath the skin at a location determined by the patient and the doctor. Information about how often medicine is administered is recorded on the central chip and that information can be scanned and downloaded by the doctor at any time. The patient and doctor can then receive detailed information about how often chemical irregularities occur. This is helpful in the case of diabetes, when the patient is attempting to make lifestyle changes in diet and exercise. The central chip is then able to give information about whether those lifestyle changes are helping improve the condition by possibly showing a decrease in the number of times the central chip has to dispense medication.

[critical thinking]

a3_hlcpesy

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations. Be sure to use evidence that you found in the background resources or your own research, to support your claims and recommendations. Whenever possible cite where your information is coming from (e.g., National Geographic 2008, your own experience, understandingnano.com, etc). Pay attention to the quality of the information you use as evidence: Is it unbiased? Relevant? Accurate? Is the evidence typical and generalizable? Is it sufficient? The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations.

[control]

a3_hlcpesy

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and

how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations.

[critical thinking]

a3_hlcpotr

Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? Be sure to consider why they might feel as they do, that is the values and interests underlying their views, and indicate if you are in disagreement with their values or with their evidence/conclusions. Pay attention to the quality of evidence that they might use to support their view, and whether you agree that the evidence is strong or not. Be sure that your answer to them lines up with and acknowledges their perspective so that you are not just “talking past” their points. The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations, even if they disagree with you.

[control]

a3_hlcpqst

What questions came up as you were answering this scenario, or would you like to have answered in order to be able to write a better response to the scenario above?

a3_hlcpvrv To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question?

- ☐ Not at all (1)
- ☐ Slightly (2)
- ☐ Somewhat (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_hlcpinf To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario?

- ☐ Not helpful at all (1)
- ☐ Slightly helpful (2)
- ☐ Somewhat helpful (3)
- ☐ Very helpful (4)

☐ Extremely helpful (5)

a3_hlcpbgh To what extent do you feel like the background document that you were provided with in Assignment 2 (before you came to reci) was helpful as you responded to this scenario?

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

a3_t4 Timing

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- Page Submit (3)
- Click Count (4)

a3_memesay Possible Scenario: Improving Human Memory Development Imagine that many years in the future Supernanotech Labs is trying to apply past nanogenomic research findings to improve human memory development. The head of the Food and Drug Administration is seeking advice from a panel of citizens regarding their opinions on how regulated this research should be. Participant 1: "This research is an abomination. God would not want us messing with his work. I don't even think this research and development should be done -- regulated or not." Participant 2: "Not everyone shares your views on what God wants. This research could help people with memory problems. What if this research could lead to cures for Alzheimer's? Plus, it would be better if we could all remember everything. We would all be so much smarter! I think that this research should be somewhat regulated, but not so much that research and creativity is stifled or delayed." Participant 3: "I'm pretty sure that only rich and important people would have access to this kind of thing. Then they will be even more rich and important, and the poor will be even more poor. The cycle will never end. Assuming this research goes forward, there needs to be regulations in place that ensure that the developments from this research are not only available to the wealthy." Participant 4: "I disagree. We live in a free market economy and if you don't let the rich buy this technology, you will slow its development. Let the rich buy it, and then more developments will occur so that it becomes cheaper for lower-income people. But if you do not let the rich buy it, future research and development won't even occur -- or it will occur very slowly and other countries will beat us to the big findings. Then THEY will have the market, because they got there first." Participant 5: "My concern is that we don't know the consequences of altering DNA."

What if memory gets better but people get more aggressive, or crazy, or something? We just don't know. Also, what will be the very long term effects of using this technology? There has to be special regulations in place to make sure that these things don't happen." What should the head of the Food and Drug Administration recommend to the FDA about regulation? How do you feel? Why? How would you respond to the participants above? Would you have a different perspective to add that they did not think of?

[critical thinking]

a3_memesay

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations. Be sure to use evidence that you found in the background resources or your own research, to support your claims and recommendations. Whenever possible cite where your information is coming from (e.g., National Geographic 2008, your own experience, understandingnano.com, etc). Pay attention to the quality of the information you use as evidence: Is it unbiased? Relevant? Accurate? Is the evidence typical and generalizable? Is it sufficient? The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations.

[control]

a3_memesay

Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations.

[critical thinking]

a3_memotr Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? Be sure to consider why they might feel as they do, that is the values and interests underlying their views, and indicate if you are in disagreement with their values or with their evidence/conclusions. Pay attention to the quality of evidence that they might use to support their view, and whether you agree that the evidence is strong or not. Be sure that your answer to them lines up with and acknowledges their perspective so that you are not just "talking past" their points. The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations, even if they disagree with you.

[control]

a3_memqst What questions came up as you were answering this scenario, or would you like to have

answered in order to be able to write a better response to the scenario above?

a3_memrvw To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question?

- ☐ Not at all (1)
- ☐ Slightly (2)
- ☐ Somewhat (3)
- ☐ Quite a bit (4)
- ☐ A great deal (5)

a3_meminfo To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario?

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

a3_membgh To what extent do you feel like the background document that you were provided with in Assignment 2 (before you came to reci) was helpful as you responded to this scenario?

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

a3_t5 Timing

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

a3_Q4 NOTICE Do not continue past this page unless your recitation instructor has directed you to do

so. Continue writing on the questions until your instructor tells you that it is time to debrief. Use the "back" button below to return to the scenarios if your instructor has not yet said it is time to debrief. If you cannot think of any thing more to write about the scenarios, please revisit the background document (available from the New Biology assignment coordinators) or other resources, or do some additional research on your own that pertains to the questions raised in the scenarios. Use the "continue" button below ONLY if your instructor has said that it is time to do so. Otherwise, use the "back" button below to continue working on the assignment.

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_regslid 2. 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_chgmnd Please answer the following questions about your attitudes with regard to when you began these exercises.

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

Overall, from the time you began these exercises, until now, to what extent did you change your mind about the questions above? (a3_chgmnd)

Overall, from the time you began these exercises, until now, to what extent did strengthen your original

opinions about the questions above? (a3_chgmnd_strength)

a3_Q6 Activity Evaluation And lastly, once again, to assist in improving these activities for future students, please answer this last page of questions.

a3_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. (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)
- Felt distracted. (a3_Engage_27)
- Was uninterested in the task I was asked to do. (a3_Engage_28)
- Thought this process was not worth my time. (a3_Engage_29)
- Felt angry. (a3_Engage_32)

- Found it aggravating. (a3_Engage_33)
- Was resentful. (a3_Engage_34)
- 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)

[ONLY THOSE IN GROUPS COMPLETED THE FOLLOWING QUESTIONS]

a3_idnty_ Please indicate how important each of the following was to you during the discussion today.

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

My identity as an individual (a3_idnty_1)

My identity as a member of my group during today's discussion (a3_idnty_2)

My identity as a student in this specific Recitation section (a3_idnty_3)

My identity as a student in Bio102 (a3_idnty_4)

My identity as a UNL student (a3_idnty_5)

My identity as an American (a3_idnty_6)

My identity as a member of my racial group (a3_idnty_7)

My identity as a human being (a3_idnty_8)

a3_t8 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

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 at any time be able to see the answers that you put down. Any information we obtain will be completely confidential.

a3_grpsat 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 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_grpdis How much disagreement was there within your group?

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

a3_grpcons How much consensus was there within your group?

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

a3_grpelsi During the discussion, my group reached a consensus as to the answers to the ethical scenarios.

- ☐ Strongly disagree (1)
- ☐ Disagree (2)
- ☐ Somewhat disagree (3)
- ☐ Neither agree nor disagree (4)
- ☐ Somewhat agree (5)
- ☐ Agree (6)
- ☐ Strongly agree (7)

a3_grpinxn_ To what extent did the interaction feel like:

	Not at all (1)	Slightly (2)	Somewhat (3)	Quite a bit (4)	Extremely (5)
--	----------------	--------------	--------------	-----------------	---------------

One group (a3_grpinxn_1)

Two or more subgroups within a larger group (a3_grpinxn_2)

Two or more subgroups (a3_grpinxn_3)

Separate individuals (a3_grpinxn_4)

a3_t9 Timing

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

The following data not included in order to de-identify data

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)

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.

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

[each group member, x1 to x4, is listed, response options are:]

Not at all familiar (1)	Slightly familiar (2)	Somewhat familiar (3)	Quite familiar (4)	Extremely familiar (5)	N/A (blank) (6)
-------------------------	-----------------------	-----------------------	--------------------	------------------------	-----------------

a3_recimem Please indicate whether each person is a member of your recitation small group.

[Note that students had small groups for their recitation that they stayed in throughout the semester and the small groups used for this study may or may not have included members also in their 'reci small group'. Thus, each "study" small group member is listed, response options are:]

No (1)	Yes (2)	N/A (blank) (3)
--------	---------	-----------------

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

[each group member is listed, response options are:]

Not at all similar (1)	A little similar (2)	Somewhat similar (3)	Quite similar (4)	Extremely similar (5)	N/A (blank) (6)
------------------------	----------------------	----------------------	-------------------	-----------------------	-----------------

a3_agreopi To what extent did you agree with the opinions expressed by each person during the discussion?

[each group member is listed, response options are:]

Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neither Agree nor Disagree (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)	N/A (blank) (8)
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a3_t10 Timing

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

a3_grpatt_ To what extent do you agree with the following statements?

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
--	-----------------------	--------------	-----------------------	--------------------------------	--------------------	-----------	--------------------

- I felt strong ties with my group. (a3_grpatt_1)
- The other group members valued my contribution to the discussion. (a3_grpatt_2)
- The other group members' ideas were excellent. (a3_grpatt_3)
- My ideas were not respected by other group members. (a3_grpatt_4)
- I felt as though everyone was cooperating with each other. (a3_grpatt_5)
- During the interaction, group members were competing with each other. (a3_grpatt_6)

a3_t11 Timing

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

[HERE ENDS THE SECTION OF QUESTIONS FOR ONLY THOSE IN GROUPS]

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_t7 Timing

First Click (1)

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

a3_Q9 Finally, here are the answers that you entered to the scenarios. Barless Prisons
xxxxq://QID73/ChoiceTextEntryValuexx Cystic Fibrosis Prevention
xxxxq://QID43/ChoiceTextEntryValuexx Healthy Chip
xxxxq://QID66/ChoiceTextEntryValuexx Improving Human Memory Development
xxxxq://QID39/ChoiceTextEntryValuexx

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.

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

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

[MODERATOR RATINGS of groups, for persons in group condition, are also included in the data set, see appendix C for the moderator data form]

4.1.5. Study 4 Assignment 4

S4 A4 post survey final version

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_Q3 At the beginning of the semester, we gave you this information about the goals of the "New Biology" assignments, and the steps we would be taking to try to meet those goals. Specifically, the New Biology assignments took you through the following steps of a specific method of public engagement: 1. Opening reflections. During this step you reflected on what you know, what you feel, who you trust and who you are. The purpose was to reflect on your "starting point" related to the discussion. 2. Information Investigation & Exploration. Then you had a reading assignment about Nanotechnology and heard a guest lecture on Ethical, Legal and Social Issues in science. 3. Issue Deliberation. Following the reading, you considered some ethical scenarios pertaining to nanotechnology and biology and deliberated about the best courses of action in light of those scenarios. 4. Public Input. The final step in the process is for you to give your input on the issues. Based on what you learned, you now will write down what you think nano-biological scientists should pursue, and how policy makers should regulate nano-biological developments. <-- You are doing this NOW!

a4_getsum 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. Would you like to receive a copy of the results from your class? -- If yes, we would use the email you enter at the end of this survey to send you a summary of your class's views. The summary would come sometime next semester.

