

INSTRUCTOR GUIDE

SIMULATION: GENE DRIVES¹

OVERVIEW

In this simulation, participants will be called upon to make a series of three morally difficult choices in a complicated decisionmaking environment. The choices they make will have consequences, for good or ill, that are determined by a combination of luck (in the form of a dice roll) and their decision. In addition to each choice being challenging on its own, the scenarios are designed to force participants to confront conflicting intuitions about what makes a course of action morally right. (E.g., the intuitively tempting “solution” in Scenario 1 may not look so good in Scenario 3.) Both during the simulation (to their groupmates) and in the debrief that follows, participants are asked to justify the decisions they made.

CORE QUESTIONS

1. How should risks of unintended consequences be weighed against known costs of inaction?
2. Who should have decision-making power? Who should bear the risks of development?
3. When is a company or inventor responsible for the uses to which their technology is put?
4. What does a rigorous normative discussion look like, and what are the rules of such a discussion?
5. Why don't normative disagreements tend to converge on a single “right” answer?

LEARNING GOALS

The scenarios are designed to emphasize the complexity of many ethical decisions. There may be no obvious “right” answer and reasonable people may disagree with one another.

- (1) *This need not mean that there are no right answers to ethical questions.* (That could be true, but it would be a conclusion requiring separate reasons for belief.) The goal of the debrief is to suggest how this could be possible.
- (2) *Productive normative analysis and discussion is a skill.* Ethics is about justifiability to others and justification requires providing principled reasons. Consequences are one source of ethical reasons, but not the only source. Identifying reasons is a skill. This is hard because of the burdens of judgment. This is why reasonable people can disagree without necessarily entailing some form of moral relativism or subjectivism.

Additionally, the scenarios are intended to highlight the inescapability of ethical considerations when developing and deploying technologies.

- (3) *Conscientious scientists must be equipped to engage in ethical reasoning.*

¹ Created by Brian Palmiter for the Scientific Citizenship Initiative at Harvard University, Spring 2020.

RUNNING THE SIMULATION

Class Time Breakdown

- Intro/set up: 10 minutes
- Simulation: 60 minutes
- Debrief: 50 minutes
- Total: 120 minutes

Materials

- Two six-sided dice for each group
- Enough of Scenarios 1-3 for each participant to get one copy of each
- Enough copies of the Group Summary Sheet for each participant to get one

Procedures

Before starting the simulation, divide participants into groups of 3-5 individuals. Distribute Group Summary Sheets to each participant but hold on to the Scenarios. (These will be distributed one at a time so that no one can look ahead.)

To begin, explain that each group should imagine themselves to constitute the executive board of the young tech startup Gene Drive Solutions, Inc. (GDSI). Inform them that they will be faced with three situations that require decisions. Decisions are to be made as a group according to the following procedure:

- 5 minutes of private reflection.
- Approx. 15 minutes of group discussion with the goal of arriving at a consensus, but consensus that does justice to the moral complexity of the cases.
- If consensus cannot be reached, majority rules.

Once the discussion period is over and each group has made its decision, the facilitator will call on the groups to roll two six-sided dice to resolve the outcome of the decisions. Make it clear that the dice are meant to represent uncertainty, not to make this a “game”. Similarly, inform participants that although they are acting in the role of members of an executive board, they should be themselves for the simulation. In other words, don’t make or accept arguments that you don’t believe “because a tech entrepreneur would think that way,” etc.

After the dice have been rolled, groups will be called upon to report their decision and the roll results. The facilitator will use this information (and the attached results tables) to inform them of the consequences of their decisions.

Throughout this process, each participant should use the Group Summary Sheets to keep a careful record of the reasons the group considered in their discussion, the votes taken, the decision the group arrived at, the results of the dice roll, and the consequences of the decision. This information will be important when the simulation ends and the activity moves to the “debrief” phase.

