

“Responsible Research and Innovation”:
Ideas, Practices, and Cases of CCC-Affiliated Lab Directors

An Educational Resource for CCC Members

CCC Ethics Study #2

by

Robert McGinn
Lead CCC Ethics Investigator and Coordinator

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I. Introduction*

The Center for Cellular Construction (CCC) hosted a NSF Science and Technology Center Visiting Committee at UCSF, October 24-26, 2018. The Visiting Committee subsequently sent CCC a “Site Visit Report,” containing findings, observations, suggestions, and recommendations. The title of the Site Visit Report’s final section was “Other issues—Ethics/Responsible Research and Innovation.” The part of the title after the dash suggests that, in the Committee’s view, CCC’s ethics-related activities, including what it called “new ethics training,” should include exploration of “responsible research and innovation.” That is the genesis of the present report.

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The phrase “responsible research and innovation” and the acronym “RRI” have become visible in recent years, especially in European Union policy discourse.¹ This is largely because RRI was designated a “key action” of the European Commission’s “Science With and For Society” objective

* The author wishes to thank the directors of CCC-affiliated labs who agreed to be interviewed. All quotes from the lab directors have been anonymized.

¹ Owen, Richard, and Macnaghten, Phil, “Responsible Research and Innovation: From Science in Society to Science for Society, with Society,” *Science and Public Policy*, December 2012, pp. 751-760. <https://academic.oup.com/spp/article-abstract/39/6/751/1620724?redirectedFrom=fulltext>.

and a “cross-cutting issue” in the EU’s “Horizon 2020” initiative.² The EU characterizes “responsible research and innovation” thus:

Responsible Research and Innovation (RRI) implies that societal actors (researchers, citizens, policy makers, business, third sector organizations, etc.) work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society.³

The EU has identified six kinds of societal involvement with research and innovation (R&I) endeavor, viewed as means for implementing RRI: public engagement with R&I, public access to scientific results, initiatives to ensure gender equality in research processes and research content, science education, ethical assessment of R&I endeavors, and improved governance of R&I.⁴

For this author, the EU approach to RRI is highly questionable. While preoccupation with aligning R&I endeavor with societal “values, needs, and expectations” may suffice to make a R&I endeavor **responsive** (to societal concerns), it does not suffice to make it **responsible** (in the ethical sense).

For example, in 1942-43, Nazi researchers carried out dangerous experiments at the Dachau concentration camp on prisoners, without their

² <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>.

³ *Ibid.*

⁴ <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society>.

consent or with specious promises of benefit if they participated. The purpose of the research was “to establish the most effective treatment for victims of immersion hypothermia, particularly crew members of the German air force who had been shot down into the cold waters of the North Sea.”⁵ While seemingly well aligned with the dominant “values, needs and expectations” of WWII German society, that fact clearly did not suffice to make that research endeavor ethically responsible.

Another problematic aspect of the EU approach is that it is not clear whether the degree of alignment – hence, for the EU, whether or how responsible a R&I endeavor is -- depends on (a) the extent of congruence between the upstream intentions or goals with which the R&I endeavor is undertaken, i.e., its intended outcomes, and the prevailing societal expectations, needs, and values; (b) the extent of congruence between the R&I endeavor’s actual downstream outcomes and society’s prevailing expectations, needs, and values; or (c) some combination of (a) and (b).

In response to the final section of the Visiting Committee’s report, CCC’s lead ethics investigator conceived an initiative to increase awareness

⁵ R. L. Berger, “Nazi Science: The Dachau Hypothermia Experiments,” *New England Journal of Medicine*, Vol. 322, 1435-1440, <https://www.nejm.org/doi/full/10.1056/NEJM199005173222006>.

and understanding of “responsible research and innovation” among CCC faculty, post-docs, and students. In autumn 2019, the author discussed RRI one-on-one with a number of directors of CCC-affiliated labs. The present report incorporates RRI-related ideas and practices drawn from those discussions and identifies aspects of RRI that merit further exploration in the CCC community. Distilled from this report, a booklet about RRI is envisioned, to be made available to CCC faculty, post-docs, and students for ethics-education purposes.

II. Lab Directors Views About Responsible Research and Innovation

In EU policy discourse and documents, the phrase “responsible research and innovation” *references* R&I endeavor that is ‘better aligned with’ prevailing societal expectations, needs, and values. However, what “responsible research and innovation” *means* is left quite vague.

For that and other reasons the author does not believe that familiarizing CCC faculty, post-docs, and graduate students with the particulars of the current EU take on RRI would be particularly useful.⁶ Of greater interest is learning what “responsible research and innovation”

⁶ It might, however, be useful for CCC practitioners to be made aware of the six modes of societal intervention in R&I endeavors that the EU has prioritized. See above, page 4.

means to CCC lab directors and how their understandings of this concept are reflected in their labs' practices.

Hence, rather than distilling and disseminating the key points of the Eurocentric scholarly literature on RRI, the author pursued an *empirical* approach, one he believes has the potential to be a more valuable way of exploring RRI. During one-on-one discussions, the author posed five questions about RRI to each of eight CCC-affiliated lab directors:

Q1. What is your personal idea/conception/understanding of “responsible research and innovation” (RRI)?

Q2. What are some obvious and non-obvious characteristics of research and/or innovation activity that you believe count toward its being properly termed *responsible*?

Q3. What are some obvious and non-obvious characteristics of research and/or innovation activity that you believe count toward its being properly termed *irresponsible*?

Q4. Are there any features or aspects of how research and/or innovation activity is organized and unfolds *in your lab* that deliberately reflect your personal idea or conception of RRI?

Q5. Are you familiar with an actual episode that you regard as an instructive example of responsible and/or irresponsible research and/or innovation activity? If so, why do you regard it as such? Without identifying the specific people involved, please describe the episode.

A. Lab-Director Ideas/Conceptions/Understandings of “Responsible Research and Innovation”

Each lab director (LD) was first asked to indicate what the phrase “responsible research and innovation” means to her/him.⁷

1. Lab-Director Notions of RRI

LD1 emphasized inclusive consideration of a R&I endeavor’s potential outcomes. RRI is activity in which the practitioner tries “to take into account all the ramifications that” her/his R&I “decisions might have, intended or otherwise,” for “all the people who could be affected” by them. Asked what s/he understands by “responsible conduct of research” (RCR), LD1 stated that it is research work carried out with attentiveness to “the potential harms or goods” that it “could generate.”⁸

Thus, for LD1, the focus appears of RCR appears to be on a *subset* of RRI’s “ramifications,” viz., its “potential harms or goods.” S/he also held that in RCR, the consideration of implications occurs not after-the-fact but *upstream*, and involves identifying *potential* harms and goods that the research “could generate.” This parallels the attention s/he drew, when

⁷ In what follows, “LD1” through “LD8” refer to the interviewed lab directors.

⁸ It may be that LD1 used the expressions “responsible research and innovation” and “responsible conduct of research” interchangeably.

characterizing RRI, to upstream identification of implications that a R&I endeavor “might have.”

For LD2, RRI involves the individual practitioner fulfilling her/his “responsibility to play the mental chess game.” This means thinking several steps ahead in an effort to figure out “where...[a] discovery is going to lead” and “what... its cascading implications” are going to be, “not just on scientists [but on] society.” In its implicit call for upstream consequential comprehensiveness, this idea resembles LD1’s. However, LD2 specified explicitly that the practitioner of RRI must seek to identify the implications of the work being done on both “scientists” and “society.”

LD2’s idea of RRI has a second element. Beyond pondering the implications of what s/he is doing, a researcher engaged in R&I work has another responsibility: “If one of these paths that you follow in your mind, [appears to be leading to] something potentially dangerous,” then the practitioner has a responsibility “to talk to other people,” both in the research community and society at large, to try to avoid missing something important about the implications of what s/he is working on. LD2 deems it “really important” for the researcher to talk to people who can see things from different angles.” In short, for LD2, RRI requires the investigator to

seriously consider the implications of what s/he is working on, and, if s/he realizes that something potentially dangerous could result from it, to reach out and talk to other people to make sure s/he hasn't missed anything important about the work's implications.

LD2 did not, however, indicate under what conditions, if any, a researcher aspiring to do RRI would have a responsibility to publicly blow the whistle about her/his work (or that of a peer). LD2 referred to the Asilomar rDNA conference in the 1970s as a possible model of what the would-be RRI practitioner should do when s/he concludes that "something potentially dangerous" might result from her/his work. But the Asilomar rDNA conference was convened to consider a new *type* of research inquiry, not a single experiment or innovation process. Hence, at least to the author, it is unclear whether mounting such a conference would be an appropriate response to a questionable instance of R&I endeavor.

LD3 appeared less concerned with probing the potential consequences of R&I activity on all parties it might affect, at the scientific-community or society-at-large levels, than s/he was with exploring what RRI involves at the *laboratory* level. LD3's comments invite consideration of

what specifically must be the case about R&I work as it unfolds in the laboratory for it to be fair to say that RRI is occurring.

LD4 mentioned three ideas that s/he sees as integral to RRI:

‘upstream embedding,’ ‘researcher openness,’ and ‘educational outreach.’