- ☐ yes, please send me a summary of the results (1)
- ☐ no thanks (2)

[Note, we actually provided a summary of results to ALL students during the recis at the end of the semester regardless of their answer to this question. Answers to this question however may indicate

level of interest in other's opinions]

a4_t2 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a4_Q4 Final Analysis: Where Do You Stand? Now that you have responded to the ethical scenarios and have had more experience thinking about the ethical, legal and social issues related to nanotechnology, you may have changed your mind about the overarching questions. Please start with the answers that you saved from Assignment 2 in which you read about nanomedicine, nanogenomics and ELSI issues. Revise your prior answers to expand upon and reflect your current opinions. Your final grade on THIS assignment will be based on your improvements between your answer in Assignment 2 and your answer below. Even if you didn't change your mind between Assignment 2 and now, your answer can be improved by expanding it.

a4_inputself (1) Your Perspective: What developments should be prioritized and what regulations are needed? 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? 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? What ethical, legal and social issues need to be considered and resolved when making decisions about the development and regulation of nano-biological technologies, especially when it comes to human enhancement? In your opinion, how should these issues be resolved, and why? Please reconsider your one paragraph response to this question from prior Assignments, and revise and expand on it now that you have had a chance to think about the ethical scenarios presented at your last recitation:

a4_chngmnd 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_inputthr (2) Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? How might others differ from you? What might they want the future of nano-biological technology development to look like in terms of human enhancement applications? What different social policies, rules, limits, and regulations might they want in place? And what ethical, legal, and social issues would they prioritize in their consideration of nano-biological technologies? Why do you think they would have their opinions? What evidence or reasons would they have for their views? How would you answer a person or persons who disagree(s) with you and holds such views? Please reconsider your one paragraph response to this question from prior Assignments, and revise and expand on it now that you have had a chance to think about the ethical scenarios presented at your last recitation:

a4_regchn 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_t3 Timing

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

a4_Q5 Final Input You've seen these questions before. You may answer them the same as before, or differently if you changed your mind. We will base the results that we report to you and your classmates (and in our other reports, if you gave consent) on these final answers of yours.

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_chgmnd_riskben 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_chgmnd_reg 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_inflnce_ To what extent did the following influence the final views that you gave about nanobiological 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 people important to me. (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 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_t4 Timing

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

a4_Q6 Final Input Most of these items you have not seen since the very first assignment, most likely before you knew much about nanotechnology. This is your chance to give your final answers, now that you know more. We will base the results that we report to you and your classmates (and in our other reports, if you gave consent) on these final answers of yours.

a4_ATTPRE_ Next, please indicate your opinions about some of the 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)
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Nanotechnology is one of the more important issues confronting government today. (a4_ATTPRE_1)

The risk of nanotechnology directly affecting physical things like human health, wildlife or the environment in general is currently too high. (a4_ATTPRE_2)

The risk of nanotechnology affecting social systems like the economy, trade and sustainable food supply is currently too high. (a4_ATTPRE_3)

The government will effectively manage any risks associated with nanotechnology. (a4_ATTPRE_4)

Scientists working with nano-biological technologies will develop them in directions that are positive for society. (a4_ATTPRE_5)

We should develop nanotechnology at full speed despite its possible risks, in order to keep the U.S. from falling behind other countries. (a4_ATTPRE_6)

There are serious ethical problems associated with not quickly developing nanotechnologies. (a4_ATTPRE_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. (a4_ATTPRE_8)

a4_genrate_ When it comes to nanobiological technologies, how important are the following general goals?

	Unimportant (1)	Slightly important (2)	Important (3)	Very important (4)	Extremely important (5)
--	-----------------	------------------------	---------------	--------------------	-------------------------

- Minimizing potential risks for humans. (a4_genrate_1)
- Minimizing potential environmental risks. (a4_genrate_2)
- Making decisions about the most important directions for future development. (a4_genrate_3)
- Studying the social and ethical impacts and implications of future developments and regulations. (a4_genrate_4)
- Maximizing potential benefits for human enhancement. (a4_genrate_5)
- Maximizing potential environmental benefits. (a4_genrate_6)

a4_gensum_ There are, of course, only a limited number of resources (time, effort, money) that can be spent on each of the things that you rated above. So, please consider what percentage of the U.S. resources (e.g., total time, effort, and money) should be spent on each. Make sure that your percentages sum to 100%, and make sure that you give the items you rated the most important the greatest percentage of resources. What percentage of resources would you assign to each category?

- Minimizing potential risks for humans. (a4_gensum_1)
- Minimizing potential environmental risks. (a4_gensum_2)
- Making decisions about the most important directions for future development. (a4_gensum_3)
- Studying the social and ethical impacts and implications of future developments and regulations. (a4_gensum_4)
- Maximizing potential benefits for human enhancement. (a4_gensum_5)

- Maximizing potential environmental benefits. (a4_gensum_6)

a4_t5 Timing

First Click (1)

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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. 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)

a4_t6 Timing

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a4specimpt 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)
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- 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_18)
- The elimination of genetic inheritance of disease. (a4specimpt_7)
- Economic development through investment and research. (a4specimpt_8)
- Economic disruption caused by the loss of traditional jobs. (a4specimpt_9)
- Loss of personal privacy due to tiny new surveillance devices. (a4specimpt_10)
- Pollution of the environment by nanomaterials. (a4specimpt_11)
- Unforeseen side-effects from nanomedicines. (a4specimpt_15)
- Loss of religious liberties (a4specimpt_19)
- The widening of the gap between the rich and the poor. (a4specimpt_16)

a4_t7 Timing

First Click (1)
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NOTE: RANDOMLY ASSIGNED ONE-HALF THE RESPONDENTS RECEIVED A4FSCNLOWR (LOWER REGULATIONS AND INCREASING DEVELOPMENT) AND ONE-HALF RECEIVED A4SCNHIR (INCREASING REGULATIONS AND DECREASING PACE OF DEVELOPMENT).

a4fscnlowr 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 nanogenomics, 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. 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, 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.

	Strongly disagree (1)	Disagree (2)	Slightly disagree (3)	Slightly agree (4)	Agree (5)	Strongly agree (6)
--	-----------------------	--------------	-----------------------	--------------------	-----------	--------------------

- The process used by the government to make decisions about this issue was fair. (a4fscnlowr_1)
- The government made the right choices with regard to this issue. (a4fscnlowr_2)
- The government made the same choices you would have made. (a4fscnlowr_3)
- The government should have made different decisions about the issue. (a4fscnlowr_4)
- The government should have used a different process to get public input about this issue. (a4fscnlowr_5)

a4fscnHlr 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 nanogenomics. 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 nanogenomics and nanomedicine, in the same way that you were asked to respond (e.g., if you discussed the issues in a group, they also did; but if you worked alone, they also worked alone) 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, 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 process used by the government to make decisions about this issue was fair. (a4fscnHlr_1)
- The government made the right choices with regard to this issue. (a4fscnHlr_2)
- The government made the same choices you would have made. (a4fscnHlr_3)
- The government should have made different decisions about the issue. (a4fscnHlr_4)
- The government should have used a different process to get public input about this issue. (a4fscnHlr_5)

a4fscnexpl_txt If you would like to comment on this scenario, or explain your ratings, please do so here.

a4_t8 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

NOTE: Participants ALSO were randomly assigned to receive one of the following two questions:

a4slowrsch If legislation were being considered that would slow down nanogenomics research and development in the area of human enhancement by decreasing funding and increasing restrictions...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)

a4fastrsch If legislation were being considered that would speed up nanogenomics research and development in the area of human enhancement by increasing funding and decreasing restrictions... 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)

a4_t9 Timing

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

a4_Q7 Who Do you Trust? Back at the beginning of the semester, we promised you would be able to change your mind on various questions. Here are a few more of those questions.

a4_knowNS_ NANOSCIENTISTS First, consider what you know about the nanoscientists responsible for researching and making discoveries involving nanotechnology.

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

- How much do you know about nanoscientists? (a4_knowNS_1)
- To what extent have you had experiences or interactions with nanoscientists? (a4_knowNS_2)
- To what extent do you feel certain in your views about nanoscientists? (a4_knowNS_3)

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)

a4_gconfNS_ In general, to what extent do you feel nanoscientists probably...

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

- Are trustworthy. (a4_gconfNS_1)
- Listen to everyone's opinion. (a4_gconfNS_2)
- Care about the community they serve (a4_gconfNS_3)
- Are primarily motivated by what will benefit them personally (a4_gconfNS_4)
- Will do the right thing only if they are punished for doing the wrong thing (a4_gconfNS_5)
- Don't really care about the long-term risks of their work (a4_gconfNS_6)

a4_t10 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a4_knowPM_ POLICY MAKERS Next, consider what you know about the policy makers responsible for making decisions about funding and regulations involving nanotechnology.

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

- How much do you know about policy makers who regulate nanotechnology? (a4_knowPM_1)
- To what extent have you had experiences or interactions with these policy makers? (a4_knowPM_2)
- To what extent do you feel certain in your views about these policy makers? (a4_knowPM_3)

a4_sconfPM To what extent do you have confidence in policy makers who help regulate nanotechnology to...

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

- Do their jobs well (a4_sconfPM 1)
- Meet their professional responsibilities (a4_sconfPM 2)
- Make decisions about the most important directions for future development. (a4_sconfPM 3)

a4_gconfPM_ To what extent do you feel policy makers who help regulate nanotechnology...

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

- Are trustworthy. (a4_gconfPM_1)
- Listen to everyone's opinion. (a4_gconfPM_2)
- Care about the community they serve. (a4_gconfPM_3)
- Are primarily motivated by what will benefit them personally. (a4_gconfPM_4)
- Will do the right thing only if they are punished for doing the wrong thing. (a4_gconfPM_5)
- Don't really care about the long-term risks of their work. (a4_gconfPM_6)

a4_t11 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a4chgscipo_ In your estimation, as you learned more about the development and regulation of nano-biological technologies, how much did you change your feelings and attitudes about ...

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

- The scientists responsible for studying and developing nanotechnologies. (a4chgscipo_1)
- The policy makers responsible for making decisions about the funding and regulation of nanotechnologies. (a4chgscipo_2)

a4_t12 Timing

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

a4_Q8 What do you know? 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

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

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)

a4_know2c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

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)

a4_know1c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

A4know4 Which of the following is between 1 and 100 nanometers?

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

a4_know4c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (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_know6c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)

- ☐ Mostly (4)
- ☐ Completely (5)

a4_know7 Which of the following is not a known risk of nanotechnology?

- ☐ Nanomaterials have been shown to be active at the cellular level, which can cause inflammation and even tumors in the lungs. (1)
- ☐ The lungs of rats and mice have been damaged in experiments using nano-sized carbon nanotubes. (2)
- ☐ Nanomaterials have been shown to interact adversely with skin cells, which have already been shown to cause skin cancer in otherwise healthy humans. (3)
- ☐ Iron nanoparticles have been shown to be able to travel with groundwater into soil and remain active for weeks. (4)

a4_know7c Please indicate how confident you are in your answer to the above question:

- ☐ Not at all (1)
- ☐ A little bit (2)
- ☐ Moderately (3)
- ☐ Mostly (4)
- ☐ Completely (5)

a4_t14 Timing

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

a4_Q10 What do you know?

a4TFABC_1_ Now, please indicate whether the following statements are true or false. Also rate how confident you are in your answer to the true/false question.