THE DEBRIEF

After the simulation is over, the facilitator will bring all the groups together for a common debrief. This is the most important element of the activity, pedagogically speaking, so it should not be given short shrift. In the debrief, the facilitator asks a series of questions that work through the decisionmaking process groups just underwent. The goal is to use metacognitive reflection to inductively achieve the learning goals.

REFLECTION QUESTIONS:

Scenario 1: Picking a test case

1. Was this a difficult decision for your group? What made it hard?
2. What reasons seemed most relevant to the decision?
3. How many groups actively discussed the costs of waiting?
4. Why didn't all the consequentialists choose D?
5. Should a private company be able to overrule popular opinion? Did your debate treat B and C as the same, or was one option easier to rule out? Why or why not, given that both populations were opposed to the technology?
6. Does it matter that Equatorial Nambia's people are opposed for religious reasons? Does that make it more or less acceptable to ignore popular opinion?
7. Do you think your group considered all the relevant reasons before making a decision? Why not?

Scenario 2: Determining liability for unforeseen consequences

8. You all drafted statements that were more or less effective at quelling activist anger. How many of you think the position you took in the statement reflects the actual responsibility and obligations of GDSI?
9. When you were crafting the statement as a group, was this primarily an exercise in ethics or PR?
10. Did the impact of the statement on GDSI's stock price come up? Is that an ethically relevant factor to consider? What does it mean to say something is *ethically relevant*?
11. What are the ethically relevant factors behind this decision? What are some ethically irrelevant factors?

Scenario 3: A repugnant request

12. How does the choice in Scenario 3 compare to the choice in Scenario 1? Are the same factors relevant and irrelevant?
13. In response to Scenario 1, we asked whether a private company should be able to overrule popular opinion. Should a private company be able to turn down a popular request?
14. Was it difficult to come up with a company values statement that justified your choices across all three scenarios?
15. Generally speaking, did disagreements within your group tend to involve disputes about what facts matter or how to weigh facts that everyone agrees matter? Give an example from one of your most contested decisions.

SCENARIO 1: PICKING A TEST CASE

SITUATION:

Gene Drive Solutions, Inc. (GDSI) is a young start-up that specializes in using gene drive techniques to eliminate invasive species in localized areas without threatening the species' broader population. GDSI recently developed an "infertility gene" for a species of rat. The technology works by pushing inheritance rates for infertility in female rats to over 90 percent. Every female rat born with the infertility gene cannot reproduce, and every male rat born with the gene is a carrier for spreading the trait to the next generation. Over a few generations' time, an affected population can be driven to extinction. This specific gene drive has been extensively tested in laboratory settings, and the development team is confident ($p < 0.05$) it is ready for real world application.

Throughout the development process, it was assumed that the first use would take place in New Wyland. New Wyland is a natural choice for many reasons:

- It is a remote island chain, which makes it far easier to prevent the gene drive from spreading beyond the targeted population.
- The rats are not native to the islands, having arrived on European ships in the late 1700s.
- The rats are a threat to several endangered species only found on the islands.
- The islands already spend a substantial amount of money on pest control for the rat population.

In addition to these practical considerations, GDSI's largest investors are an environmentalist foundation based in New Wyland and the government of New Wyland itself.

NEW WYLAND:

Population:	4.8 million
Per capita GDP:	\$42,200
Anticipated benefits:	<ul style="list-style-type: none">• Increased income from tourism, decreased pest control expenses, etc. (est. \$800 per capita)• Prevent the extinction of several bird species only found on the island
Public support:	42 percent in favor, 58 percent opposed

Just as the technology has become ready to be deployed, however, New Wyland's participation has been cast into doubt. Despite having expressed support for the last several years, a recent public opinion poll revealed that a majority of New Wylanders presently *oppose* releasing modified rats in the country at this time. The negative public response appears to be driven by risk aversion, not an objection to the goal of eliminating the rats. New Wylanders would be happy to see the rats gone, they just don't want to be the gene drive technology's guinea pig. If the technology were proven safe elsewhere first, they would be glad to use it. In response to the shift in public opinion, the New Wyland Parliament has reversed its support for the plan—and its investment in GDSI. If the company cannot demonstrate its technology's large-scale efficacy soon, its stock price will suffer.