‘Upstream embedding’ means getting non-scientists, e.g., anthropologists and policy experts, actively integrated into the actual R&I process *while it is underway*. LD4 contrasted this approach with the 1990s ELSI approach to probing research acceptability. In that approach, non-technical experts pose questions about the ethical, legal, and social implications of research “at a late date,” after the research is well underway or done. In contrast, especially for controversial research like synthetic biology, LD4 believes that RRI requires that non-technical experts be “ingrained in the community with an active voice from the very beginning.” They would be “present in all meetings from the very beginning and could challenge the visions and the thoughts [of the researchers] and bring in their expertise.”

‘Researcher openness’ means that the researchers “need to be aware that [they’re] not experts in everything and be open to sharing not just [their] results, but what [their] aims are, what [their] vision is, and be

open to input, from other scientists and from the non-science sector as well.”

‘Educational outreach’ involves “making sure that the community understands the research that you’re doing.” For LD4, “outreach to the community” is “a huge part” of RRI.

Another noteworthy point LD4 made about RRI pertains to the U.S. government’s official definition of “research misconduct” as “fabrication, falsification, or plagiarism [FFP] in proposing, performing, or reviewing research, or in reporting research results.”⁹ For LD4, holding that an R&I endeavor is responsible if it simply avoids FFP is “a very low bar. We need to do much better than that.”

For LD5,

research and innovation is responsible when it’s conducted with thoughtful consideration of the eventual users, the society in which those users live, and also the researchers themselves. So, the process and the outcome are done in a thoughtful manner, considering consequences, trying to illuminate potential impacts.

Clearly, to a significant degree, LD5’s views parallel those of LD1-LD4, as when s/he argues that likely consequences on a wide range of parties need

⁹ <https://ori.hhs.gov/definition-research-misconduct>.

to be considered, and holds that if it is unclear what the impacts of the research or innovation could be, the practitioner has the obligation

to give our best take on what those impacts could be and not necessarily make our own decisions about what should be done in response to those potential impacts, but to spark that conversation [in an appropriate forum] whether this is a good thing to go forward with. Clearly some decisions have to be made within a lab but oftentimes I think the more important considerations are ones that are maybe not up to one individual to make about how we want to proceed with our society.

Like LD3, LD6's notion of RRI pertains to the *laboratory* level. LD6 contends that there is a responsibility to "[carry] out research in a rigorous and proper way. Under that umbrella I would put not plagiarizing, not fabricating data, [and where] what you report you swear is true to the best of your knowledge." But, there is also

a more grey area, a more subtle kind of way that we conduct our research, where [the question is] do we carry out the controls or do we do the extra experiments that might show that our idea is not what we think it is, that sort of thing.

Thus, for LD6, RRI involves not just avoiding FFP but also avoiding certain other practices, for example, failing to do the last 20% of the appropriate experiments in order to take "the shortest path to a paper," or choosing not to report all the recorded data that one could and should.

Regarding the innovation phase of the R&I process, LD6 made a critical point about RRI:

if you skimp on the scientific [research] phase then you're going to pay for it, the whole house of cards will crumble or fall apart if you try to innovate on top of shoddy science.

In short, for LD6, RRI requires ensuring that the downstream innovation work is based on solid upstream scientific research.

For LD7, "...responsible research is research that tends to minimize the risks associated with it when it comes to fruition for everybody." The researcher aspiring to do RRI must be able to say "in good conscience" about her/his research, "I've done everything [I can] to minimize the risk that this [research] becomes something [negative or harmful. But] everything can become a weapon," and the responsible researcher must "try to minimize the risk that that happens."¹⁰

¹⁰ These remarks about risk mitigation are reminiscent of NIH's current policy on "dual-use research of concern" (DURC): "IREs [Institutional Review Entities] should conclude their risk-benefit assessment of DURC by developing a draft risk mitigation plan. The plan should indicate the DURC-associated risks identified by the IRE, the specific risk mitigation measures to be employed, and how these measures address the identified risks." See "Tools for the Identification, Assessment, Management, and Responsible Communication of Dual Use Research of Concern: A Companion Guide to the United States Government Policies for Oversight of Life Sciences Dual Use Research of Concern," <http://www.phe.gov/s3/dualuse/Documents/durc-companion-guide.pdf>, p. 35. However, one difference is that LD7 attributes a risk-minimizing responsibility to *the researcher*, whereas the NIH policy appears to place that responsibility on *the pertinent institutional review entity*.

LD8's idea of RRI "is expressed in what kind of work I do and then, inside the work I choose to do, what aspects (and how) I go about implementing that research." S/he makes all those choices in accordance with his "ethical principles" and so that they agree with her/his "inner values." For this lab director, RRI "means to me basically 'Do good!' or "Try and make the world a better place." Thus, as regards RRI, for LD8 the *intention or goal of the practitioner* is critical.

LD8 also called attention to the critical role of money in enabling much contemporary R and I activity. While sometimes the source of money for research may be ethically suspect or tainted, LD8 denies that that necessarily makes the R and I work done with such money irresponsible. LD8 strongly believes that doing R and I work responsibly requires that the practitioner be "open" or "transparent" about the source of the money that enables it, as well about what work is being done with the provided money. For if that transparency occurs, "...then you can have a public discussion about what's right or wrong," hence whether to continue with the work. This recalls LD2's idea about 'sparking a conversation' about potentially dangerous implications of research.

2. Comments

While there were overlaps, the responses of the interviewed CCC-affiliated lab directors to Q1 varied considerably. The proper response to that variability is not to choose one or two ideas or aspects, anoint them as valid, and dismiss the others or deem them unimportant. Rather, an acceptable idea of RRI must, above all, be *comprehensive*. It should encompass most or all of the aspects brought up by the LDs and, as we shall see, some others as well.

This author's view is that a comprehensive notion of RRI must take into account at least the following four considerations:

- i. the **total social context** in which a R&I endeavor is embedded. This context includes the *microsocial* or lab, office, or factory level; the *macrosocial* level of society-at-large; and the *mesosocial* or mezzanine level, involving interactions between parties active at the micro and macro levels, such as the interactions of researchers or innovators with funding agencies, venture capital firms, courts, and regulators. Responsibility issues can arise and confront practitioners at any of these social-contextual levels. In thinking about RRI, it is imperative to *avoid decontextualizing the R&I endeavor* from its multi-leveled social 'situation.' If the social context is neglected or watered down, the full range of intended, expected, probable, and actual effects of the endeavor may not be taken into account. That seriously risks disqualifying the R&I endeavor as responsible.
- ii. **the likely benefit- and harm-related effects of the R&I work** on all affected parties in that robust multi-leveled social context. It is

also imperative that “benefit” and “harm” be understood broadly, including certain social effects, and not be limited to financial, economic, and physiological effects. “Parties” must include *all* affected beings, including colleagues, end-users, non-users, and society at large. Consideration of the relevant effects must also recognize that while they are sometimes immediate, direct, and tangible, other times they are delayed, indirect, and intangible.

iii. **the multiple, sometimes partly overlapping phases of a complex R&I endeavor.** Those phases or aspects, in any of which responsibility issues can arise, include the following:

- a. problem selection
- b. preliminary conceptualization
- c. fundraising practices
- d. experiment design
- e. human subjects practices
- f. execution practices
- g. data practices
- h. authorship practices
- i. publication practices
- j. literature search practices
- k. design practices
- l. prototype practices
- m. manufacturing practices
- n. marketing practices
- o. diffusion practices
- p. regulatory practices
- q. maintenance practices
- r. design-revision practices

iv. **the fact that whether a R&I endeavor is responsible hinges on both “how” (or “in what manner”) its phases are navigated, and on the intended, projected, or actual “outcomes” of the endeavor on society at large.** For example, whether a certain R&I endeavor qualifies as RRI could depend partly on **how** authorship is handled, data is recorded or deployed, and testing is conducted

in that instance. But whether a certain R&I endeavor qualifies as RRI also depends in a particular case on whether the endeavor, with its intended, projected, possible, and/or actual outcomes, aligns with or is incompatible with societal priorities, needs, or values.

In light of the foregoing, as a first approximation, the author proposes that a R&I endeavor is responsible, i.e., qualifies as RRI, to the extent that all responsibilities that pertain to navigating its phases and to the endeavor as a whole, on all of its social-contextual levels, are fulfilled rather than violated or disregarded. It is essential to note that **the concept of “responsible research and innovation” is not a ‘yes/no,’ ‘on/off,’ or other kind of ‘binary’ construct.** “RRI” is a ‘continuum term’ or ‘degree term’ that applies to a R&I endeavor **to one extent or another.** The degree to which it applies depends on the extent to which all how-related and outcome-related responsibilities relevant to any of the endeavor’s phases (or the endeavor as a whole) are fulfilled.

A specific R&I endeavor could qualify as RRI as regards **how** (or the manner in which) it was carried out in its various phases, and yet still fall well short of perfectly embodying RRI. For if the endeavor’s purpose or actual or likely **outcomes** are inconsistent with some important consensual societal value, goal, or priority, such as preservation of human dignity,

diminished inequality, or environmental sustainability, then the endeavor would fall short of being completely RRI, even though carried out in a responsible manner in all its phases. Conversely, if a R&I endeavor was universally expected to be benign in outcome and consistent with all societal needs and priorities, it would still fall short of being completely RRI if actions that occurred in one or more its phases were not carried out in a way that fulfilled the pertinent ethical responsibilities, e.g., if, say, authorship was handled promiscuously, fundraising relied on distortion or deception, or data was misleadingly or selectively used.