	This statement is: (1)	I am _____ confident in my answer: (2)
--	------------------------	--

	True (1)	False (2)	Not at all (1)	A little bit (2)	Moderately (3)	Mostly (4)	Completely (5)
--	----------	-----------	----------------	------------------	----------------	------------	----------------

SET A (MATCHES A2 SET A)

Nanotechnology is already being used to map the human genome (a4TFABC_1_22, **conf questions are similar but named with a '2' as in: a4TFABC_2_22**)

Breakthroughs in nanogenomics already allow very wealthy parents to manipulate the intelligence of their children. (a4TFABC_1_7)

A good example of a nano-sized object is a red blood cell. (a4TFABC_1_8)

Nanomaterials in the environment can enter the body; certain nanoparticles have already been shown to interfere with normal bodily processes. (a4TFABC_1_21)

The term "human enhancement" includes advancements like curing diseases. (a4TFABC_1_9)

Liposomes have been used to house and deliver drugs in a way that gets a higher proportion of the drug to the target and less to the rest of the body. (a4TFABC_1_10)

Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines. (a4TFABC_1_11)

Research at the interface of nanotechnology and biology has been used for seemingly non-biological applications such as the creation of faster computer chips. (a4TFABC_1_25)

SET B (MATCHES A2 SET B)

Although they both deal with biological applications of nanotechnology, there is no overlap between nanogenomic and nanomedicine research. (a4TFABC_1_15)

Numerous nanotechnology products are already on the market; therefore, research and development in nanotechnology is already affecting economic systems. (a4TFABC_1_16)

The government currently uses nano-scale devices to monitor people. (a4TFABC_1_17)

The "second order effects" of nanotechnology can be accurately predicted from "first order effects." (a4TFABC_1_18)

Most traditional pollutant filters are able to catch and stop nanoparticles. (a4TFABC_1_19)

One outcome already identified as possible with nanotechnology is innovative diabetes treatments that stimulate insulin production from outside the body. (a4TFABC_1_24)

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_1_14)

Nanotechnology has already been used to develop materials to improve products such as tennis rackets. (a4TFABC_1_13)

SET C (MATCHES A1)

Materials that are harmless at the macro-level could be harmful at the nano-level. (a4TFABC_1_2)

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_1_3)

All nanoscale materials can conduct electricity because of their extremely small size. (a4TFABC_1_4)

Nanoparticles exist naturally in the environment. (a4TFABC_1_5)

A limitation of nanoparticles is they cannot penetrate into the brain. (a4TFABC_1_6)

SET D (NEW)

The major risks associated with the use of nanomedicine have been identified. (a4TFABC_1_1)

Currently, it is really hard to predict the potential second order-effects of nano-technology. (a4TFABC_1_12)

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_1_20)

Due to the increased cost of surgical and diagnostic tools, nanotechnology will definitely increase the cost of health care. (a4TFABC_1_23)

a4_t15 Timing

First Click (1)

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Click Count (4)

a4_traits_1_ On this page, please complete the following questions about your general views about citizenship and social issues.

	Extent of Agreement					
	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. (a4_traits_1_1)
- A good citizen should allow others to challenge their political beliefs. (a4_traits_1_2)
- A good citizen should discuss politics with those who disagree with them. (a4_traits_1_3)
- A good citizen should be willing to justify their political views. (a4_traits_1_4)
- If a citizen is dissatisfied with the policies of government, he or she has a duty to do something about it. (a4_traits_1_5)
- I follow political and social issues because I want to learn new things. (a4_traits_1_6)
- I follow political and social issues because that's what I'm expected to do. (a4_traits_1_7)
- I follow political and social issues because it bothers me when I don't. (a4_traits_1_8)
- Being politically and socially conscious is important to who I am. (a4_traits_1_9)
- I follow political and social issues because that's what I'm supposed to do. (a4_traits_1_10)
- I follow political and social issues because I will feel bad about myself if I don't. (a4_traits_1_11)
- I follow political and social issues because I think it's important. (a4_traits_1_12)
- People like me don't have any say about what the government does. (a4_traits_1_13)
- Sometimes politics and government seem so complicated that a person like me can't really understand what's going on. (a4_traits_1_14)
- I consider myself well-qualified to participate in politics. (a4_traits_1_15)
- I think that I am better informed about political and social issues than other students. (a4_traits_1_16)
- I feel I have a pretty good understanding of current political and social issues facing my world. (a4_traits_1_17)
- I consider myself well qualified to provide input on political and social issues. (a4_traits_1_18)

a4_t16 Timing

First Click (1)

Last Click (2)

Page Submit (3)

Click Count (4)

a4_Q11 At the beginning of the semester, you saw this text: Are changes needed in biology

education? To ensure that biology majors are equipped to work across traditional subdisciplinary boundaries? To provide biology curricula that equip physical scientists and engineers to take advantage of advances in biological science? And to provide nonscientists with a level of biological understanding that gives them an informed voice regarding relevant policy proposals? --From "A New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution" One purpose of a university education is to create well-informed community members (i.e., citizens) who can advise government on the direction that society should move and public policies. While "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" divorced from society. Science developed apart from a consideration of its role in society may not be utilized or utilized correctly.

a4_IrnELSI_txt 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.

a4ELSIchgm To what extent did you change your mind about the question above over this semester?

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

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)

a4_t17 Timing

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

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)
- Click Count (4)

a4_Q13 FULL CONSENT Language was here

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)

Last Click (2)

Page Submit (3)

Click Count (4)

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.

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.

[data below not included due to deidentification of data]

a4email Finally, 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)

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a4_Q15 THANK YOU! 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. Email to which you sent your work: xxxxq://QID232/ChoiceGroup/AllChoicesTextEntryxx Your answers: Your Perspective: xxxxq://QID293/ChoiceTextEntryValuexx Other Perspectives: xxxxq://QID346/ChoiceTextEntryValuexx

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4.1.6. Compiled Measures and Scales

What follows is a brief description of the measures included in each assignment.

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.

- 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?)

Parental Education. Answers on a nine-point scale including: I don't know; did not complete high school; completed high school; completed some post-secondary education, but no degree; received a 2-year degree, e.g. associate's degree; received a 4-year college degree, e.g. B.A., B.S., etc.; completed some post-graduate courses, but no additional degree; received a 2-year post-graduate degree (e.g. M.A., M.S., etc.); received a 4-year post-graduate degree (e.g. PhD, D.Ed, etc.)

- What is the highest level of education of your mother?
- What is the highest level of education of your father?

Subjective Knowledge. Answers on a five-point scale including: Not at all familiar; slightly familiar; somewhat familiar; very familiar; 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.

- 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 1 and 100 nanometers wide?
 - **DNA;** the head of a pin; a human hair; DNA base-pairs; a hydrogen atom.
- Which of the following is a known fact that is sometimes used to argue for caution when it comes to research and development in nanotechnology?
 - **Materials that are harmless at the macro-level often have different properties at the nano-level;** Researchers are using advances in nanogenomics to create biological weapons that could fall into the wrong hands; Researchers are using nanogenomics to create nano-sized, self-replicating organisms; DNA "scaffolds" have been shown to be sentient.
- 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 "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 new technologies; all of the above; none of the above

Objective Knowledge: True/False. After each statement was assessed as either true or false, students were asked to complete the statement "I am _____ confident in my answer" with responses falling on a five-point scale including: not at all, a little bit, moderately, mostly and completely.

- (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) All nanoscale materials can conduct electricity because of their extremely small size.
- (T) Nanoparticles exist naturally in the environment.
- (F) A limitation of nanoparticles is they cannot penetrate into the brain.

Likelihood to Change Attitudes.

- 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; unlikely; somewhat unlikely; undecided/can't judge; somewhat likely; likely; very likely

Attitudes towards Nanotechnology.

- 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.

Nanotechnology Attitudes: General Goals. Each goal was first assessed in terms of importance on a five-point scale ranging from “unimportant” to “extremely important.” Students were then asked to complete the following exercise: “There are, of course, only a limited number of resources (time, effort, money) that can be spent on each of the things that you rated above. So, please consider what percentage of the U.S. resources (i.e., total time, effort, and money) should be spent on each. Make sure that your percentages sum to 100%, and make sure that you give the items you rated the most important the greatest percentage of resources.”

- 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.

Likelihood/Importance of Specific Risks and Benefits. Students were asked to assess each of the following specific risks and benefits on two separate scales. The first is a five-point scale measuring the perceived likelihood that each risk/benefit will be realized by nanotechnology research and development, and ranged from “not at all likely” to “extremely likely.” The second is a seven-point scale measuring the importance of achieving or avoiding each risk/benefit, and ranged from “very important to AVOID” to “very important to ACHIEVE.”

- 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 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.

Nanotechnology Attitudes: Specific Issues. Responses for all fell of a seven-point Likert scale scale ranging from “strongly disagree” to “strongly agree.”

- Risks/Concerns (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.
- Support/Pro-nanotechnology (3 items)
 - We should develop nanotechnology at full speed despite its possible risks, in order to keep the U.S. from falling behind other countries.
 - There are serious ethical problems associated with *not* quickly developing nanotechnologies.
- Trust authorities
 - 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.

Likelihood to Change Attitudes. Responses fell on a seven-point scale ranging from “very unlikely” to

“very likely.”

- “In your estimation, as you learn more about nano-biological technologies, how likely is it that you may change your feelings and attitudes about the following.
 - The overall risk to benefit ratio of nano-biological developments.
 - The extent to which nano-biological development needs to be regulated.

Familiarity with Nanoscientists. (3 items) Answers for all on a five-point scale ranging from “not at all” to “a great deal.”

- First, consider what you know about the nanoscientists responsible for researching and making discoveries involving nanotechnology.
 - How much do you know about nanoscientists?
 - To what extent have you had experiences or interactions with nanoscientists?
 - To what extent do you feel certain in your views about nanoscientists?

Confidence in Nanoscientists. (11 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.
 - Meet their ethical responsibilities.
 - Go above and beyond what is expected of them professionally in order to better society.
 - Go above and beyond what is expected of them professionally in order to protect society from risks.
 - Minimize potential risks for humans.
 - Minimize potential environmental risks.
 - Study the social and ethical impacts and implications of future developments and regulations.
 - Maximize potential benefits for human enhancement.
 - Maximize potential environmental benefits.
 - Make decisions about the most important directions for future development.

Familiarity with Policymakers. (3 items) Answers for all on a five-point scale ranging from “not at all” to “a great deal.”

- Next, consider what you know about the policy makers responsible for making decisions about funding and regulations involving nanotechnology.
 - How much do you know about nanoscientists?
 - To what extent have you had experiences or interactions with nanoscientists?
 - To what extent do you feel certain in your views about nanoscientists?

Confidence in Policymakers. (11 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 policy makers who help regulate nanotechnology to...
 - Do their jobs well.
 - Meet their professional responsibilities.
 - Meet their ethical responsibilities.
 - Go above and beyond what is expected of them professionally in order to better society.
 - Go above and beyond what is expected of them professionally in order to protect society from risks.
 - Minimize potential risks for humans.
 - Minimize potential environmental risks.
 - Study the social and ethical impacts and implications of future developments and regulations.
 - Maximize potential benefits for human enhancement.
 - Maximize potential environmental benefits.
 - Make decisions about the most important directions for future development.

Trust in Policymakers. (4 items) Answers for all on a five-point scale ranging from “not at all probably” to “very probable.”

- To what extent do you feel policy makers who help regulate nanotechnology...
 - Are trustworthy.
 - Are fair.
 - Care about people like you, your friends, and your family.
 - Are motivated to “do the right thing.”

Distrust in Policymakers. (3 items) Answers for all on a five-point scale ranging from “not at all probably” to “very probable.”