A search for other possible test sites revealed another promising candidate: Equatorial Nambia.

EQUATORIAL NAMBIA:

Population:	2.0 million
Per capita GDP:	\$2,700
Anticipated benefits:	<ul style="list-style-type: none">• Increased income from agriculture, productivity, etc. (est. \$1,200 per capita)• Reduced malnourishment and the spread of disease (est. 11,000 lives saved per year)
Public support:	29 percent in favor, 71 percent opposed

Equatorial Nambia is an island nation off the west coast of Africa with an invasive rat problem as well. The rats, which were brought over on Dutch slavers' ships in the late seventeenth century, cause tremendous damage to the country's farmers and pose a public health hazard. Despite the benefits rodent elimination promises, the Nambians are even less inclined to allow GDSI to release their modified rats in their country than the Wylanders. Nambian opposition is evenly split between two groups. One group, like the Wylanders, opposes GDSI's plan due to the risks involved. The perception of the plan's riskiness is exacerbated by Nambians' historical mistrust of Western science and business interests. However, if a Western country (like New Wyland) were to test the technology first, they could be persuaded to embrace it. The other source of opposition is the country's significant religious fundamentalist population. The fundamentalists argue that GDSI is interfering with God's plan by deciding which species deserve to live and die. These people would not be persuaded to accept GDSI's services even if it was proven safe elsewhere first.

Though the population is opposed to using the gene drive, the Nambian dictator, His Excellency, President for Life, Generalissimo Johnson, has offered to ignore popular opinion and allow GDSI to use Equatorial Nambia as its test case. All that is necessary is that the company pay him a small "friendship fee" of two million U.S. dollars. The bribe would be a drop in the bucket for GDSI, as long as it can secure a contract with New Wyland by proving its technology's safety. What is more, the economic benefits of rat elimination to the Nambian people could be life changing.

What action should GDSI take?

OPTIONS:

- A. Delay deployment of the technology by two years to collect further safety data in more lab-based trials, then try again to convince New Wyland to be the test case.
- B. Bribe the generalissimo, using Equatorial Nambia as the test case. Hopefully it will lead New Wyland to change its mind and become a second adopter.
- C. Have GDSI lobbyists twist arms to get Parliament to ignore public opinion and move quickly to test the technology in New Wyland anyway. Ignore the generalissimo's offer.
- D. Bribe the generalissimo and aggressively lobby Parliament to ignore public opinion, using both nations as simultaneous test cases.

OUTCOMES:

A. Result of 2 – 11:

- Delay for further testing reconfirmed that the gene drive technology appears safe and ready for implementation. In the meantime, New Wyland forewent \$7.7 billion in GDP growth as a result of inaction. Additionally, two of the endangered bird species were driven to extinction by rats that preyed on the eggs of their young. Equatorial Nambia forewent \$4.8 billion in GDP growth as a result of inaction. Additionally, 22,000 people who could have been saved died of malnourishment and diseases carried by the rodents that were not eliminated. GDSI's stock price fell \$10/share because of the delays.

Result of 12:

- Delay for further testing uncovered a defect, which has been corrected. Had the defect not been corrected, the gene drive could have spread from the targeted rat population to several adjacent native species, leading to the extinction of the native species as well as the targeted rats. The long-term impact on the ecosystem had this occurred is unknowable, but economists estimate that the total costs of a faulty release could have run to over \$100 billion. GDSI dodged a bullet!
- That said, delaying the implementation of the gene drive resulted in two of the endangered bird species being driven to extinction by rats that preyed on the eggs of their young. Additionally, 22,000 people in Equatorial Nambia who could have been saved had the rats been eliminated died of malnourishment and disease. Additionally, GDSI stock price falls \$15 as the discovered defect has made investors nervous.