To clarify these dualistic comments about “responsible” R&I endeavor, consider an analogy. When ethicists speak of “justice,” they often distinguish two things about which justice judgments are made. Sometimes what are deemed as just or unjust -- put differently, held to embody or not embody justice -- are the **outcomes** of certain actions, policies, or practices. When such justice judgments are made they are often said to be about the **substantive justice** of the outcomes in question. Other times, when justice judgments are made what is judged is not the justice of the outcomes, but rather the justice of the **processes** by which the

outcomes were reached. In such cases, what is at issue is said to be the **procedural justice** of the processes in question.

Thus, for example, the question of whether the outcome of a trial of a defendant accused of first-degree murder was **substantively just** is different from the questions of whether the process by which the trial jury was selected was **procedurally just**.

Like “justice”, “responsibility” has two foci. If one inquires into how (or the manner in which) a R&I endeavor was carried out in its various phases and finds that it was done impeccably, one is exploring whether the R&I endeavor was procedurally responsible. But if one inquires into the intended, most likely, or actual outcomes of a R&I endeavor, in relation to societal priorities, needs, and core values, then one is trying to determine whether the R&I endeavor was substantively responsible.

Thus, even if the work of the Chinese researcher who in 2018 edited the genes of human embryos using CRISPR-Cas9, ostensibly to make them immune to the AIDs virus, had been universally hailed as likely to have a benign **outcome**, that work would still **not** be properly described as unconditionally responsible if, say, the practitioner’s **process** of recruiting the human subjects involved relied on deception, distortion, or incomplete

disclosure about benefit and risk, or if the **process** of obtaining ethics board approval for the planned experiments was deceptive or fraudulent. In other words, **any assessment of whether an R&I endeavor is responsible must consider whether it was procedurally responsible and substantively responsible.**

In checking whether and the extent to which a R&I endeavor qualifies as RRI, one must ascertain how the endeavor stacks up regarding fulfillment of the responsibilities raised in each of its phases, e.g., the human subjects practices, publication practices, data practices, and testing practices phases. But to do that it helps to have clearly in mind **The Four Fundamental Ethical Responsibilities of Scientists and Engineers (FERSEs):**

- to not *cause* harm or *create* an unreasonable risk harm to others through one's technical work;
- to *try to prevent* harm or an unreasonable risk of harm to others from one's work or work about which one is technically knowledgeable;
- to *try to alert and inform* about the risk of harm those vulnerable to being harmed by one's technical work or work about which one is technically knowledgeable;

and, for employed technical workers,

- to *work to the best of one's ability* to serve the legitimate interests of one's employer or client.¹¹

For each phase of a specific R&I endeavor, applying the relevant FERSE or FERSEs to the particular features of that phase, situated in the specific context in which it unfolds, would enable one to identify specific responsibilities associated with that phase. Thus, in trying to determine the extent to which an entire R and I endeavor is RRI, one would have to determine, among other things, the extent to which the practitioners' decisions, actions, and practices were compatible or incompatible with the responsibilities that pertain to the endeavor's various phases.

In short, determining whether a R&I endeavor qualifies as *responsible* research and innovation (RRI) requires exploring whether both its processes and outcome(s) are/were responsible. While procedural responsibility does not guarantee outcome responsibility, since a procedurally responsible endeavor can still have an irresponsible outcome, the hope is that being procedurally responsible makes a substantively responsible outcome more likely.¹²

¹¹ See R. McGinn, *The Ethical Engineer* (Princeton University Press: Princeton, 2018), pp. 26-38, for detailed statements of these responsibilities for engineers.

¹² In the same vein, while procedural justice in jury selection does not guarantee a substantively just trial outcome, it is widely believed to be conducive to it.

B. Lab Director Views on Characteristics of Responsible Research and Innovation (RRI)

The second question posed to the lab directors asked them to identify *specific characteristics* of R&I endeavor that they believe count toward its being deemed responsible, i.e., as RRI. The hope was that this question would elicit answers that were more specific than the often abstract or general ideas of RRI elicited by the preceding question.

One lab director cited certain practitioner traits. “The big [characteristic of RRI] would be” openness by the researcher or innovator to the possible refutation of her/his ideas, even one which s/he “love[s] and [is] highly invested in.” A second characteristic is the complementary trait of not accepting a “counterargument” to one of one’s favored idea too quickly, but rather ‘taking [the objection] seriously and being willing to see if it can be replicated or tested a different way.’ Another characteristic of RRI is a researcher’s not putting her/his personal interest over what is right for her/his field in her/his decision-making and conduct. The lab director cited the example of a researcher who, when refereeing a submitted paper that came close to scooping her/his own work, did not allow her/his personal interest in protecting the work of her/his lab to trump doing what

was best for the field and evaluated the paper objectively, with that priority in mind.

For another lab director, “the key” characteristic of RRI is exhibited by the practitioner who “take[s] time to reflect and think about what the implications of what [s/he is] doing are.” A second such characteristic is willingness to “engag[e] with other people, [and] talk about what you’re doing to people who are not narrowly focused on the deliverables of that project [and] just want to get the paper out.” For this director, that is “super important” when it comes to deciding whether “to hold off publishing something” temporarily. Finally, the RRI practitioner must exhibit “willing[ness] to take action” rather than “sitting on the situation” after reflecting on implications and engaging with others about them.

Yet another lab director identified an interesting RRI-making characteristic: a kind of transparency, whereby a researcher, especially young ones, in “an engineering discipline like synthetic biology,” deliberately includes the flaws and limitations of her/his work in the text and figures of her/his submitted paper, “thinking this will advance the field more than if I sweep these under the rug.” For a researcher to be responsible in this way is especially impressive since reviewer failure to give

due credit to author attempts to be transparent “happens all the time.”

This is a variation on the theme raised by the first lab director, viz., being unwilling to allow the self-interest of the practitioner to trump what is right or best for her/his field of inquiry. It should be noted that this lab director focused on a personal characteristic of the researcher, not on a structural feature of the R&I endeavor itself.

Rather than identifying specific RRI-making characteristics, another lab director chose to remain at the general, philosophical level. S/he called attention to “the power” of the researcher to “propose ideas, get money for those ideas, train students, [and] introduce new compounds [and] cells.” “We’ve been given...this power to create knowledge and educate people and so it’s...about using that power in a responsible way. That’s the way I would think about...all questions of responsibility.” In the context of research, this power engenders a responsibility “to make the right decisions about that research,” viz., “to [do] our best to use [the] power we have to help others think about new ideas and new capabilities we’re creating.”

Another lab director posited a specific RRI-making characteristic: “One big one would probably be radical transparency in sharing data.”

“I like some of these catch phrases, like ‘trust but verify.’ If I read someone’s paper [I] trust that they’re working in good faith. But I’d like to have the option to dig into the data myself and redo the analysis to verify and maybe extend, go beyond what they reported. One characteristic is, it’s really how you see yourself with respect to the field, the community, as a scientist. Like, think of the joy that we get being the first ones to play with new data we’ve collected for the new system. If you can enjoy that part of it but then also realize that the way that you work, the way that you collect data and then report on it and share it, I think a really good way to do that would be to share everything, all your notebooks, all your data, give everyone enough so that they can reproduce your written assessment, the narrative that you built. The flip side of that is when we just share the narrative – and this is especially bad in computer science – there is some pseudo code but no source code, and okay he did this algorithm, here’s this pseudo code, [but] what’s left doesn’t exercise the reader, we don’t give you any of that, we don’t give you the answer book, that kind of thing...[that] doesn’t seem consistent with this idea of responsible research.

After citing several “kind of obvious” characteristics, such as “responsibility to peers in the lab, fairness, [and] crediting the right people,” another lab director emphasized a characteristic similar to transparency: viz., “openness.” By “openness,” s/he meant not only...

being able to share the results, but also how you get to an output is incredibly important. So if you make an algorithm or if you make a new compound or if you have a pipeline to making something, making it very open is a way, I think, of being responsible, because people can evaluate, they can relate, they can reproduce, and so forth. Reproducibility is also an important part of responsibility in research.

The remaining lab director also focused on characteristics of the person or persons doing the research, such as being willing to “talk about the use cases, positive and negative, [of one’s product], to see both sides, and to be a devil’s advocate [re] one’s own work.”

To recap, RRI-making characteristics identified by the lab directors include the following:

- The practitioner having a habit of reflecting seriously on the implications of her/his work and its possible consequences.
- The researcher being open to considering objections made to even her/his favorite ideas and to would-be attempted refutations of same.
- The researcher not agreeing too readily with challenges to her/his ideas, theories, and hypotheses.
- The researcher putting the best interests of her/his field ahead of her/his own private interests
- The researcher being transparent in revealing the limitations and defects of her/his work in her/his publication.
- The researcher’s being transparent in sharing data and methods from her/his work with other researchers.

Clearly, some of these characteristics are attitudinal, i.e., they have to do with the attitudes of the practitioner. Others have to do with certain practices to be followed by the practitioner in traversing phases of the R&I

process. The characteristics cited have to do primarily with phases of the *research* stage, not the *innovation* stage. With one exception, none of the lab directors addressed characteristics of responsible innovation as opposed to responsible research. The one exception was the key point, made by one lab director, that responsible innovation must be anchored in solid fundamental research if it is not to be akin to a house of cards.