- To what extent do you feel policy makers who help regulate nanotechnology...
 - Are dishonest.
 - Are primarily motivated by what will benefit them personally.
 - Don’t really care about the long-term risks of their work.

Perceived Competence of Policymakers. (3 items) Answers for all on a five-point scale ranging from “not at all probably” to “very probable.”

- To what extent do you feel policy makers who help regulate nanotechnology...
 - Are competent to do their jobs.
 - Have the knowledge need to do their jobs well.
 - Have the training to do their jobs well.

Likelihood to change trust and confidence. Answers fall on a seven-point scale ranging from “very unlikely” to “very likely.”

- In your estimation, as you learn more about the development and regulation of nano-biological technologies, how likely are you to change your feelings and attitudes about ...
 - The scientists responsible for studying and developing nanotechnologies.
 - The policy makers responsible for making decisions about the funding and regulation of nanotechnologies.

Personality Traits. Answers for all on a six-point scale ranging from “strongly disagree” to “strongly agree.”

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. (6 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.
- I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.
- 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.

Deliberative values (6 items)

- I usually end up deliberating about issues even when they do not affect me personally.
- 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 discuss politics with those who disagree with them.
- 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 new things.
- I follow political and social issues because I think it's important.

Introjected 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 it bothers me when I don't.

Political efficacy (4 items)

- Sometimes politics and government seem so complicated that a person like me can't really understand what's going on.
- 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. (reverse coded)
- I am not interested in abstract ideas. (reverse coded)

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

- How interested are you in *national* politics and *national* affairs?
- 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

Assignment 2.

Subjective Knowledge. All three items repeated from Assignment 1.

Attitudes towards Nanotechnology. Both questions repeated from Assignment 1.

Objective Knowledge: Multiple Choice. All items repeated from Assignment 1.

Objective Knowledge: True/False. One of the following two sets of six true/false questions were randomly assigned to each student. After each question, students were asked to complete the statement “I am _____ confident in my answer” with responses falling on a five-point scale including: not at all, a little bit, moderately, mostly and completely.

- Set A
 - (F) Nanotechnology is already being used to map the human genome.
 - (F) Breakthroughs in nanogenomics already allow very wealthy parents to manipulate the intelligence of their children.
 - (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) Liposomes have been used to house and deliver drugs in a way that gets a higher proportion of the drug to the target and less to the rest of the body.
 - (T) Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines.
 - (T) Research at the interface of nanotechnology and biology has been used for seemingly non-biological applications such as the creation of faster computer chips.
- Set B
 - (F) Although they both deal with biological applications of nanotechnology, there is very little overlap in nanogenomic and nanomedicine research.
 - (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.
 - (F) One outcome already identified 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.

Attitudes towards Nanotechnology. Both questions were again repeated from Assignment 1. This time, each was followed by the additional question presented below:

- During this assignment, to what extent did you change your mind about the... question above?
 - Not at all, just a little, some, quite a bit, a great deal

Objective Knowledge: Multiple Choice.

- 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 1 and 100 nanometers wide?
 - **DNA**; the head of a pin; a human hair; DNA base-pairs; a hydrogen atom.
- Which of the following is not a known risk of nanotechnology?
 - Nanomaterials have been shown to be active at the cellular level, which can cause inflammation and even tumors in the lungs; the lungs of rats and mice have been damaged in experiments using nano-sized carbon nanotubes; **nanomaterials have been shown to interact adversely with skin cells, which have already been shown to cause skin cancer in otherwise healthy humans**; iron nanoparticles have been shown to be able to travel with groundwater into soil and remain active for weeks
- 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 “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 new technologies; all of the above; none of the above

Objective Knowledge: True/False. Students were again presented with the same set of eight true/false questions they first answered at the beginning of this assignment.

Time spent on assignment.

- Estimated time spent completing this assignment (in *Minutes*).
Please only include the time you spent actively working on the assignment. Do not include any breaks you took, interruptions that may have lengthened your time on the pages, or any time spent on web pages not relevant to the assignment.
 - Reading and exploring information (number of minutes)
 - Writing your answers to questions (number of minutes)
 - Total time (number of minutes)

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 (6 items)
 - Was impatient to get this over.
 - Wished I were doing something else.
 - Felt bored.
 - Felt distracted.
 - Was uninterested in the task I was asked to do.
 - Thought this process was not worth my time.
 - o Angry Engagement (5 items)
 - Felt angry.
 - Found it aggravating.
 - Was resentful.
 - 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. Answers to the following questions fell on a five-point scale including: not at all, just a little, some, quite a bit, 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.

Background Document Evaluation. Answers for all on a five-point scale including strongly disagree, disagree, neither agree nor disagree, agree, strongly agree.

- The information presented in this assignment was...
 - o Trustworthy.
 - o Untrustworthy.
 - o A biased portrayal of the issues.
 - o A neutral portrayal of the issues.
 - o Not always fair in its presentation of the issues.
 - o Fair in its presentation of the issues.
 - o Balanced.
 - o Unbalanced.
 - o Written to try to persuade people of a certain viewpoint.
 - o Written to allow people to make up their own minds on the issues.
 - o Inaccurate.
 - o Not always accurate in its characterization of the facts.
 - o Pretty accurate in its characterization of the facts.
 - o Thorough.
 - o Not thorough enough.
 - o A good resource for understanding multiple perspectives on the issues.
 - o Not very good for understanding multiple perspectives on the issues.
 - o A high quality source of information.
 - o Clear and easy to understand.

- Unclear and difficult to understand.
 - Well-written.
- 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, slightly, somewhat, quite, extremely
- How much do you feel you learned about nanotechnology as a result of working on this assignment?
 - 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?
 - Not at all familiar; Slightly familiar; Somewhat familiar; Very familiar; Extremely familiar
- Now that you've done some reading....How familiar are you with how nanotechnology is used in medical research and development?
 - Not at all familiar; Slightly familiar; Somewhat familiar; Very familiar; Extremely familiar
- Now that you've done some reading....How familiar are you with how nanotechnology is used in genetics research and development?
 - Not at all familiar; Slightly familiar; Somewhat familiar; Very familiar; Extremely familiar

Quality Check. Question repeated from Assignment 1.

Assignment 3.

Material Evaluation. Both questions were asked after each ELSI scenario.

- To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question?
 - Not at all, slightly, somewhat, quite a bit, a great deal
- To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario?
 - Not helpful at all, slightly helpful, somewhat helpful, very helpful, extremely helpful
- To what extent do you feel like the background document that you were provided with in Assignment 2 (before you came to reci) was helpful as you responded to this scenario?
 - Not helpful at all, slightly helpful, somewhat helpful, very helpful, extremely helpful

Attitudes towards Nanotechnology. Both questions were repeated from Assignment 1.

Overall Attitude Change. Answers fell on a five-point scale including: not at all, just a little, some, quite a bit, a great deal.

- Overall, from the time you began these exercises, until now, to what extent did you change your mind about the questions above?
- Overall, from the time you began these exercises, until now, to what extent did strengthen your original opinions about the questions above?

Engagement. All questions repeated from Assignment 2.

Identity. Answers fell on a five-point scale including: not at all important, slightly important, somewhat important, quite important, extremely important.

- Please indicate how important each of the following was to you during the discussion today.
 - My identity as an individual
 - My identity as a member of my group during today's discussion
 - My identity as a student in this specific Recitation section
 - My identity as a student in Bio102
 - My identity as a UNL student
 - My identity as an American
 - My identity as a member of my racial group
 - My identity as a human being

Group assessment.

- 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
- 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 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 BEGINNING of the discussion?
 - No consensus at all; Little consensus; Some consensus; A lot of consensus; Total consensus
- 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 members. 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

Group dynamics. 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.

Assignment 4.

Attitudes towards Nanotechnology. Both questions were again repeated from Assignment 1 along with the follow-up questions first introduced in Assignment 2.

Changes in Attitudes. Answers fell on a five-point scale including: not at all, just a little, some, quite a bit, a great deal.

- To what extent did the following influence the final views that you gave about nano-biological technologies and human enhancement?
 - Talking about the issue with others.
 - The background information that I read about the topics.
 - Learning about new arguments that I'd not thought of before.
 - My own research on the issue.
 - Views of people important to me.
 - The additional resources provided by the background documents.
 - My study and knowledge of biology in this course.

Nanotechnology Attitudes: General Goals. All questions repeated from Assignment 1.

Likelihood/Importance of Specific Risks and Benefits. All questions repeated from Assignment 1.

Nanotechnology Attitudes: Specific Issues. All questions repeated from Assignment 1.

Process Acceptance. The following questions were asked after each scenario. Responses fell on a six-point Likert scale.

- The process used by the government to make decisions about this issue was fair.
- The government made the right choices with regard to this issue.

- The government made the same choices you would have made.
- The government should have made different decisions about the issue.
- The government should have used a different process to get public input about this issue.

Nanotechnology Attitudes: Specific Legislation. After both of the following prompts, students were asked “Would you be FOR or AGAINST such legislation?” Responses fell on six-point scale including: strongly AGAINST, moderately AGAINST, slightly AGAINST, slightly FOR, moderately FOR, strongly FOR.

- If legislation were being considered that would slow down nanogenomics research and development in the area of human enhancement by decreasing funding and increasing restrictions...
- If legislation were being considered that would speed up nanogenomics research and development in the area of human enhancement by increasing funding and decreasing restrictions...

Familiarity with Nanoscientists. (3 items) All items repeated from Assignment 1.

Confidence in Nanoscientists. (3 items) A selection of three items were repeated from Assignment 1. Responses fell on a five-point scale ranging including: not at all, just a little, some, quite a bit, 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. (3 items) Responses fell on a five-point scale ranging including: not at all, just a little, some, quite a bit, a great deal.

- In general, to what extent do you feel nanoscientists probably...
 - Are trustworthy
 - Listen to everyone’s opinion
 - Care about the community they serve

Distrust in Nanoscientists. (3 items) Responses fell on a five-point scale ranging including: not at all, just a little, some, quite a bit, a great deal.

- In general, to what extent do you feel nanoscientists probably...
 - Are primarily motivated by what will benefit them personally
 - Will do the right thing only if they are punished for doing the wrong thing
 - Don't really care about the long-term risks of their work

Familiarity with Policymakers. (3 items) All items repeated from Assignment 1.

Confidence in Policymakers. (3 items) A selection of three items were repeated from Assignment 1.

Responses fell on a five-point scale ranging including: not at all, just a little, some, quite a bit, a great deal.

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

Trust in Policymakers. (3 items) A selection of three items were repeated from Assignment 1. Responses fell on a five-point scale ranging including: not at all, just a little, some, quite a bit, a great deal.

- In general, to what extent do you feel policy makers who help regulate nanotechnology...
 - Are trustworthy
 - Listen to everyone's opinion
 - Care about the community they serve

Distrust in Policymakers. (3 items) A selection of three items were repeated from Assignment 1. Responses fell on a five-point scale ranging including: not at all, just a little, some, quite a bit, a great deal.

- In general, to what extent do you feel policy makers who help regulate nanotechnology...
 - Are primarily motivated by what will benefit them personally
 - Will do the right thing only if they are punished for doing the wrong thing
 - Don't really care about the long-term risks of their work

Changes in Trust/Confidence. Responses fell on a five-point scale including: not at all, just a little, some, quite a bit, a great deal.

- In your estimation, as you learned more about the development and regulation of nano-biological technologies, how much did you change your feelings and attitudes about ...
 - The scientists responsible for studying and developing nanotechnologies.
 - The policy makers responsible for making decisions about the funding and regulation of nanotechnologies.

Subjective Knowledge. All items repeated from Assignment 1.