B. Result of 2 – 11:

- For a mere \$2 million bribe, GDSI secured access to Equatorial Nambia as a test case, and the technology passed its trial with flying colors. Implementation in Equatorial Nambia confirmed the safety of the gene drive technology! As a result, Equatorial Nambia experienced \$4.8 billion in GDP growth and 22,000 Nambians are still alive who would have died had the rodent problem gone unaddressed. Things are less rosy in New Wyland: New Wyland forewent \$7.7 billion in GDP growth as a result of inaction. Additionally, two of the endangered bird species were driven to extinction by rats that preyed on the eggs of their young. The success of the trial in Equatorial Nambia has made New Wyland anxious to acquire GDSI's services. GDSI stock soars \$100/share!

Result of 12:

- For a mere \$2 million bribe, GDSI secured access to Equatorial Nambia as a test case. Unfortunately, implementation in Equatorial Nambia revealed an undiscovered defect in the gene drive technology! The gene drive was able to spread from the targeted rat population to several adjacent native species, leading to the extinction of the native species as well as the targeted rats. The long-term impact on the ecosystem is unknowable, but economists estimate that the total costs of the faulty release will run to over \$100 billion. GDSI stock falls \$50/share!
- New Wyland forewent \$7.7 billion in GDP growth as a result of inaction and two of the endangered bird species were driven to extinction by rats that preyed on the eggs of their

young. However, given the technology's catastrophic consequences in Equatorial Nambia, New Wylanders are counting themselves lucky.

C. Result of 2 – 11:

- Implementation without public support in New Wyland was risky, but the people came around when the release confirmed the safety of the gene drive technology! As a result, New Wyland experienced \$7.7 billion in GDP growth and no endangered bird species were lost.
- Equatorial Nambia, which did not receive the technology, forewent \$4.8 billion in GDP growth and 22,000 people died of preventable malnourishment and disease. In light of the technology's successful implementation in New Wyland, a majority of Nambians now support using gene drives to eliminate their rodents, too. GDSI stock rises \$80/share!

Result of 12:

- Implementation without public support in New Wyland was risky, and that risk didn't pan out when implementation revealed an undiscovered defect in the gene drive technology! The gene drive was able to spread from the targeted rat population to several adjacent native species, leading to the extinction of the native species as well as the targeted rats. The long-term impact on the ecosystem is unknowable, but economists estimate that the total costs of the faulty release will run to over \$100 billion. GDSI stock collapses, losing \$80/share!
- In Equatorial Nambia, 22,000 people died of preventable malnourishment and disease. However, given the technology's catastrophic consequences in New Wyland, Nambians are counting themselves lucky.

D. Result of 2 – 11:

- Implementation without public support in New Wyland was risky, but the public came around when the release confirmed the safety of the gene drive technology! As a result, New Wyland experienced \$7.7 billion in GDP growth and no endangered bird species were lost. GDSI stock soars \$50/share!
- For a mere \$2 million bribe, GDSI secured access to Equatorial Nambia and the technology passed its trial with flying colors. Implementation in Equatorial Nambia confirmed the safety of the gene drive technology! As a result, Equatorial Nambia experienced \$4.8 billion in GDP growth and 22,000 Nambians are still alive who would have died had the rodent problem gone unaddressed. A second successful demonstration of the gene drive technology is drawing further interest around the globe! GDSI stock rises an additional \$30/share!

Result of 12:

- For a mere \$2 million bribe, GDSI secured access to Equatorial Nambia as a test case. Unfortunately, implementation in Equatorial Nambia revealed an undiscovered defect in the gene drive technology! The gene drive was able to spread from the targeted rat population to several adjacent native species, leading to the extinction of the native species as well as the targeted rats. The long-term impact on the ecosystem is unknowable, but economists estimate that the total costs of the faulty release will run to over \$100 billion. GDSI stock falls \$50/share.
- The premature implementation in New Wyland as well resulted in an additional \$100 billion or more in damages. The fact that Parliament caved to GDSI lobbyist pressure cost the company half a dozen friendly faces in the legislature. GDSI stock tanks an additional \$45/share!