The diversity of RRI-making characteristics the LDs specified suggests an important point about RRI. When, in reflecting about the extent to which a R&I endeavor is responsible, one considers the extent to which all responsibilities in all phases of the endeavor have been fulfilled, it is critical to realize that those responsibilities are **owed to various parties**: to one's research or innovation colleagues, to non-located researchers or innovators in the practitioner's field, to the field itself, to users of the products of one's work, and, of course, to society at large. The expression "RRI," as used in the EU, seems to direct attention primarily to practitioner responsibilities to society at large. However, if "RRI" is to be an improvement on "RCR," it must call attention to practitioner responsibilities owed at the microsocial and mesosocial levels no less than at the macrosocial level.

C. CCC-Affiliated Lab Directors' Views on Characteristics of Irresponsible Research and Innovation (IRI)

The lab directors were then asked to identify characteristics of R&I endeavor that count toward its being deemed *irresponsible* research and innovation (hereafter: IRI).

One lab director immediately replied, “obviously: falsification.” S/he then went on to point to “a less obvious one,” which s/he dubbed, using Sidney Brenner’s phrase, “Ockham’s dust broom.” This is the practice of ‘sweeping inconvenient facts under the rug’ to project a tidy, unqualified conclusion, one that is clean, not ‘grey.’ As this director put it,

what I see a lot is people that report their data accurately, but when it comes time to describe the conclusion, they may gloss over some parts that are inconvenient. There’s a lot of pressure to do that...

On the other hand, the same lab director also noted that some researchers exhibit the IRI-making characteristic of succumbing to “peer pressure to never change” their ideas or hypotheses, even when data call for doing so.

Another lab director described “a moral slippery slope.” By this s/he means a pattern in which a researcher initially rules out doing something as morally reprehensible, but then over time finds that s/he is doing

something that brings her/him closer and closer to doing that very thing.

For example, this director referred to

collaborating with someone who is doing the thing you promised you'd never do, [then] someone from your lab goes to the lab doing it,...and [then] the next thing you know you ask that lab to do it, and then the next thing you know you're doing this thing.

A practitioner stepping onto or remaining on such a moral slope would be courting a judgment of IRI.

Another director called attention to the phenomenon of "disenfranchisement." By this s/he means a process in which the legitimate interests of some researchers in a laboratory are not recognized or given the same priority as those of other researchers in the same lab. This lab director called particular attention to the interests of female and minority researchers, which may be shortchanged in various, often subtle ways. For example, female and ethnic minority graduate student researchers may be discouraged from speaking up or have their ideas taken less seriously than those of male, majority-ethnicity peers by an insensitive lab director or senior lab researcher. They may fail to receive their fair shares of time on key instruments or not be afforded opportunities to lead inquiries like male or non-minority counterparts are. A critical factor to which this lab director

called attention is the *culture* that prevails in a research laboratory.

Whether a R&I endeavor merits being called RRI depends in part on whether the prevailing lab culture promotes equal valuation, opportunity, and 'voice' for all laboratory members, rather than reinforcing or fostering acquiescence in differential opportunity, valuation, and voice as a function of gender and ethnicity. A key point here is that the culture of a research laboratory can be IRI-making by fostering subtly biased treatment of some lab members.

Another lab director ventured the following description of IRI-making characteristics:

A brazen attitude, a damn-the-torpedoes approach to research, willingly disrespecting or being unwilling to consider the impact of the research, not using your skills and the responsibility you've been given to further legitimate purposes of the organization. I would count those as signs of irresponsibility...So I think that finding ways to get in the habit of being responsible, or asking questions that would lead us to be responsible is part of, it's a practice. It's not just a state of being, it's a practice of re-engaging with the ideas... We're all pulled in different directions by different influences and this [responsibility] is a certain way of behaving that we want to encourage and therefore we need it to be a practice.

This lab director also advanced a quite different characteristic of IRI.

Normally I think about irresponsibility in terms of actively doing something bad, but maybe the converse of passively not doing

something good is also irresponsible. If we're given the power to work on topics that could have great positive impact on society, and we squander that opportunity, I feel like that falls into the irresponsible category as well. Not making the most use of our talents, of our resources, of the time we have, of an appreciation of the problems that exist, that's also a kind of irresponsibility.

Thus, for this lab director, launching or persisting with R&I work that effectively wastes an opportunity to do research with potential for having a "great positive impact on society" would count toward IRI.¹³ This variation on the theme of negligence is a useful consideration for publicly funded practitioners to bear in mind in the problem- or innovation-selection phase of R&I endeavor.

A different lab director called attention to a quite different IRI-making characteristic. S/he noted that when a practitioner doing research is also serving as a mentor to younger colleagues, the relationship between research productivity and mentorship can become irresponsibly 'imbalanced.' Asked whether, if a professor doing research has mentees, it makes sense to speak about her/him as having a responsibility to ensure

¹³ When referring to squandering opportunities to do research with the potential for "great positive impact on society," this lab director implicitly invokes an outcomes-based notion of responsible research.

that the mentees have growth opportunities, rather than being assigned mundane and straightforward tasks, this lab director observed:

Yeah, I think that...this is where we get into a grey area and it's a very difficult question because each person is different, the mentee is one person and the projects in the lab evolve over time. So that's two moving targets, and matching the person with what they need, [coupled with the fact that] the students may or may not recognize or know what they need, oftentimes there's sort of an imperfect situation, which we only recognize in retrospect: 'Oh, yeah, that wasn't ideal but I didn't understand it at the time'. Recognizing that you're in a situation that needs correction I think is really hard, so it's the positive proactive and the negative inverse of the same question. In a negative sense, it would be like isolating people and making ultimatums or refusing to let them spend time on personal development or career development, you know, workshops, opportunities to network and talk with other people. There's a risk that they can go out and discover that they really want to leave the lab or switch projects or do something else. Accepting that risk and accepting that people may do that if they are given enough freedom to think about what they want to do, that's a positive thing that we should try to do.

In short, negligently failing to do anything about a serious imbalance in the research productivity-mentorship relationship, to the benefit of the senior researcher's established career and the detriment of a young researcher's nascent career, counts towards IRI.

Yet another lab director focused on a facet of the R and I enterprise in general. S/he called attention to the fact that it is critical "to understand the importance of negative results," presumably meaning findings from

experiments that certain ideas, theories, methods, and hypotheses have not panned out. “In a way, to be more responsible in research, we should allow or we should have forums for negative results, things that don’t work. We only publish things that work.” The lab director’s implication was that this research- publishing convention is not conducive, perhaps antithetical, to RRI.

Finally, a lab director cited several characteristics of IRI, including ‘not looking at the pros and cons of what you’re doing.’ But what this LD regards as “doubly irresponsible” is “knowing that [a process or product] is going to harm people but you’re doing it because it’s making money.” S/he gave as an analogy the example of people who, for reasons of financial gain, cut their THC product with vitamin E oil, even though they know that smoking vitamin E oil gives the smoker ‘popcorn lung.’ They then sell that cut product for use by young people in vaping devices “because of...greed for profit.”

To recap, the lab directors suggested a number of IRI-making characteristics:

- falsification
- use of Ockham’s broom

- resistance to reconsideration of one's ideas in face of compelling evidence of their invalidity
- stepping on a 'moral slippery slope' regarding practice
- insufficient support or appreciation of 'negative results'
- causing or acquiescing in disenfranchisement
- adopting a damn-the-torpedoes approach to R&I
- pursuing a project that squanders an opportunity to make a great positive impact on society
- acquiescing in or exploiting an imbalance in the research productivity-mentorship relationship
- greed for profit from one's R&I endeavor

D. Features of Research and Innovation Activity in Directors' Labs that Reflect Their Personal Ideas of RRI

The lab directors were next asked whether any features or aspects of how R&I activity is organized and unfolds *in their own labs* reflect their personal ideas, conceptions, or understandings of RRI. Some respondents cited informal policies they had implemented, others noted specific R&I practices they had introduced in hopes of making work in their labs more fully responsible.

One lab director has adopted several policies reflecting her/his ideas about RRI. S/he does not allow post-docs in her/his lab to work on anything that is “core to the lab.” They must work on a topic that is “their own thing,” “something they can eventually take with them” when they leave the lab. Her/his rationale for doing so is that it would not be responsible to force post-docs to work on a topic that, because it is what the lab host is working on, would make them uncompetitive for jobs or grants for which they will eventually apply.

This lab director’s general goal is to push the lab’s post-docs to be “entirely independent, as much as possible.” The idea is that “eventually they’re going to be running their own show. I don’t think you’re going to learn how to do that by doing what someone else tells you to do.” It would, s/he holds, be irresponsible to retard the development of students and post-docs into autonomous researchers by tightly restricting their research topics.

[O]ne of the ways you can be irresponsible is to exploit the people who are doing the work....I also think that the goal of having trainees is to sort of expand science and so you want trainees to go off and launch their own branches of things. That’s something you see a lot: people see their labs as a bunch of hands to get stuff done, and the problem is that there’s a tendency for trainees to also fall for that, because if someone hands you a project and

says, 'here, turn the crank on this for six more months and you'll get a paper,' that's very tempting. If you do that again and again and again someone can get ten papers very quickly... but then they'd never actually learn how to do their own thing and now they're out on their own and they just do incremental work.

One factor underlying this director's adoption of these policies is to make "fighting over intellectual territory" less likely, as in disputes over to whom a given question 'belongs,' something which can easily precipitate authorship disputes. While having people work together has its benefits, it also creates "many problems," e.g., protracted disputes over "who owns what."