Objective Knowledge: Multiple Choice. All multiple choice knowledge questions from Assignment 2 were repeated.

Objective Knowledge: True/False. After each statement was assessed as either true or false, students were asked to complete the statement "I am _____ confident in my answer" with responses falling on a five-point scale including: not at all, a little bit, moderately, mostly and completely.

SET A (MATCHES A2 SET A)

- (F) Nanotechnology is already being used to map the human genome.

- (F) Breakthroughs in nanogenomics already allow very wealthy parents to manipulate the intelligence of their children.
- (F) A good example of a "nano"-sized object is a red blood cell.
- (T) Nanomaterials in the environment can enter the body; certain nanoparticles have already been shown to interfere with normal bodily processes.
- (T) The term "human enhancement" includes advancements like curing diseases.
- (T) Liposomes have been used to house and deliver drugs in a way that gets a higher proportion of the drug to the target and less to the rest of the body.
- (T) Because of their special properties, nanomedicines may be able to reach the brain more effectively than traditional medicines.
- (T) Research at the interface of nanotechnology and biology has been used for seemingly non-biological applications such as the creation of faster computer chips.

SET B (MATCHES A2 SET B)

- (F) Although they both deal with biological applications of nanotechnology, there is very little overlap in nanogenomic and nanomedicine research.
- (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.
- (F) One outcome already identified 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.

SET C (MATCHES A1)

- (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) All nanoscale materials can conduct electricity because of their extremely small size.
- (T) Nanoparticles exist naturally in the environment.
- (F) A limitation of nanoparticles is they cannot penetrate into the brain.

SET D (NEW)

- (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) 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) Due to the increased cost of surgical and diagnostic tools, nanotechnology will inevitably increase the cost of health care.

Individual Differences. All questions repeated from Assignment 1.

Satisfaction with Process.

- To what extent did you change your mind about the question above over this semester?
 - Not at all, just a little, some, quite a bit, a great deal
- 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

4.2. Appendix B – Assignment 2 Materials

4.2.1. Lecture Outline

Note: The lecture took place prior to or during the same week as students were assigned Assignment 2 in their recitation class and 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*

4.2.2. Recitation Introduction to Assignment 2

Note: Below is the transcript of Video used in class by the recitation instructors, to prompt student interest in the public engagement activities.

https://www.ted.com/talks/gregory_stock_to_upgrade_is_human/up-next

The future of life, where the unraveling of our biology -- and bring up the lights a little bit. I don't have any slides. I'm just going to talk -- about where that's likely to carry us.

And you know, I saw all the visions of the first couple of sessions. It almost made me feel a little bit guilty about having an uplifting talk about the future. It felt wrong to do that in some way. And yet, I don't really think it is because when it comes down to it, it's this larger trajectory that is really what is going to remain -- what people in the future are going to remember about this period.

I want to talk to you a little bit about why the visions of Jeremy Rivkins, who would like to ban these sorts of technologies, or of the Bill Joys who would like to relinquish them, are actually -- to follow those paths would be such a tragedy for us. I'm focusing on biology, the biological sciences. The reason I'm doing that is because those are going to be the areas that are the most significant to us. The reason for that is really very simple. It's because we're flesh and blood. We're biological creatures. And what we can do with our biology is going to shape our future and that of our children and that of their children -- whether we gain control over aging, whether we learn to protect ourselves from Alzheimer's, and heart disease, and cancer.

I think that Shakespeare really put it very nicely. And I'm actually going to use his words in the same order that he did. (Laughter) He said, "And so from hour to hour we ripe and ripe. And

then from hour to hour we rot and rot. And thereby hangs a tale." Life is short, you know. And we need to think about planning a little bit. We're all going to eventually, even in the developed world, going to have to lose everything that we love. When you're beginning to rot a little bit, all of the videos crammed into your head, all of the extensions that extend your various powers, are going to begin to seem a little secondary. And you know, I'm getting a little bit gray -- so is Ray Kurzweil, so is Eric Drexler.

This is where it's really central to our lives. Now I know there's been a whole lot of hype about our power to control biology. You just have to look at the Human Genome Project. It wasn't two years ago that everybody was talking about -- we've found the Holy Grail of biology. We're deciphering the code of codes. We're reading the book of life. It's a little bit reminiscent of 1969 when Neil Armstrong walked on the moon, and everybody was about to race out toward the stars. And we've all seen "2001: A Space Odyssey." You know it's 2003, and there is no HAL. And there is no odyssey to our own moon, much less the moons of Jupiter. And we're still picking up pieces of the Challenger. So it's not surprising that some people would wonder whether maybe 30 or 40 years from now, we'll look back at this instant in time, and all of the sort of talk about the Human Genome Project, and what all this is going to mean to us -- well, it will really mean precious little. And I just want to say that that is absolutely not going to be the case. Because when we talk about our genetics and our biology, and modifying and altering and adjusting these things, we're talking about changing ourselves. And this is very critical stuff.

If you have any doubts about how technology affects our lives, you just have to go to any major city. This is not the stomping ground of our Pleistocene ancestors. What's happening is we're taking this technology -- it's becoming more precise, more potent -- and we're turning it back upon ourselves. Before it's all done we are going to alter ourselves every bit as much as we have changed the world around us. It's going to happen a lot sooner than people imagine. On the way there it's going to completely revolutionize medicine and health care; that's obvious. It's going to change the way we have children. It's going to change the way we manage and alter our emotions. It's going to probably change the human lifespan. It will really make us question what it is to be a human being.

The larger context of this is that there are two unprecedented revolutions that are going on today. The first of them is the obvious one, the silicon revolution, which you all are very, very familiar with. It's changing our lives in so many ways, and it will continue to do that. What the essence of that is, is that we're taking the sand at our feet, the inert silicon at our feet, and we're breathing a level of complexity into it that rivals that of life itself, and may even surpass it. As an outgrowth of that, as a child of that revolution, is the revolution in biology.

The genomics revolution, proteomics, metabolomics, all of these "omics" that sound so terrific on grants and on business plans. What we're doing is we are seizing control of our evolutionary future. I mean we're essentially using technology to just jam evolution into fast-forward. It's not at all clear where it's going to take us. But in five to ten years we're going to start see some very profound changes. The most immediate changes that we'll see are things like in medicine. There is going to be a big shift towards preventative medicine as we start to be able to identify all of the risk factors that we have as individuals. But who is going to pay for all this? And how are we

going to understand all this complex information? That is going to be the IT challenge of the next generation, is communicating all this information.

There's pharmacogenomics, the combination of pharmacology and genetics: tailoring drugs to our individual constitutions that Juan talked about a little bit earlier. That's going to have amazing impacts. And it's going to be used for diet as well, and nutritional supplements and such. But it's going to have a big impact because we're going to have niche drugs. And we aren't going to be able to support the kinds of expenses that we have to create blockbuster drugs today. The approval process is going to fall apart, actually. It's too slow. It's too risk-averse. And it is really not suited for the future that we're moving into.

Another thing is that we're just going to have to deal with this knowledge. It's really wonderful when we hear, "Oh, 99.9 percent of the letters in the code are the same. We're all identical to each other. Isn't it wonderful?" And look around you and know that what we really care about is that little bit of difference. We look the same to a visitor from another planet, maybe, but not to each other because we compete with each other all time. And we're going to have to come to grips with the fact that there are differences between us as individuals that we will know about, and between subpopulations of humans as well. To deny that that's the case is not a very good start on that.

A generation or so away there are going to be even more profound things that are going to happen. That's when we're going to begin to use this knowledge to modify ourselves. Now I don't mean extra gills or something -- something we care about, like aging. What if we could unravel aging and understand it -- begin to retard the process or even reverse it? It would change absolutely everything. And it's obvious to anyone, that if we can do this, we absolutely will do this, whatever the consequences are.

The second is modifying our emotions. I mean Ritalin, Viagra, things of that sort, Prozac. You know, this is just clumsy little baby steps. What if you could take a little concoction of pharmaceuticals that would make you feel really contented, just happy to be you. Are you going to be able to resist that if it doesn't have any overt side effects? Probably not. And if you don't, who are you going to be? Why do you do what you do? We're sort of circumventing evolutionary programs that guide our behavior. It's going to be very challenging to deal with.

The third area is reproduction. The idea that we're going to choose our children's genes, as we begin to understand what genes say about who we are. That's the focus of my book "Redesigning Humans," where I talk about the kinds of choices we'll make, and the challenges it's going to present to society. There are three obvious ways of doing this. The first is cloning. It didn't happen. It's a total media circus. It will happen in five to 10 years. And when it does it's not going to be that big a deal. The birth of a delayed identical twin is not going to shake western civilization.

But there are more important things that are already occurring: embryo screening. You take a six to eight cell embryo, you tease out one of the cells, you run a genetic test on that cell, and depending on the results of that test you either implant that embryo or you discard it. It's already done to avoid rare diseases today. And pretty soon it's going to be possible to avoid virtually all

genetic diseases in that way. As that becomes possible this is going to move from something that is used by those who have infertility problems and are already doing in vitro fertilization, to the wealthy who want to protect their children, to just about everybody else. And in that process that's going to morph from being just for diseases, to being for lesser vulnerabilities, like risk of manic depression or something, to picking personalities, temperaments, traits, these sorts of things. Of course there is going to be genetic engineering. Directly going in -- it's a little bit further away, but not that far away -- going in and altering the genes in the first cell in an embryo. The way I suspect it will happen is using artificial chromosomes and extra chromosomes, so we go from 46 to 47 or 48. And one that is not heritable because who would want to pass on to their children the archaic enhancement modules that they got 25 years earlier from their parents? It's a joke; of course they wouldn't want to do that. They'll want the new release.

Those kinds of loose analogies with (Laughter) computers, and with programming, are actually much deeper than that. They are really going to come to operate in this realm. Now not everything that can be done should be done. And it won't be done. But when something is feasible in thousands of laboratories all over the world, which is going to be the case with these technologies, when there are large numbers of people who see them as beneficial, which is already the case, and when they're almost impossible to police, it's not a question of if this is going to happen, it's when and where and how it's going to happen.

Humanity is going to go down this path. And it's going to do so for two reasons. The first is that all these technologies are just a spin-off of mainstream medical research that everybody wants to see happen. It is being funded very very -- in a big way. The second is, we're human. That's what we do. We try and use our technology to improve our lives in one way or another. To imagine that we're not going to use these technologies when they become available, is as much a denial of who we are as to imagine that we'll use these technologies and not fret and worry about it a great deal. The lines are going to blur. And they already are between therapy and enhancement, between treatment and prevention, between need and desire. That's really the central one, I believe.

People can try and ban these things. They undoubtedly will. They have. But ultimately all this is going to do is just shift development elsewhere. It's going to drive these things from view. It's going to reserve the technology for the wealthy because they are in the best position to circumvent any of these sorts of laws. And it's going to deny us the information that we need to make wise decisions about how to use these technologies. So, sure, we need to debate these things. And I think it's wonderful that we do. But we shouldn't kid ourselves and think that we're going to reach a consensus about these things. That is simply not going to happen. They touch us too deeply. And they depend too much upon history, upon philosophy, upon religion, upon culture, upon politics. Some people are going to see this as an abomination, as the worst thing, as just awful. Other people are going to say, "This is great. This is the flowering of human endeavor."

The one thing though that is really dangerous about these sorts of technologies, is that it's easy to become seduced by them. And to focus too much on all the high-technology possibilities that exist. And to lose touch with the basic rhythms of our biology and our health. There are too

many people that think that high-technology medicine is going to keep them, save them, from overeating, from eating a lot of fast foods, from not getting any exercise. It's not going to happen.