SCENARIO 2: UNFORESEEN CONSEQUENCES

SITUATION:

Five years have passed since Decision 1 was made. GDSI's gene drive has been deployed, with details of effects determined by choices in Decision 1:

- A. After collecting further safety data in more lab-based trials, GDSI was able to secure a successful contract with New Wyland. After demonstrating its efficacy there, the company also signed a contract with Equatorial Nambia, although doing so required bribing the country's leader, Generalissimo Johnson. The rodent problems in both countries are on their way to being solved.
- B. After using Equatorial Nambia as a [proof of concept] / [chance to work the kinks out], GDSI was able to secure a contract with New Wyland. The rodent problems in both countries are on their way to being solved.
- C. After using New Wyland as a [proof of concept] / [chance to work the kinks out], GDSI was able to secure a contract with Equatorial Nambia, although doing so required bribing Generalissimo Johnson with \$2 million. Despite the cost, the rodent problems in both countries are on their way to being solved.
- D. After [demonstrating the efficacy of] / [working out the kinks in] the gene drive in New Wyland and Equatorial Zambia, the rodent problems in both countries are on their way to being solved.

GDSI's gene drive technique is beginning to drawing interest from clients around the world. As the company's profile rises, however, a protest movement has arisen that poses a growing PR threat. Activists argue that GDSI's willingness to work with Generalissimo Johnson is responsible for strengthening the dictator's hold on power. The activists argue that GDSI is morally liable for this outcome and they want the company to 1) publicly apologize and 2) pay reparations to the victims of the generalissimo's abuses of power.

Draft a public statement from the Board of Directors responding to the activists.

OUTCOMES:

Roll 2d6. At the discretion of the class/instructor, add or subtract from 1 to 4 points from the result for particularly persuasive/unpersuasive statements from the Board.

- 2 – 5: The statement has the exact opposite affect it was intended to have. GDSI shares lose 20 percent of their value.
- 6 – 8: The statement rubbed much of the public the wrong way. GDSI share value declines by 10 percent.
- 9 – 11: The statement adequately addressed activists' criticisms. GDSI stock stays stable.
- 12+: The statement was a resounding success. GDSI share price increases 20 percent!

SCENARIO 3: A REPUGNANT REQUEST

SITUATION:

Shortly after the events of Scenario 2, GDSI is approached by the Indian prime minister. India offers to hire the company to help it eliminate the country's population of wild Bengal tigers. The tiger population is small in number (they are on the endangered species list), but a spate of tiger attacks on humans over the last decade has turned the public against the great cats. Last year alone, over three hundred tiger attacks occurred, and a majority of the victims were small children. Polling indicates that 71 percent of Indian citizens support eliminating all wild tigers, and that number has been consistently rising for years. The governing party in India's parliament explicitly campaigned on tiger elimination and credits this position with much of its support in rural districts.

The government already employs hunters to control the tiger population as much as possible, but completely eliminating the predators has proven slower than anticipated and the attacks on humans have increased yearly as the tigers' traditional hunting territory shrinks and human settlements expand. The government hopes GDSI's technology will boost the thoroughness of the elimination program beyond what hunting is capable of achieving.

Despite being terrifically popular domestically, India's tiger elimination program has been heavily criticized by other countries, especially in the West. India's response to its critics emphasizes three points:

1. India is a democracy and its citizens overwhelmingly support this policy.
2. Indian citizens are the ones bearing the cost of tiger attacks, not foreigners. They should have the final say over how to respond.
3. The West's desire to protect the tigers is hypocritical given its willingness to support eliminating pests that plague Western countries, *like New Wyland's rats*.