A general contention that underlies these policies and practices is that **responsible socialization of newcomers to a research lab** is an element of RRI. These and other responsibility-promoting socialization practices should appeal to a lab director or PI seeking, proactively, to be a practitioner of RRI. According to this lab director, practitioners are often "reactive," acting downstream only after a problem emerges, rather than going to the trouble upstream of introducing and monitoring for adherence to responsible socialization practices in order to promote intellectual growth and preclude ownership disputes.

A different lab director indicated that while s/he had not adopted any specific policies, s/he had worked “to cultivate an environment [in the lab] where people talk to each other and are willing to have nontechnical conversations about the science.” S/he works hard to ensure that the lab is “a super-safe place,” in terms of not just physical but also social safety. When there are group meetings, this director encourages lab members to feel free to ask questions, not feel that if they do so the director might “shoot them down.” S/he also fosters candid conversations in the lab about “where things might go” as a consequence of the lab’s research, both positively and negatively.

While yet another director doesn’t think s/he has introduced “any specific innovations” in her/his lab’s practice, s/he is a “big believer in having the whole group think about everyone’s work.” To that end, this director has established multiple levels of social interaction in her/his lab. “At the ground level,” s/he makes use of “SLACK” -- Searchable Log of All Conversations and Knowledge – a group software program. It has different channels and students can select which channels they want to be in. This allows the group to share papers or results and talk about projects, their own or that of a colleague. The director also makes “a point of walking

through the lab at least a couple of times a day,” to make her/himself available for one-on-one interaction. Lab subgroups meet weekly or biweekly to talk about what they’ve been doing, solve problems, and decide where they’re going. Finally, each student is required to give, once every three months, a formal talk that is accessible to other subgroups and even to non-lab members. The director insists that all students ask questions, to combat them falling completely into their Slack channels. “I find this multi-tiered way of working to be advantageous for forcing the students to, obviously, make progress on their projects, but also do the hardest thing for graduate students and post-docs:...taking a step back from their day-to-day work and trying to think of the bigger picture.” Each of this director’s group practices can be viewed as involving a researcher responsibility, for example, *to not inadvertently decontextualize her/his research or innovation work*. This director sees the social structures s/he has built in the lab as a form of “peer mentorship,” which s/he welcomes as a believer that learning from peers is vitally important.

Another lab director identified three practices that s/he has introduced in the lab that reflect her/his general idea about RRI. The first is *outreach activities*.

I support and encourage students in my lab to participate in and lead outreach activities, where we go to schools or go to science exhibits, like the Exploratorium, to try and communicate our excitement about science, and to familiarize the public with what scientists look like and what they do, as a way of paying back the taxpayers who are funding us.

The second is delivering an *annual address to the lab* .

I do a 'State of the Lab' address every January, to coincide with the 'State of the Union' address. I give up the lab meeting for that week and we talk about our overall accomplishments for the year before. I tell them how much money we spent, I tell them where all the funds came from, and every year I tell them the same thing: these are taxpayer funds, many of them. Except for the Foundation funds, this is money that the Federal government had that did not go to school lunches, did not go to healthcare for people who need it, this did not go to X, Y, and Z. It went to us, and it went to us because there's a belief that investing in research is going to lead to positive outcomes that are going to benefit everyone. And so, while we may be focused on some very nuanced questions that we argue need to be solved, we have an inherent responsibility to pass on that knowledge, and passing on that knowledge is not just publishing a paper, it's engaging in the next step of the translation process. So, if we come up with a new idea I challenge the students to figure out how we get it to the next stage. Maybe it's not something that our lab would do, but who needs to know about it? How do we get in contact with them, how do we introduce people to the ideas that we've come up with? So that's a second way. I try to help people understand where the money comes from so that we can be responsible with it.

The third practice this lab director has introduced is to “support students who want to go and do startups, [and] actually take the translation [from research to innovation] in hand and move it out.”

I’ve had a number of students who’ve become entrepreneurial and decided they wanted to take technology and move it out. Providing support for a broad range of different jobs, post-PhD. is another way I try to help with that.

The practices aimed at helping students who aspire to launch startups is a special case of a more general lab practice, one this lab director calls maintaining a “culture of support.” To get a sense of what that means, consider that this lab director has weekly lab meetings, at which communication, research, and paper-writing skills are stressed. S/he also tries to

model what collaborative work looks like. When people present [at these meetings], I expect everyone to contribute ideas and comments, [emphasizing] that this is a community effort... Maybe that helps through repeated lab meetings. Everyone sees that they’re not doing this alone, and that everybody else has good ideas and thoughts to contribute, and so it reinforces the community aspect of research.

In effect, nurturing such a culture in the lab is a robust form of mentoring and can be viewed as a form of RRI practice.

Another aspect of this director's idea of culture of support takes the form of concern with "empowerment" in the lab.

I think that empowerment and starting to see yourself as an independent scientist, that transition is fast for some, slow for others. Ensuring that everyone is on 'the right path,' moving toward that perspective [of the independent scientist] at a rate that feels comfortable to them is part of that [empowerment] process, inherently, to see themselves as they present, [as] you're presenting your data, this is your demonstration that you are a scientist.... Lab mates mentoring each other provides some...support, and if there's a culture of support, mentoring, giving advice, receiving advice, then it shares some of the load. I think the PI is always going to have an important role, but if students can see themselves as mentors as well, if they are working with an undergraduate student and take on that role of mentor, then there's many layers of mentoring going on and communication about topics related to mentoring.

Finally, this lab director's notion of mentoring includes organizing an annual "professional development meeting"...

where we don't talk about research at all. While research topics can come up, it's all about what they want to do with their life. I ask them to come in with three things they think they are doing well and three things they want to work on. It's so much fun because I get the chance to, for those who are shy, to add to their list of things they do really well, so they get that reinforcement, but also it's an opportunity for them to say 'here's where I think I'm not doing well' and I can either agree or disagree, add a few to the list, and then we talk about what are we going to do to improve those things. Are there more opportunities to speak, are there writing workshops? Are there time-management tricks we can work on? Things like that this feed into the mentorship idea.

For this director, “free-flowing communication” is a norm that would-be responsible R&I practitioners should promote and sustain in their labs, not just as a social lubricant but also as something that is critical to safety. “If communication isn’t free-flowing in a lab, then everything suffers. And it’s free-flowing if [the organization is] very flat, everyone feels like they’re a member of a team, and their thoughts are valued,” including their concerns and suggestions about ensuring lab safety.

Another lab director also cited ‘lab culture’ as an important factor in RRI. But, for this person, ‘lab culture’ means something quite different than practices or symbols that reinforce the safety or community dimensions discussed above. This director has established in her/his lab a culture in which publication comes “at a much slower pace than expected,” because s/he is deeply committed to “doing very rigorous work” and to “being transparent and making things complete,” rather than to “just cut[ting] corners and put[ting] something out ASAP.” On occasion, s/he has even held a lab researcher back from submitting a paper because in her/his opinion it wasn’t yet sufficiently deep or comprehensive. The director believes that in so doing s/he is doing the responsible thing regarding training her/his students and post-docs. This lab director gives the student

or post-doc an opportunity to write a first draft of a paper, they “pick apart the analysis” together, and s/he has the student refine the draft.

Sometimes

[I] take over the project at the writing stage and basically write the paper and do the analysis myself, or together with the student, like ‘Here’s what we need to do.’ But I can’t necessarily ask them to do that on the first try if they’re new to the subject. [Although] there’s a lot of demands on my time, finding the time to write the first paper with each student, that’s part of the job.

Thus, for this lab director, socializing graduate students and post-docs into **a culture that prizes fastidious and rigorous research and publishing** is a vital form of mentorship, an element of RRI.

Another lab director has established certain operational rules that govern how work is done in her/his lab, in the name of fostering RRI.

One thing...that we have established is that everybody who writes code...has to check it into a group repository, where everybody else can take it and use it. And credit is given because when you write a code, the first thing you write is the author, and so I think that makes people think [more broadly] than their own result and more [like] ‘yeah, I’m going to make sure that somebody else can use it and [that] it works fine and [that] there are no bugs, [that] it’s working the way it should, [and that] it’s not breaking anything or doing anything wrong.’ And you would be surprised by how many people resist that idea. Younger people. My feeling is that it’s more [that] people think that what they do is *ad hoc*, and sometimes they feel it’s difficult, it’s hard for their work to be reused. Because everybody thinks they’re special. Part of this could be ‘oh well, I don’t want people to see how I write my

programs' because they're not up to the standards of an ideal of software engineering. That could be one thing.

There are several reasons why this director enforces the repository rule. "[O]ne of these is reuse. The idea that the software we are writing has at least to be general in some sense, [such that it can be applied] in different systems...without having to rewrite it from scratch. Some of these programs are incredibly long and have taken months to develop and so you don't want that, that's not good.

The second thing...is the fact that...when students leave they take their own things with them. In the sense that because they have written it, [effectively it] doesn't exist anymore [when they leave]. If you send them an email they will send it to you, but you don't have it, right? So, I want the code that is developed in my lab to be available for the next batch of students so that they don't have to rediscover the wheel.

The third reason why this lab director insists that her/his researchers "put their code in the repository" is that

I want people to be accountable for what they have done. And I've seen this: ...there have been people in my lab in the past who have done things very *ad hoc*, to the point of being not okay, right? So, having a system of checks is, I think, very good. Sometimes it comes from experience. You don't know that people who are just doing their undergraduate or graduate work are going to realize that certain things are not okay, from a peer-review perspective. And so, I think that this is a way for people who are more junior, but at any level I guess, to learn some of this praxis. This is funny for someone who works for [XYZ] research. I strongly believe in openness, although I do patents and [XYZ] likes me to do patents and intellectual property. I like very much 'open source' and 'open access.'