In the midst of all this amazing technology, and all these things that are occurring, it's really interesting because there is sort of a counter-revolution that is going on: a resurgence of interest in remedies from the past, in nutraceuticals, in all of these sorts of things that some people, in the pharmaceutical industry particularly, like to brand as non-science. But this whole effort is generated, is driven, by IT as well because that is how we're gathering all this information, and linking it, and integrating it together. There is a lot in this rich biota that is going to serve us well. And that's where about half of our drugs come. So we shouldn't dismiss this because it's an enormous opportunity to use these sorts of results, or these random loose trials from the last thousand years about what has impacts on our health. And to use our advanced technologies to pull out what is beneficial from this sea of noise, basically.

In fact this isn't just abstract. I just formed a biotechnology company that is using this sort of an approach to develop therapeutics for Alzheimer's and other diseases of aging, and we're making some real progress. So here we are. It's the beginning of a new millennium. If you look forward, I mean future humans, far before the end of this millennium, in a few hundred years, they are going to look back at this moment. And from the beginning of today's sessions you'd think that they're going to see this as this horrible difficult, painful period that we struggled through. And I don't think that's what's going to happen. They're going to do like everybody does. They are going to forget about all that stuff. And they are actually going to romanticize this moment in time. They are going to think about it as this glorious instant when we laid down the very foundations of their lives, of their society, of their future. You know it's a little bit like a birth. Where there is this bloody, awful mess happens. And then what comes out of it? New life. Actually as was pointed out earlier, we forget about all the struggle there was in getting there.

So to me, it's clear that one of the foundations of that future is going to be the reworking of our biology. It's going to come gradually at first. It's going to pick up speed. We're going to make lots of errors. That's the way these things work. To me it's an incredible privilege to be alive now and to be able to witness this thing. It is something that is a unique instant in the history of all of life. It will always be remembered. And what's extraordinary is that we're not just observing this, we are the architects of this. I think that we should be proud of it. What is so difficult and challenging is that we are also the objects of these changes. It's our health, it's our lives, it's our future, it's our children. And that is why they are so very troubling to so many people who would pull back in fear. I think that our choice in the choice of life, is not whether we're going to go down this path. We are, definitely. It's how we hold it in our hearts. It's how we look at it. I think Thucydides really spoke to us very clearly in 430 B.C. He put it nicely. Again, I'll use the words in the same order he did. "The bravest are surely those who have the clearest vision of what is before them, both glory and danger alike. And yet notwithstanding, they go out and they meet it."

Thank you. (Applause)

4.2.3. Background documents: Varied in organization

All students saw the common introduction. Students were randomly assigned to see one of the two versions of the ELSI portion of the background reading: Traditional format or NIF-inspired format.

Common Introduction

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.

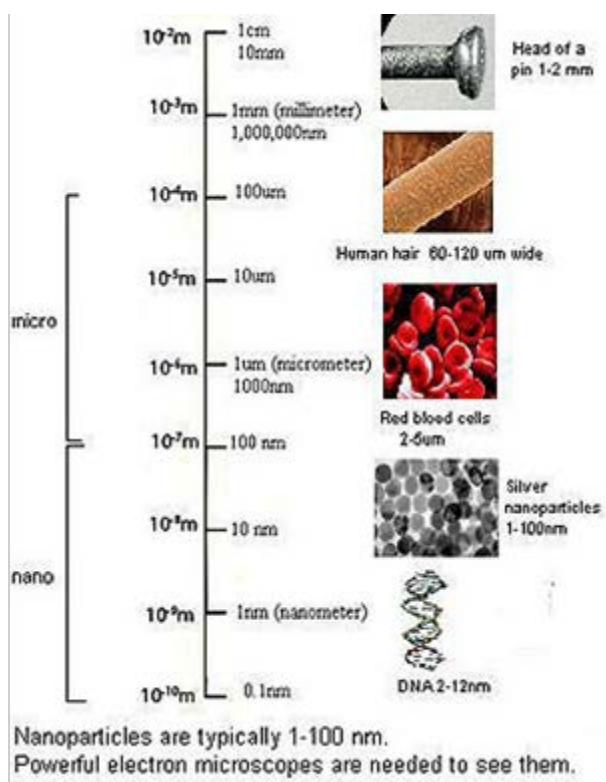


Figure 1- Source: BPDNB (2010)

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 long. As illustrated in Figure 1, DNA and silver nanoparticles are examples of "nano"-sized materials, red blood cells are bigger "micro"-sized, and objects we can see easily are

"macro"-sized. At the nanoscale, only the most powerful microscopes are able to actually see objects.

An important feature of nanoscale materials is how their properties differ from normal-scaled materials. Everyday common materials can have [new and different properties](#) when reduced to nano-sized objects. For example, elements may change color and materials that would normally not conduct electricity may do so when made into nano-sized objects. In fact, scientists have found that they can manipulate carbon atoms and molecules to create nano-sized 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. This has been a concern for some scientists because some materials that are harmless at their normal size could be dangerous at the nano-level.

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, and 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](#). Meanwhile, certain nanoparticles are extremely effective in absorbing light and are being used in cosmetics and sunscreens. As for developments in science industries, 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 thus far.

These developments are having broad impacts on many levels of society. For example, the economies of several nations have been influenced by nanotechnological development. 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 [automotive catalytic converters](#), thus making certain chemical reactions more efficient and resource-saving, which have [industrial implications](#). Additionally, the United States stands to potentially gain from nanotechnological development by using it to more efficiently utilize renewable energy (especially because the U.S. has been said to be [falling behind](#) in its use of "green" energy).

On the other hand, many people are concerned about the potential risks of these developments. According to [Sandler and Bosso \(2007\)](#) from the National Academy of Sciences, the social context of nanotechnology must be acknowledged because it affects aspects of society like access to resources, social and political power, individual rights, and justice in general. Sandler and Bosso argue that the reactions of U.S. federal regulatory organizations have not traditionally acted in ways "optimal for the promotion and protection of the public good," but have rather been somewhat delayed in reacting to technological developments that necessitate regulatory oversight. Thus, they recommend that caution be

used in pursuing advances in nanotechnology.

[Hoet et al. \(2004\)](#) talk about some of the known risks of nanotechnology that should be considered seriously. They explain how nanomaterials can 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. Nanoparticles have been shown to be active at the cellular level, where 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 nano-sized carbon nanotubes, which can be used for their unique properties, can damage the lungs of rats and mice. 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 remaining 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 ([Health Council](#)). “Free form” nanoparticles can be released in the air or water via manufacturing nanomaterials, but they can also make their way into the environment via most [traditional pollutant filters’ inability to catch nano-sized particles](#).

New Biology: Biology Meets Technology

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 to anything designed to improve or augment human capabilities. Human enhancement does not necessarily refer to extreme examples—such as altering average human beings to have special powers. Instead, human enhancement mainly includes common activities such as higher education and athletic training, as well as plastic surgery and the creation and use of artificial prostheses. Human enhancement can include both curing diseases and disabilities and 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 deliver highly potent anticancer

chemotherapy drugs in a way that gets 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 non-nanotechnologically-delivered 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 ([Freitas, 2005](#)). Additionally, there is a newer class of "biological medications" (called biologics), which are destroyed in the stomach and thus can't 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 more 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, diagnostic techniques that involve injecting nano-sized particles into the bloodstream prior to an MRI (magnetic resonance imaging) have been developed. The presence of the iron oxide nanoparticles serves to significantly enhance 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 researched for the 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 internal use of engineered nanosized gold-coated silica particles. These nanoshells, which are being tested in mice, collect in tumor tissues. The nanoshells can be selectively heated when illuminated from outside the body with near infrared light. The heat 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 this technique will someday result in [new treatments for cancer, diabetes and some neurological disorders](#). If this research and development continues to be successful, as doctors hope, we will be able to target and treat tumors more efficiently and with fewer side effects than with 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 using nanotechnologies that might be applied to change single genes within the genetic code. Here, we are using the term nanogenetics or nanogenomics broadly to refer to any research and development involving both nanotechnology and genetics.

Nanogenomics has some 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.

Traditional Format

ELSI: 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 a variety of viewpoints 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.

The Costs of Not Pursuing Available Benefits

According to some, 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. Even [some of the risks that do exist are somewhat unlikely](#). It is often argued 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. Therefore, some argue that we should keep regulation on nanogenomic and nanomedical research to a minimum, and fund such research aggressively.

Some benefits of nanomedical and nanogenomic research that people bring up include that nanobiological human enhancements could be used to [increase the quantity and quality of life](#), to provide cheaper and more [universal healthcare](#), and to make the country [stronger and more independent](#) by creating a new industry based on nanobiological research and human enhancement

developments that could produce jobs.

However, some bring up tradeoffs of these benefits, such as the fact that there could be [side effects](#) of nanogenomic and nanomedical research, or that [traditional jobs might be lost](#). However, for those who support nanobiological research, these tradeoffs are not severe enough to warrant heavy regulation. In fact, according to these people, [the existence of risks does not mean you should completely refuse to fund this research](#). [Every risk has a benefit](#) that can be achieved with it. Besides, some say, it is in our nature to advance, and [without progress, we are lost](#).

Changing Social Concepts

It is often noted that these benefits might produce significant structural changes in society that could change how we think about many aspects of life. For example, the concepts of [“age” and “disease”](#) could come to be understood quite differently. There is also much discussion as to what the implications of such research would be for the concept of [“human nature.”](#)

Right to Autonomy

Some people believe that [we should have the right](#), especially in the United States, to alter ourselves, and to some extent, our children via nanobiological technology. On the other hand, some people note that the nanobiological research can be *contrary* to human autonomy because [it violates the rights of children](#) whose parents decide to alter their genes.

Risks: Unforeseen, Unpredictable, and Unacceptable?

Some say that the risks of pursuing nanogenomic and nanomedical research and development too quickly are quite serious, 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. Some people 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. It is often suggested even that [the “promises” offered by nanobiological research could be unrealistic](#). Therefore, some argue that nanogenomic and nanomedical research should be extremely regulated, if allowed at all; and that only very limited amounts of funding should be used for clearly beneficial research.

Some of the specific risks of nanomedical and nanogenomic technologies and research that people bring up include the [possibility of overpopulation](#) that could result from increased life expectancy and new treatments of diseases, and the fact that there could be [unpredictable and unacceptable health and genetic-related problems](#). Others note that there is always the possibility of [“second-order” effects](#). That is, effects that happen indirectly rather than directly from the new

technologies. For example, traditional jobs may be lost, raising unemployment for certain groups of people and causing [economic disruption](#). There could also be severe environmental and national security implications down the road. In the case of nanogenomics, a [genetics gap](#) might result, where people with “good genes” are significantly different than those with “bad genes.” This could, according to some, spark a new eugenics movement. Finally, some claim that [personal privacy](#) could be threatened by nanobiological research.

On the other hand, tradeoffs of taking these risks so seriously are often noted. For example, some say there might be some [admitted benefits](#) of nanobiological research, such that some forms of nanotechnological research might be okay to fund, and some people might be helped that wouldn't if there was heavy regulation. However, for those who oppose nanobiological research, these tradeoffs are not convincing enough to warrant a lack of regulation on nanogenomic and nanomedical research.

National Issues Forum (NIF) Inspired Format

[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:

- [Quality of life](#): With nanobiological technologies, we may be able to increase the *quantity and quality of life*.
- [Universal healthcare](#): We may be able to provide *cheaper and more universal healthcare*.
- [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*.
- [Human autonomy](#): Individuals have the *right to self-improvement*, if they want it.

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

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.
- [Unrealistic promises](#): Many of the benefits and promises are unrealistic.
- [Economic disruption](#): Economic disruption could result from the introduction of this new industry.