Accepting India's business would pay well, which would boost GDSI's profitability, but the medium to long-term effects on the company's reputation are hard to predict given international feelings about the project. That said, if GDSI refuses the Indian government's offer, it is likely the country will turn to an unproven competitor for the same gene drive service. Further complicating the decision facing GDSI is the fact that gene drives are not an especially efficient way of eliminating the tiger population, at least not in the short term, because tigers have a much longer reproductive cycle than rats. GDSI is confident its services could eliminate the tigers eventually, but it might take as long as half a century before they are truly eradicated.

What action should GDSI take?

OPTIONS:

- E. Develop an infertility gene drive to eliminate the local Bengal tiger population.
- F. Refuse to aid development of a gene drive to eliminate the local Bengal tiger population.

In addition to deciding on a course of action for this case, draft a company values statement that expresses GDSI's principles regarding what contracts it will accept.

OUTCOMES:

E. Result of 2 – 6:

- GDSI releases a gene drive targeting Bengal tigers. Because tigers have a longer reproductive cycle than rats, the effects are not immediate, but over the next few decades the tiger population that escapes hunting should dwindle to nothing.
- Global reaction to GDSI's actions is uniformly negative. Many people are beginning to question the ethics of using gene drives for animal management entirely. GDSI's stock falls 50 percent.

Result of 7 – 9:

- GDSI releases a gene drive targeting Bengal tigers. Because tigers have a longer reproductive cycle than rats, the effects are not immediate, but over the next few decades the tiger population that escapes hunting should dwindle to nothing.
- GDSI's reputation suffers from its decision to eliminate a popular species like tigers, and animal rights protestors make the company a prime target of their ire. GDSI's stock falls 25 percent.

Result of 10 – 12:

- GDSI releases a gene drive targeting Bengal tigers. Because tigers have a longer reproductive cycle than rats, the effects are not immediate, but over the next few decades the tiger population that escapes hunting should dwindle to nothing.
- Global reaction to GDSI's actions is surprisingly muted. In light of the steady cash flow generated by the contract with India, GDSI's stock rises 10 percent.

F. Result of 2 – 6:

- GDSI refuses to supply India with a gene drive targeting Bengal tigers. This plays well around the globe. However, GDSI's refusal does not deter India's tiger elimination program. Instead, India offers its business to an upstart GDSI competitor, Death Drive Inc. Unfortunately Death Drive's gene drive technology was less well developed. As a consequence, its gene drive contained a fault that allowed it to cross from the Bengal tiger population to the Caracal cat population as well. Now both Bengal tigers and Caracal cats are expected to go extinct within a few generations.

Result of 7 – 12:

- GDSI refuses to supply India with a gene drive targeting Bengal tigers. This plays well around the globe. However, GDSI's refusal does not deter India's tiger elimination program. Instead, India offers its business to an upstart GDSI competitor, Death Drive Inc. DDI releases a gene drive targeting Bengal tigers. Because tigers have a longer reproductive cycle than rats, the effects are not immediate, but over the next few decades the tiger population that escapes hunting should dwindle to nothing.

DECISION RECORD SHEETS

DECISION 1: PICKING A TEST CASE

Option	# of Votes	Reasoning
A		
B		
C		
D		

Dice Roll: _____

Consequences:

Lives lost/saved:	Initial GDSI Stock Price: \$100 / share Resulting Stock Price: \$____ / share
GDP gained/lost:	Other:

Impact Modifier: _____

Dice Roll: _____

Initial Stock Price: \$_____ / share

Resulting Stock Price: \$_____ / share

DECISION 3: A REPUGNANT REQUEST

Option	# of Votes	Reasoning
E		
F		

Text of GDSI's Values Statement:

Dice Roll: _____

Consequences:

Effects:
Initial GDSI Stock Price: \$____ / share
Final Stock Price: \$____ / share