Thus, there are rules in this director's lab such that the people who write the code and put it into the repository must identify its stage of development, whether it's been checked out, etc. The rules are intended to make sure that anybody else who makes use of the code knows the realities of the situation, rather than just picking it up and having no clue about how carefully it's been checked, whether it's finally finished, totally checked out, etc. That is especially true of the program's domain of valid application.

If you think about things like computer vision, a computer that looks at images and extracts information from images, if this algorithm has been written for a certain kind of cell, e.g., yeast, there's no guarantee that it will work on bacteria images. So, that's something, you know, it's part of this set of checks, and you know, 'this has been tested on this set with this degree of accuracy.' And I guess that makes people more responsible, it makes people think a bit more.

Another lab director has not institutionalized any specific material or policy innovations in her/his lab in order to implement her/his idea of RRI. S/he takes a more personal, *ad hoc* approach. Whether it is "the project we choose, ...the tasks we do in the project, the organization being rather flat, [the fact that] we talk about what we're doing, who we present it to, [and] who we partner with," "basically all aspects of the activity" reflect her/his

principles and values. “Everything around me that I touch is in harmony with [them] otherwise I wouldn’t do it.” “Basically, if I’m uncomfortable with any of those reasons – how people treat others, who our customers are, etc. – then I can’t work because I won’t feel happy.”

Asked about female researchers in her/his group, this director replied that because of the culture of his parent organization, the default culture in her/his lab is that people are treated equally. However, the director recognizes the persistence of gendered expression in the workplace, such as “okay, guys, let’s do this,” about which s/he sometimes “second-guesses” her/himself.

E. RRI Cases Offered by Lab Directors

The final question posed asked the lab directors to describe a specific actual instance or episode of RRI that they had encountered in their careers. The example offered could, of course, show exemplary RRI, but it could also show RRI being challenged, eroded, or violated.

Case 1: *Data accessibility*

One lab director described a situation in which a post-doc, P, moved on from the director’s research lab to take a better-paying job in industry. Her/his paper was not completed before s/he left. P took the data set with

her/him in order to finish the paper s/he was working on. The problem is that it is difficult to work on finishing a paper while holding a full-time job. The upshot is that the director's lab no longer had the data, even though the university arguably 'owned it,' since the work was done on a government-funded grant. The lab director wondered how s/he could get the data set back "in house" without the post-doc feeling persecuted or that s/he was the target of a "witch-hunt." It was difficult to make that happen. To the director, it seemed like it took "forever."

From a RRI perspective, it would have been good had there been a policy been in place requiring departing researchers to leave copies of the relevant data sets with the lab. The lab director eventually adopted a policy that, before leaving, a departing researcher must leave a complete copy of all data in the lab where it was generated. Moreover, each researcher must deposit a copy of her/his data *as it is being generated*. Most post-docs leave to take an academic position, and the hiring-and-leaving process is sufficiently slow that it leaves time for a workable "exit strategy" to be devised. But in industry, "you find out today that they want to hire you tomorrow for a big salary and a great opportunity." Thus, the researcher is apt to quickly accept and depart.

The responsibility problem arises from tension between accommodating the interests of the departing post-doc and being fair to both the university that made the research possible and the remaining students in the lab who “could really use the data to take the next step in their projects,” but who are held back by the fact that it is not accessible. “At some level,” the lab director noted, some projects are effectively put on hold and “we’re not doing the thing we should be doing” because we’re keeping it for someone who, in principle, is going to work on it but might not. So, one consideration that applies here is “fairness to the lab people” who want to build on data from earlier work that is not available because of consideration shown to the interests of the suddenly departing researcher with an unfinished manuscript. One thing that would foster RRI in such cases is for the lab director to formulate an explicit responsibility-based code or set of policies spelling out the terms of entrance to and exit from the lab.

Case 2: *Manufacturing organs*

A different lab director related an episode in which a project idea of hers/his, building organs for people using tissue engineering, did *not* come to fruition. This lab director had an idea for how to achieve this goal and

applied for grants to help make it a reality. Unfortunately, the grant applications were not successful. Nevertheless, the director found thinking through her/his vision to be intellectually fruitful.

S/he asked her/himself several general questions: “What if we succeeded, what would the world look like?”, “What if all the competing methods succeeded?” “What would be the ethical ramifications of all those different methods?” The lab director wondered if the various proposed methods for manufacturing organs could be put on “a scale whose extremities were ‘practical but unethical’ and ‘ethical but unpractical’.” Of the competitors’ ideas, the approaches that s/he thought would work s/he deemed “unequivocally unethical..., whereas the things that I thought would never work would be unequivocally ethical, not taking financial stuff [hence accessibility to the public] into account.” (For this “mental exercise,” the lab director assumed that “there are always going to be economies of scale.”¹⁴)

¹⁴ Regarding this assumption, it might apply to those parts of the production process that are amenable to economies of scale being realized, e.g., any hardware involved that could eventually be mass produced at lower unit cost. However, it might not apply to parts of the production or intervention process that are labor-intensive, hence not amenable to realizing economies of scale, at least for the foreseeable future.

The RRI relevance of this episode hinges on whether using a method of making such organs that s/he believed impractical but ethical would count as RRI, and, conversely, whether using a method that s/he deemed practical but unethical would qualify as irresponsible research and innovation. This episode raises the question of whether it is plausible to assess whether a R&I endeavor is responsible *without* taking into account the nature of the social context in which it will unfold. The lab director was and is concerned that, since access to medical products and processes in the United States generally depends on ability to pay their going market prices, one consequence of proceeding with developing expensive manufactured organs could be that the rich get immediate access to them while the poor do not. Thus, social inequality could be exacerbated, arguably a “social harm.” More generally, can a R&I endeavor reasonably be deemed RRI if its likely outcome, in the society in question, is both a *direct benefit for those able to access its products* **and** an *indirect public harm*, such as intensified social inequality?

This lab director is a strong advocate of using the Golden Rule (GR) to think critically about “what you are doing in research” and “whether it’s right.” Using it promotes empathy by encouraging people to think about

how they would feel if they were on the receiving end of what they're thinking of doing that would affect others. The GR offers "a simple litmus test that you can use to ask 'should I do this thing?'" Thus, instead of thinking about this project by using the concepts of benefit and harm, this director prefers to take a GR approach to identifying "responsible conduct of research." S/he argues that if a practitioner is considering research that could result in harm, the Golden Rule could be applied in a "simplistic sense" to conclude "don't do research that, if I put a chemical in this thing, it can explode and people around me can get hurt." But the Golden Rule can also be applied in a more subtle way, to rule out, or seriously consider ruling out, actions whose "more distant" consequences "could [affect] you in a much more roundabout way," for example by causing or worsening a social harm in the society in question.

In exploring this case, the interviewer and interviewee had an interesting exchange on the positive and problematic aspects of relying on "a really complex set of ways of weighing what you're doing in research" versus relying on "a simple litmus test" or rule, like the Golden Rule, one "that you can use to ask 'should I do this thing?'" The lab director's position is that...

While you can put together a really complex set of ways of weighing what you're doing in research,...what people need is a simple rule to help them think about what they're doing and whether it's right.

In effect, the exchange that occurred during the interview explored positive and problematic aspects of what might be called 'complex consequentialist' and 'simple rule-based' approaches to assessing whether a R&I endeavor is RRI. It may be that *both* have a place in RRI assessments of R&I endeavors that are thoughtful *and* practical.

Case 3: *Biosynthesizing new medicines*

One lab director described "the most interesting case my lab has had." S/he and a collaborator have a shared interest in "making a strain that's viable for producing a wide range of BIAs, a family, a small percentage of [whose]... members, 2,500 natural products, is the opiates." But the duo's "foremost interest" is in "using synthetic biology to make so-called unnatural natural products, including enzymes [that belong to a much] larger family, and be able to screen for therapeutics." For a long time, the prospect of being able to do so seemed remote, but then, suddenly, "it became much closer." S/he believes that with the right

graduate student for a year, “I could get to a viable titer...of morphine [sufficient] to get an illicit response.”

The problem I see with illicit opiate production is that the amount you need to get the illicit function is a thousand-fold lower than what you need to get a commercial titer for selling, to compete with the poppy. For just getting a high, illicitly, it is a thousand-fold lower bar, and I think we could clear that without too many years of work. But the pushback...that we got [about this work] was [that] well, this wasn't really a concern because the titers are so low. So, we've continued doing this work for the upstream part of the pathway...We've dramatically improved the titer for that upstream part... I would like to keep the story there, but there's a lot of push from editors to demonstrate it on an opiate. And...I'm not sure what the right answer to that is. I think it's clear that if I go in that direction, that should be done again with... a policy expert [from whom] to get advice on *how* that should be done. Should it be published? Should something be withheld? Should the strain that's produced not be shared with others? Should it only be under special circumstances that you can get the strain to verify our experiment?...Things like that need to be thought through. That's an example where what the responsible action is not clear-cut, other than [that]...I don't think the scientists, i.e., myself and my collaborator, have all the answers to that. That involves the wider community.