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.
- [Unacceptable risks](#): There could be unpredictable and unacceptable health and genetic-related problems.
- [Second-order effects](#): "Second-order" effects could result that are unexpected.
- [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 *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.
- [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 *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.
- [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.

4.2.4. 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

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!

4.3. Appendix C—Assignment 3 Materials

4.3.1. Ethical Scenarios Used in Assignment 3

Initial Control Instructions: The following are FICTIONAL potential FUTURE scenarios. Please write your responses to the scenarios.

IMPORTANT NOTE: Some of the scenarios include things commonly said by people reacting to nanotechnology. These are NOT necessarily FACTS. It is your job, as you reflect on what the fictional people say, to determine if it is likely true or false, and the extent to which you agree with it. Use your background document that was provided to you, and any additional materials or your own research, to make these determinations.

Initial Critical Thinking Instructions: The following are FICTIONAL potential FUTURE scenarios. Today, you will be reading some scenarios that have to do with some of the Ethical, Legal, and Social Issues related to the use of nanotechnology for human enhancement. Each scenario might bring up different issues, so we want to encourage you to think thoroughly about each issue as it comes to mind and write down any opinions or thoughts that you have. Remember to evaluate the evidence of different points of view. Is the evidence relevant or strong enough? Is there enough evidence? Keep an eye out for bias. Are some points of view more driven by values than others? Also try to think of any details relevant from when you read the background document, and incorporate those into your responses. Please write your responses to the scenarios.

IMPORTANT NOTE: Some of the scenarios include things commonly said by people reacting to nanotechnology. These are NOT necessarily FACTS. It is your job, as you reflect on what the fictional people say, to determine if it is likely true or false, and the extent to which you agree with it. Use your background document that was provided to you, and any additional materials or your own research, to make these determinations.

Barless Prisons

Imagine that sometime in the future, researchers develop a caged drug (a drug within a nano-sized capsule) that is injected into prisoners that becomes activated by radio control if prisoners cross designated boundaries. The following scenario reflects this possibility.

Ever since the first true nanomedicine product came on the market, a caged cancer drug that releases once bound to the cancer cell, researchers have been working towards utilizing these technologies for control purposes. This week it was announced that NanoCage, in collaboration with United Penitentiary Systems, have developed the first barless prison. Upon entry, inmates are injected with a cocktail of caged drugs that have a variety of effects when released via radio control. The base technology utilizes focused radio waves to target deep tissue tumors in places such as the abdominal cavity.

The basis for security is a net of radio transmitters that surrounds the facility. As a prisoner crosses the perimeter threshold, the radio signals will cause the release of one type of caged drug. For instance, if the prisoner crosses an inner “warning” perimeter, a drug will be released that causes extreme vertigo and mild nausea. If the prisoner continues, the next perimeter will signal the release of incapacitating sedatives, and if the next signal is reached it will trigger a fatal dose of narcotics. These perimeters are spaced far apart enough to prevent unintentional crossing of more than the first. The caged drug is connected to an antenna that upon receipt of a specific radio signal causes the physical break down of the carbon-nanotube-based cage.

The package including the antenna is roughly half the size of a red blood cell. A coating of biocompatible molecules minimizes the physiological side effects from the caged drugs. There is, on very rare occasions, mild inflammatory responses that can be treated with over the counter anti-inflammatory

drugs. Because some degradation of the caged drugs occurs naturally in the body, supplemental injections are advised every six weeks and always after drugs have been released.

Guards in barless facilities will be equipped with radio transmitters that can be aimed at individual inmates or larger areas to quell local unrest. The transmitters used by the guards will be unable to access the frequencies that trigger the fatal dosages. NanoCage and United Penitentiary Systems claim this is the new model for working prisons, where inmate labor is unencumbered by restraints or monitoring devices and physical investment costs are not much more than traditional factories. The perimeter of these facilities need only be physically secured to keep people from trespassing on the grounds.

Cystic Fibrosis Prevention

Imagine that some time in the future nanotechnology has enabled doctors to be able to screen for and prevent many common genetic disorders. The following scenario reflects this possibility.

Mr. and Mrs. Vanderbilt have decided they would like to have a baby. Both Mr. and Mrs. Vanderbilt have the genetic markers for Cystic Fibrosis. Their doctor informs them that for xx250,000, he can, through the use of nanogenetics, ensure that their baby is not born with Cystic Fibrosis. The Vanderbilt family can afford this, but wonder if they should.

Mrs. Vanderbilt favors any kind of intervention that may keep their future children healthy, "we have a responsibility to our future children to keep them from suffering," she says. "If there is something that can be done to ensure that our son or daughter is born healthy, then how could we *not* take advantage of it and still call ourselves good parents?"

Mr. Vanderbilt is against use of this technology. He thinks that technology that is applied to genetics is always wrong. Sure, this technology may benefit his child, but he worries that the same technology could be misused and that people will engineer children based on physical appearances. "This technology should be outlawed," he says. "It can only lead to no good. For example, people will start to create super-babies," he says, "and future generations will all end up looking and acting the same." "Furthermore," he worries, "what does this say about people alive now who have diseases and disabilities? Does this mean that we think that they are less worthy of life than others? And what if 'mistakes' are made in messing with our human genetic code and these mistakes are passed down from generation to generation?"

Healthy Chip

Imagine that sometime in the future, a new breed of smart nanodevices makes tedious, often inaccurate, disease monitoring and treatment processes a thing of the past. The following scenario reflects this possibility.

The Healthychip Network System, available to patients through their doctors, can not only continuously monitor chemical deficiencies or saturations within the body, but can deliver medicine before the patient is even able to recognize any physical symptoms.

Patients who have been diagnosed with a disease that can be monitored and regulated with the

Healthychip Network System are injected with a large set of networked nanoscale electronic chips referred to as receptor chips. The receptor chips contain nanowires that have attached to them specially designed molecules. These specially designed molecules are able to bind to very specific chemicals within the bloodstream. When the chemical that is being monitored within the blood binds to one of these molecules on the nanowire, an electronic property of the nanowire changes, and the receptor chip is able to detect the chemical within the bloodstream. With many nanowires on each chip, the receptor chip calculates the concentration of that chemical in the bloodstream at its location by reading the changes in electronic properties of the many nanowires.

Every few seconds, each of these electronic receptor chips uses a wireless signal to send the data regarding chemical concentrations to a central computer chip implanted beneath the skin. This central chip takes in the data from all of the chips located throughout the body, and calculates whether or not to release medication needed to regain, or maintain, healthy chemical levels in the bloodstream. This chip, equipped with a medication reservoir, is then able to release the required amount of medicine within the body. In the case of diabetes, the central chip can choose to release insulin or a sugar derivative depending upon sugar levels within the blood. This centralized chip can be refilled when the medicine within it runs out, or removed when a disease is cured.

Once a disease has been diagnosed and a chemical treatment plan ascertained, doctors can choose the correct Healthy Chip Network System. The receptor chips are then injected into the blood stream through an IV. The central chip is calibrated prior to insertion, to make sure that it is working correctly with the receptor chips. Finally, the central chip with corresponding medicine is inserted beneath the skin at a location determined by the patient and the doctor. Information about how often medicine is administered is recorded on the central chip and that information can be scanned and downloaded by the doctor at any time.

The patient and doctor can then receive detailed information about how often chemical irregularities occur. This is helpful in the case of diabetes, when the patient is attempting to make lifestyle changes in diet and exercise. The central chip is then able to give information about whether those lifestyle changes are helping improve the condition by possibly showing a decrease in the number of times the central chip has to dispense medication.

Improving Human Memory Development

Imagine that many years in the future Supernanotech Labs is trying to apply past nanogenomic research findings to improve human memory development. The head of the Food and Drug Administration is seeking advice from a panel of citizens regarding their opinions on how regulated this research should be.

Participant 1: "This research is an abomination. God would not want us messing with his work. I don't even think this research and development should be done -- regulated or not."

Participant 2: "Not everyone shares your views on what God wants. This research could help people with memory problems. What if this research could lead to cures for Alzheimer's? Plus, it would be better if we could all remember everything. We would all be so much smarter! I think that this research should be somewhat regulated, but not so much that research and creativity is stifled or delayed."

Participant 3: "I'm pretty sure that only rich and important people would have access to this kind of thing. Then they will be even more rich and important, and the poor will be even more poor. The cycle will never end. Assuming this research goes forward, there needs to be regulations in place that ensure that the developments from this research are not only available to the wealthy."

Participant 4: "I disagree. We live in a free market economy and if you don't let the rich buy this technology, you will slow its development. Let the rich buy it, and then more developments will occur so that it becomes cheaper for lower-income people. But if you do not let the rich buy it, future research and development won't even occur -- or it will occur very slowly and other countries will beat us to the 'big' findings. Then THEY will have the market, because they got there first."

Participant 5: "My concern is that we don't know the consequences of altering DNA. What if memory gets better but people get more aggressive, or crazy, or something? We just don't know. Also, what will be the very long term effects of using this technology? There has to be special regulations in place to make sure that these things don't happen."

What should the head of the Food and Drug Administration recommend to the FDA about regulation? How do you feel? Why? How would you respond to the participants above? Would you have a different perspective to add that they did not think of?

Writing Instructions

Control Instructions: Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations.

Critical Thinking Instructions: Your Perspective: In your opinion, what ethical, legal and social issues are raised by this scenario and how do you think those issues should be handled? Please write a paragraph or two explaining how you feel and your recommendations. Be sure to use evidence that you found in the background resources or your own research, to support your claims and recommendations. Whenever possible cite where your information is coming from (e.g., National Geographic 2008, your own experience, understandingnano.com, etc). Pay attention to the quality of the information you use as evidence: Is it unbiased? Relevant? Accurate? Is the evidence typical and generalizable? Is it sufficient? The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations.

Other Perspectives: What do you think someone who disagrees with you would say, and how would you answer them? Be sure to consider why they might feel as they do, that is the values and interests underlying their views, and indicate if you are in disagreement with their values or with their evidence/conclusions. Pay attention to the quality of evidence that they might use to support their view, and whether you agree that the evidence is strong or not. Be sure that your answer to them lines up with and acknowledges their perspective so that you are not just "talking past" their points. The above techniques are likely to increase the likelihood that policy makers will give weight to your recommendations, even if they disagree with you.

Other Questions after Scenarios

What questions came up as you were answering this scenario, or would you like to have answered in

order to be able to write a better response to the scenario above?

To what extent did you review or explore your background information or other sources (e.g., Google searches, links to other resources) as you answered this question? (not at all, slightly, somewhat, quite a bit, a great deal)

To what extent do you feel like the information you explored or reviewed during recitation was helpful as you responded to this scenario? (not helpful at all, slightly, somewhat, quite, extremely helpful)

To what extent do you feel like the background document that you were provided with in Assignment 2 (before you came to reci) was helpful as you responded to this scenario? (not helpful at all, slightly, somewhat, quite, extremely helpful)

4.3.2. Moderator Scripts and Questions

“New Biology: ELSI Scenario Discussions”

Discussion Leader Guide

You will be helping to lead the discussion of the ethical scenario questions related to nano-biological technology. Students should answer the questions on their computers (via a link provided during class), but those who do not bring a laptop will be given a paper version.

IMPORTANT: We expect to have about 30 min total for these discussions -- that is 15 min per each of the 2 questions. It would be good if the discussion were 7-10 min and the writing 5-7 min. Move on to the next to discussion questions if you have time. If discussion is dragging, use the “Follow up” questions (#6) to encourage participants to talk so that each question takes about one half of the time.

1. Handouts:

- a. **Sign-in sheet:** Will contain URL for backgrounder as well as URL for A3.
- b. **Handout & Ask students to read it.** This will be a “Put on your thinking cap!” OR a “Get ready to explore!” sheet. Everyone in your group should have the same one.

2. Introductions: Introduce yourself, and ask everyone their name. Note that you were involved in some discussions like this last year, and are helping lead this year.

3. Say the following to introduce the discussion:

- a. “Today, we will be discussing some scenarios that have to do with some of the Ethical, Legal, and Social Issues related to the use of nanotechnology for human

enhancement. Each scenario might bring up different issues, so I want to encourage you think thoroughly about each issue as it comes to mind and voice any opinions or thoughts that you have.”

- b. **FOR CT Condition:** “Remember to evaluate the evidence of different points of view. Is the evidence relevant or strong enough? Is there enough evidence? Keep an eye out for bias. Are some points of view more driven by values than others? Also, try to think of any details relevant from when you read the background document, and incorporate those into your responses.”
 - c. **FOR Control Condition:** “Please be sure to think hard about what you really think about the issues. Don’t hesitate to voice as much detail as you can. Also, try to think of any details relevant from when you read the background document, and incorporate those into your responses.”
 - d. “That being said, let’s get started!” [Insert Enthusiasm] Pause for cheers.
4. **Have the students read the first ELSI Scenario.**
5. **Ask each group member to give an opinion: How would they answer the scenario questions?** First, ask for volunteers. If no one wants to volunteer then go around the group to have each person give an answer. No need to be pushy if someone doesn’t want to add much to the discussion, but if someone isn’t saying anything, ask what they think about what has been said so far, and why.
6. **Ask Follow-Up Questions:** Now that you have given some initial answers, let’s go a little deeper into your thoughts about this question...

CRITICAL THINKING:

If you are leading a Critical thinking group: Ask them to consider the Critical Thinking Tips on the sheet they were given. Ask:

- a) **Backgrounder Reminder:** Is there anything you can think of from the background document that relates to this scenario?
- b) **Quality of evidence:** Student X claimed Y.
 - o Is the claim accurate?
 - o What is the evidence for that claim?
 - o Is the evidence clear, strong, relevant? Is it sufficient (is there enough?) to support the claim?
- c) **Bias:** Values need to influence our decisions – but hopefully the values inform our decisions without biasing them. Do you see bias either in your own views (within the group), or in the views of the persons in the scenarios?
 - o What makes you think that X (whatever view was noted) is biased? What is the evidence for it being a biased viewpoint?
 - o Is there a kernel of truth in the claim that you see as biased? What is that kernel of truth?

CONTROL:

If you are leading the Control group: Ask them to look again at their handout that has the question written on it. Ask:

- b) **Backgrounder Reminder:** Is there anything you can think of from the background document that relates to this scenario?
- c) **Clarification questions: Ask:** As the moderator, you can also ask clarification questions, e.g., as follows:
 - Tell me a little more about what you meant when you said...
 - Tell me a little more about situations that you are thinking about when you said...
- d) **Ask for additional input:** Does anyone else want to react to what student X just said?
- e) **Ask for details about input:** Give us some more details regarding your position. Try to think of all of the reasons you have for having that opinion.

7. **Once all the students have had a chance to say something, give students time to write their answers.** It's ok if they started writing during the discussion (so long as they also contributed to the discussion).

- **During this time, please take notes** (use the paper copy of the questions or this script to take notes upon) **on how you feel the question went** (see Data Form for some specific questions to answer)

8. **Move on to the 2nd question once all or most students are done writing.**

9. **Remind students during the discussions that they can change or add to any of their answers at any time.**

10. **Repeat steps 1-9 for other scenarios if applicable.**

4.3.3. Data Form for Moderators

[begins on next page]

Group Discussion Data Form

Initial Questions (PLEASE FILL OUT ALL INFORMATION):

Your (Discussion Leader) Name: _____

Reci Instructor: _____

Reci #: _____

Date: _____ **Day of week:** *Wed Thurs*

Group Number: _____

What “condition” is this group in? Circle one: Crit Think or Control Circle one: NIF or Traditional
(purple) (green) (yellow) (blue)

First names and Last Initials of group members:

Missing group members:

Number of Males: _____ **Number of females:** _____ **Total number:** _____

Time Start Discussion: _____

(1) Barless Prisons

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 question?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
How disagreement was there within the group?	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
Did students seem to reach a consensus by the end of the discussion?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely

- **What were the most common topics that came up in response to the scenario?** (Scale of 0 to 5, where **0 = not at all common/wasn't mentioned** and **5 = very common/dominated the conversation**)

- a. Health risks: -----
- b. Health Benefits: -----
- c. Overpopulation: -----
- d. Wealth Gap: -----
- e. Genetics Gap: -----
- f. Religion: -----
- g. Universal Healthcare: -----
- h. National Security: -----
- i. Nature (for or against): -----
- j. The Economy/Jobs: -----
- k. Social Changes: -----
- l. Privacy: -----
- m. Human Autonomy: -----
- n. Other (Explain below): -----

- **What were the most common disagreements about?** (Scale of 0 to 5, where **0 = no disagreement** and **5 = a lot of disagreement**; LEAVE BLANK IF TOPIC WASN'T MENTIONED)

- a. Health risks: -----
- b. Health Benefits: -----
- c. Overpopulation: -----
- d. Wealth Gap: -----
- e. Genetics Gap: -----
- f. Religion: -----
- g. Universal Healthcare: -----
- h. National Security: -----
- i. Nature (for or against): -----
- j. The Economy/Jobs: -----
- k. Social Changes: -----
- l. Privacy: -----
- m. Human Autonomy: -----
- n. Other (Explain below): -----

- **Is there anything that the students said that you think was false?** (ie., misconceptions you thought they had)? **If so, how influential was this misconception in the discussion?**

About how long did students spend discussing this question: _____ Writing about the question: _____

(2) Cystic Fibrosis

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 question?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
How disagreement was there within the group?	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
Did students seem to reach a consensus by the end of the discussion?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely

- **What were the most common topics that came up in response to the scenario? (Scale of 0 to 5, where 0 = not at all common/wasn’t mentioned and 5 = very common/dominated the conversation)**

- a. Health risks: _____
- b. Health Benefits: _____
- c. Overpopulation: _____
- d. Wealth Gap: _____
- e. Genetics Gap: _____
- f. Religion: _____
- g. Universal Healthcare: _____
- h. National Security: _____
- i. Nature (for or against): _____
- j. The Economy/Jobs: _____
- k. Social Changes: _____
- l. Privacy: _____
- m. Human Autonomy: _____
- n. Other (Explain below): _____

- **What were the most common disagreements about?** (Scale of 0 to 5, where **0** = **no disagreement** and **5** = **a lot of disagreement**; LEAVE BLANK IF TOPIC WASN'T MENTIONED)

- | | |
|-----------------------------|-------|
| a. Health risks: | ----- |
| b. Health Benefits: | ----- |
| c. Overpopulation: | ----- |
| d. Wealth Gap: | ----- |
| e. Genetics Gap: | ----- |
| f. Religion: | ----- |
| g. Universal Healthcare: | ----- |
| h. National Security: | ----- |
| i. Nature (for or against): | ----- |
| j. The Economy/Jobs: | ----- |
| k. Social Changes: | ----- |
| l. Privacy: | ----- |
| m. Human Autonomy: | ----- |
| n. Other (Explain below): | ----- |

- **Is there anything that the students said that you think was *false*?** (ie., misconceptions you thought they had)? **If so, how influential was this misconception in the discussion?**

About how long did students spend discussing this question: _____ Writing about the question: _____

(3) Healthy Chip

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 question?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
How disagreement was there within the group?	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
Did students seem to reach a consensus by the end of the discussion?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely

- **What were the most common topics that came up in response to the scenario? (Scale of 0 to 5, where 0 = not at all common/wasn’t mentioned and 5 = very common/dominated the conversation)**

- a. Health risks: _____
- b. Health Benefits: _____
- c. Overpopulation: _____
- d. Wealth Gap: _____
- e. Genetics Gap: _____
- f. Religion: _____
- g. Universal Healthcare: _____
- h. National Security: _____
- i. Nature (for or against): _____
- j. The Economy/Jobs: _____
- k. Social Changes: _____
- l. Privacy: _____
- m. Human Autonomy: _____
- n. Other (Explain below): _____

- **What were the most common disagreements about?** (Scale of 0 to 5, where **0** = **no disagreement** and **5** = **a lot of disagreement**; LEAVE BLANK IF TOPIC WASN'T MENTIONED)

- | | |
|-----------------------------|-------|
| a. Health risks: | ----- |
| b. Health Benefits: | ----- |
| c. Overpopulation: | ----- |
| d. Wealth Gap: | ----- |
| e. Genetics Gap: | ----- |
| f. Religion: | ----- |
| g. Universal Healthcare: | ----- |
| h. National Security: | ----- |
| i. Nature (for or against): | ----- |
| j. The Economy/Jobs: | ----- |
| k. Social Changes: | ----- |
| l. Privacy: | ----- |
| m. Human Autonomy: | ----- |
| n. Other (Explain below): | ----- |

- **Is there anything that the students said that you think was *false*?** (ie., misconceptions you thought they had)? **If so, how influential was this misconception in the discussion?**

About how long did students spend discussing this question: _____ Writing about the question: _____

(4) Memory Enhancement

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 question?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely
How disagreement was there within the group?	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
Did students seem to reach a consensus by the end of the discussion?	Not at all	Slightly/Somewhat	Moderately	Quite	Very/Extremely

- **What were the most common topics that came up in response to the scenario? (Scale of 0 to 5, where 0 = not at all common/wasn’t mentioned and 5 = very common/dominated the conversation)**

- a. Health risks: _____
- b. Health Benefits: _____
- c. Overpopulation: _____
- d. Wealth Gap: _____
- e. Genetics Gap: _____
- f. Religion: _____
- g. Universal Healthcare: _____
- h. National Security: _____
- i. Nature (for or against): _____
- j. The Economy/Jobs: _____
- k. Social Changes: _____
- l. Privacy: _____
- m. Human Autonomy: _____
- n. Other (Explain below): _____

- **What were the most common disagreements about?** (Scale of 0 to 5, where **0** = **no disagreement** and **5** = **a lot of disagreement**; LEAVE BLANK IF TOPIC WASN'T MENTIONED)

- a. Health risks: -----
- b. Health Benefits: -----
- c. Overpopulation: -----
- d. Wealth Gap: -----
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- f. Religion: -----
- g. Universal Healthcare: -----
- h. National Security: -----
- i. Nature (for or against): -----
- j. The Economy/Jobs: -----
- k. Social Changes: -----
- l. Privacy: -----
- m. Human Autonomy: -----
- n. Other (Explain below): -----

- **Is there anything that the students said that you think was *false*?** (ie., misconceptions you thought they had)? **If so, how influential was this misconception in the discussion?**

About how long did students spend discussing this question: _____ Writing about the question: _____

Final Questions (ANSWER ALL):

Time End Discussion: _____

Was the amount of time for this assignment: (circle one below)

Not nearly enough Almost but not quite enough Just right A little too much Way too much

Which follow-up questions (on the moderator sheet) did you discuss with your group? (check all that apply)

- ___ ONLY the critical thinking discussion questions
- ___ ONLY the control group discussion questions
- ___ I accidentally asked students BOTH types of questions
- ___ I accidentally asked students the WRONG set of questions

What colors of handouts did the students in your group have?

Single sheets: Green or Purple

Background documents: Blue or Orange