Although this lab director is not sure what the responsible course of action would be, s/he agrees that going full speed ahead *without* thinking things through would *not* be responsible R&I endeavor. To compound the situation, “there are forces that [are] push[ing] for going forward.”

Case 4: Lab Safety and the Research Community

Asked for a case study, one lab director offered two safety-related episodes, both having to do with “starting new projects, where we work with something that could be hazardous.” One involved “a pathogenic virus that, when it infects something, expresses a protein in cells that causes them to fuse.” The other involved “bringing an influenza virus into the lab in order to carry out research on it.”

And the question is... where one person or several people might be working with a new reagent that scares other people, how do we address the topic... how do we handle that responsibly?

In her/his parent organization “responsibility according to the rule book” must be fulfilled.

In both cases, the university rules are you need to fill out your biological use authorization forms, you need to do the appropriate safety training, etc. And that’s the formal part of it.

But the lab director, who “really wanted to do some experiments with these things,” has a broader notion of “responsible research“:

I think that responsibility suggests that we need to treat our researchers as important members of the community that have a say in whether or not something that could be authorized by the book is going to be present around them.

But he began to hear that “some people were not so comfortable with [bringing those viruses into the lab].” While s/he was initially impatient with the concerns being expressed,

the bigger and more important picture is [that] we’re not going to do good research if people aren’t comfortable. We’re not going to continue to have people express concern, which I’m very happy that they do and feel ok doing it, if it’s ignored, and so...in both cases, we devoted a lab meeting to talking through all the issues, to figuring out what are protocols that we can all agree would make us feel safe, we designed them together, talked about them, and then I offered, for anyone who individually wants to talk further about these topics, ‘the door’s open.’ So, we went through that process for a month or so to get people comfortable, to make sure that if we did this, it was a group decision, that this is where we want to go, that it is worth taking whatever small risk there is of bringing these pathogens into lab, for the outcome we could gain from it. So, we had to think about what’s the cost-benefit and the impact. Those are two examples where I think being responsible is not just following the university rules and not just thinking about eventually, years from now when the research is done, is it going to have a positive impact on society, but [also] how is it going to affect that community of researchers who are around that project?

From an RRI perspective, using a more robust notion of “responsible conduct of research” may well have important beneficial outcomes downstream. In doing what s/he did, the lab director may have empowered other researchers downstream, in a different situation or working on a different project, to express their concerns, precisely because they saw that

other people's concerns, voiced earlier, were in fact heeded and time was taken to build a group consensus about the desirability and acceptability of proceeding. So, in a way, making an effort upstream to heed researcher concerns could be viewed as engendering protection against serious risks being suppressed downstream because of concern that they wouldn't be taken seriously if vocalized. This was another way that this lab director made operational her/his key idea that RRI involves *free-flowing information being a norm of lab culture*.

Case 5: Intellectual Property and Collaborative R&I

Another lab director related a protracted episode that occurred years ago when s/he was a post-doctoral scholar (hereafter: "PDS"). S/he and a more senior principle investigator (PI) were working on related technologies and decided to "use these two technologies together and maybe do something new and exciting." The PI hired several people into her/his lab. According to the lab director,

I trained those people and started working with them on this new technology, on my technology, and I assumed that they would do the thing that their lab was expert at. After six months or a year, the project had advanced to the stage where the parts that I had done were working. [As for] the other technology, it was clear that there was not a good path forward with that.

At a certain point, the PI proposed that the PDS stop working on the parts that s/he “had sort of seeded and initiated and then trained all their people on.” According to the lab director, the PI told the PDS...

‘You have your own other research, you’re going to be fine, my post-docs need projects. So, what we need to do is, you know there’s three parts to this project. There’s the one that isn’t working, you can take that one over, and the two parts that you did that you’re working with them [on], that are working. Person A needs to take that one and they’ll get that paper and then person B should have the second part, but I really think the third one that’s not working, could be made to work. So, we’ll probably have three major papers by the end of this process. But I need you to stop working on the other parts that you’re [already working on].’ I wasn’t okay with that.

The PDS had started an “outreach design competition” for the technology s/he was working on. To get everyone to buy-in, s/he...

invited some of the faculty to a meeting at the very beginning and we discussed the ideas for the project, and that was the only thing that anybody [else] ever contributed. Then I spent another 2-3 years by myself working on the thing. Once it had been launched and was successful, [the PI] came to me and demanded to be listed as the co-founder of the [project], he wanted to be credited for founding it. There are all sorts of funny things that people do, like he tried to demand that I come to his office. I said, ‘sorry, I’m busy right now at my bench. I’m not going to relocate to a venue where you can sit on your throne and yell at me.’ He started making threats and calling me ‘unprofessional’ and stuff like that.

Reflecting on this episode, the lab director observed,

These characters are all over the place in science. I've dealt with a number of them. [I]n each case I basically just decided to cut off the interaction. There's a sunk cost; I put effort into each of these and I had to be willing to let go of that and not worry about getting credit. I always made this calculation that whatever credit I could get would not be worth the amount of heartache of dealing with this kind of person. They manage to bully and abuse lots of other people who somehow don't make that calculation and still think that they can get something out of it, so I try to encourage students to recognize when they're being bullied or exploited and just stand up for themselves and refuse and trust that things will be okay if they have to switch labs, lose a year at work, switch projects, or something like that.

The relevance of this situation to RRI is clear. If the facts of the episode are as related, then the PI's treatment of the PDS counts against the R&I endeavor in question being deemed responsible.

This lab director ended his remarks with some important observations about the ethics of R&I endeavors:

Often missing from ethics training, or the mandated training that I had as a grad student aimed at teaching students this or that, is this: [it's great to promote] day-to-day, low-level ethical and moral behavior. But one thing I'd like to see more discussion about is the macro-scale ethical and moral concerns about how does the technology we're developing, e.g., a block-buster cancer drug available only to millionaires and billionaires, [get distributed]. It's not hard to predict or guess which of these things is going to end up being expensive in the future, so is it actually appropriate to work on these things? We should at least talk about it, and decide if we're okay with that. Pretty much all research I've ever seen or engaged with [has to do with] big macro-scale topics of, like, how does this technology fit into

society and is it actually pushing us towards more inequality? That kind of thing is a concern of mine that I think about but I don't feel I have a good framework, guidance, or mentoring from even much more senior people, because we don't even talk about it. It's just intrinsically assumed to be a good thing if you can cure cancer, [even if] only for rich people, for example. I'm not taking a stance on whether any specific project should be done, because I think that we often cannot predict where technologies are going to go, what opportunities will be created, and there's also the possibility that something that starts out expensive will become less expensive. Take penicillin; the first dose of penicillin cost millions of dollars, they recovered the urine of the first soldier that used it because half the world's supply was right there, and then eventually we figured out how to mass produce it. So, I think that there's a time component. I wouldn't immediately say 'for [extremely] expensive cancer therapies, it's not okay to work on those because of x, y, and z.' But I'd like to have more of that kind of discussion, think about that kind of thing, and see if there are ways to consider that and reconcile the injustices.

Like the lab director in Case 2, who had an idea for manufacturing organs through tissue engineering and described the thinking s/he did about that possibility in social context, in the reflections just quoted this lab director raises a question of "responsible innovation," and suggests that whether certain therapeutic innovation endeavors qualify as RRI sometimes depends on 'outcome considerations,' in this case, on the cost required to access the therapeutic product. When this lab director, referring to expensive new cancer therapies, asked, "is it actually appropriate to work

on these things?”, it is probable that one aspect of what “appropriate” means to her/him is “responsible.”

Case 6: Incomplete Disclosure of Code

One lab director initially did not offer a specific case or episode of RRI. S/he took the position that...

responsible research is done in the small things that you do every day. Everything that you do every day contributes to responsible conduct, anything, from sharing a piece of data to sharing a piece of software to helping somebody achieve a goal to asking somebody for help. That’s a very responsible way of doing research, to realize one’s own limits. These are things that I see every day in my lab.

However, later in the interview s/he stated that “...there have been episodes in which some people, more from a character standpoint, have withheld data or code.” But,...“in my mind, I can’t find a single episode that really stands out, that has been irresponsible.”

Nevertheless, the lab director continued as follows:

I’ve had in the past a student who, [when] we were writing a paper, withheld some information from me that was negative. That came up in the reviews. One of the reviewers asked a specific question that pointed to something I did not realize and they wanted to see a piece of code. [W]e had a piece of code that was doing something on a data set. The result looked in one way, the reviewer thought that the result didn’t fit the description of the code that we had. And I didn’t realize that. Going back to the student, he told me, ‘oh yeah, of course, that didn’t work that day

but I added this piece of code and now it works.’ And that piece of code was not disclosed in the paper and the piece of code had not been written by him. It was something that was available in the literature. So that gave the impression that he had come up with this amazing method that was just by itself giving these incredible results, but that was not true. And so..., that’s something now that I think about...I was very mad, I was so mad, I was so upset about that, I think that’s absolutely irresponsible and is not okay.

What exactly was it that this lab director regarded as “absolutely irresponsible and not okay”?

[S/he] was taking credit for somebody else’s work without giving credit and [s/he] was taking more credit than he or she should have in regard to the code that he or she had written. I didn’t think it was ethically good, right? It is difficult for me to talk about because I was really mad. (I don’t know if it’s ethical to get mad)...One thing that I tell my students is to ‘write everything’, so you write everything you have done, and then we will take out whatever we think is already part of the literature or is obvious, but you write everything, everything you’ve done, every single thing, you have really to have everyone document where you write every single piece of work you have done, even if it is “I read this paper and in the paper they said we cannot do it...,” you have to write that down, then we’ll cite the paper and we’ll do it. And to me this was breaking a contract.

Regarding the norm that ‘everything must be written down and included,’ the question arises: was that something the lab director decided to insist upon and tried to impart to the young researchers in her/his lab as a result of the episode that angered her/him?

Yeah, in a sense that was a learning experience. This was never dealt with publicly. It was not like I made an example of this person. But in the next iteration, in the next paper that we wrote, it was 'okay, remember what happened last time, it was not pretty and I don't think it's the way you're supposed to work, so make sure that you write everything [down] and make sure that you tell me everything. I also gave this person the benefit of the doubt. This person explained to me that it wasn't done because they wanted to hide it. They thought it was obvious that this piece of code was in the literature was being used. I didn't think that was true but I gave them the benefit of the doubt. I said, 'experience makes you think these things' and it was also partially my fault because I didn't check correctly...Yeah, I insisted on that, that it was a learning experience.

Given the pressure that people are under these days in research -- time pressure, money pressure, status and publication pressure -- and given that grad students and post-docs, drawn from around the world, have not undergone a common socialization process in which they have learned such rules, one cannot simply assume that researchers have internalized and will adhere to even obvious or rudimentary rules of responsible lab practice. The individual lab director who aspires to be doing RRI must establish and oversee an appropriate socialization process within her/his own lab. That appears to be something that this lab director is doing, with respect to specified rules of practice and her/his repository requirement. This lab

director denied that s/he had done anything exceptional, pointing to the fact that s/he had “good teachers.”

I didn't learn these things by myself. In some sense I did, but in a lot of ways the examples I [was exposed to] were good examples, [my teachers] always did these things.

One moral of this situation is that RRI, arguably more important than ever before, “takes a village” to effect. That is why a responsible lab culture is vital.

Cases 7 and 8: *Gender Transition and Military Contracts*

The last lab director interviewed offered two mini-cases from her/his experience. The first occurred at a large technical company where s/he used to work. It involved a company practitioner whose sex was male and who was transitioning from masculine to feminine gender. In the lab director's words, “a man had started becoming a woman.” To the lab director, while “the organization I was with talked the talk...[it] didn't want to walk the walk.” Was the transitioning engineer treated appropriately? Put differently, was the company's conduct toward this employee responsible? Was this employee treated with appropriate dignity, respect, and professionalism in the workplace in the context of her changing gender orientation?

In thinking about this case, the lab director noted her/his good fortune that “two very brave people” were involved.

One was the man who transitioned to a woman. We’d go out to a Mexican restaurant and it was obvious that she was still a man, the Adam’s apple, the big hands, and I thought ‘What guts to take all the ridicule, the looks, the sneers, the comments,’ and then ‘What guts [on the part of] this manager who stood up for her.’ [This was] a company which prides itself on being politically correct but when it came down to the real test case, they punted.

In the second mini-case, the lab director was working for a startup, of which s/he was a co-founder. The startup eventually started doing military work, realizing considerable government money. The lab director had left the startup well before it commenced doing military work. But then one of his former colleagues left the startup. “He didn’t want to work for a company that was doing military contracts.” The military work utilized the lab director’s invention so he was very conflicted. “But I was already gone so I didn’t really have to face [the] issue of ‘would I object.’ As a company founder, would I make a stink that we shouldn’t accept this huge amount of money...from [a government agency]?” The lab director would have faced a strong conflict of interest between the fact that it was her/his own invention that would bring in big money and make the startup successful, and her/his concern over the likelihood that use of that invention for

military purposes could well have problematic outcomes. Would the startup's R&I endeavor qualify as RRI?

In both cases, what might be termed "moral luck" played a decisive role in sparing the lab director tough decisions about being responsible. In the gender case, luck took the form of his unit's having a manager willing to stand up and fight for treating the transitioning engineer colleague with dignity, thus sparing the future lab director the need for deciding what to do, if anything, to support that colleague. In the startup case, luck appeared in the form of fortuitous timing. The lab director happened to have left the startup before the large military contract appeared, thus sparing her/him a difficult decision about what the responsible thing to do would be. As the director-to-be put it,

I guess the fact that I can't think of any more [cases in which RRI is an issue] indicates that I've been pretty blessed, people around me have been pretty ethical.

The gender case is not about whether some specific R&I phase is navigated responsibly. Rather, it is about how a second-order process is handled: whether a practitioner's organization behaves in a responsible manner toward one of its employees, in this case one whose conduct is legal but outside the mainstream. Earlier, the author argued for an

expanded notion of RRI, one that, in determining whether a R&I endeavor is responsible, involves inquiry into both outcomes and how actions in the various stages of the R&I process are carried out, either in accordance with and/or in violation of responsibilities that apply within those phases in their respective contexts. In the name of comprehensiveness, this author believes that it would be fruitful to further expand the concept of RRI, so as to also encompass inquiry into whether and the extent to which a practitioner's organization treats its R&I employees in a responsible manner, e.g., by respecting their privacy and dignity in the workplace, regardless of their sexual, gender, and religious orientations. There are multiple ways that R&I endeavor can fail to be responsible, some directly tied to how technical activity is carried out, others to the resultant outcomes, and yet others to how actors treat each other in the microsocial context of the workplace.

III. Conclusion

A. Elaborating the 'I' in 'RRI'

As noted, the U.S. Office of Research Integrity defines research misconduct as “fabrication, falsification, or plagiarism in proposing,

performing, or reviewing research, or in reporting research results.”¹⁵ It has taken time for the realization to diffuse in the research community that the responsible conduct of research (RCR) involves avoiding a wide range of ethically questionable deeds and practices, not just the canonical Unholy Trinity of FFP.¹⁶ Similarly, there is much more to “responsible research and innovation” than “responsible conduct of research.” Yet, the innovation stage, whose phases must also be navigated responsibly, remains relatively unmapped as regards its phase-specific responsibilities.

Although the questions posed to the lab directors consistently referred to RRI, many if not most of their responses focused on RCR. Very few addressed responsible innovation. **If researchers and innovators are to become conversant with “responsible research and innovation” in a way that improves on the EU’s emphasis on aligning R&I with societal “values, needs and expectations,” additional work is needed to unpack the innovation process into its constituent phases and to identify their respective responsibilities.**

¹⁵ <https://ori.hhs.gov/definition-research-misconduct>

¹⁶ In the author’s opinion, that realization remains far from universal.

The author noted four considerations to be kept in mind in thinking about whether and the extent to which a R&I endeavor is responsible.¹⁷

The third delineated 18 (sometimes partially overlapping) phases of R&I endeavor, the last nine of which belonged to the innovation stage:

- j. literature search practices
- k. design practices
- l. prototype practices
- m. manufacturing practices
- n. marketing practices
- o. diffusion practices
- p. regulatory practices
- q. maintenance practices
- r. design-revision practices

The author is not suggesting that phases j through r offer a definitive elaboration of the innovation stage. However, there is no doubt that researchers and innovators can face challenges to responsible R&I endeavor in most if not all of those phases.

A real-life example might be helpful here. Some phases of the R&I endeavor involved in developing VW's "TDI" passenger cars, vehicles that used diesel engine EA 189, were carried out in a patently irresponsible manner. Responsibilities pertinent to the applied research, design, testing, regulatory, and marketing phases of the developmental cycle were violated

¹⁷ Page 17.

by the installation of an engine-control computer chip or “defeat device,” actually “a sophisticated software algorithm.”¹⁸ When the programmed microprocessor recognized that the car was undergoing stationary emissions testing by regulators, it fully activated the cars’ emission-control system to reduce emissions to legal levels. When the chip recognized that the car was being driven on the road, the emissions-control system was not activated and emissions increased far beyond legal levels. Thus, the testing and regulatory phases of the innovation stage involved fraud to secure certification of emissions compliance with government regulations and access to the consumer market. Marketing the vehicles in question as “Clean Diesel” to consumers trying to make responsible automotive purchase decisions was no less fraudulent and irresponsible.

In September 2015, Volkswagen Group admitted that the testing-regulatory and marketing phases of the TDI diesel innovation stage were fraudulent. This resulted in a company buyback from consumers of about 300,000 VW Group diesel cars made and sold between 2008 and 2015.¹⁹

¹⁸ <https://www.theguardian.com/business/2015/sep/18/epa-california-investigate-volkswagen-clean-air-violations>.

¹⁹ <http://news.mit.edu/2017/volkswagen-emissions-premature-deaths-europe-0303>.

This innovation-stage episode echoed the 2001-02 fabrication and falsification of data that took place in the write-up and publication phases of the research stage for a number of scholarly articles by J. Hendrick Schön and co-authors.²⁰ The latter episode also resulted in a kind of ‘pullback’: the withdrawal by the journals in question of 28 suspect publications that subjected their ‘consumers’ to unjustifiable risks of harm, such as waste of time and other precious resources.

Besides being procedurally irresponsible, the innovation of the VW Group diesels in question also failed to be substantively responsible. For the use worldwide between 2008 and 2015 of about 11 million VW, Audi, Skoda, and SEAT cheat-software-equipped diesel cars had outcomes, e.g., the release into the environment of hundreds of thousands of tons of toxic nitric oxides (NOx) and about 1,200 premature deaths in Europe²¹, that were profoundly incompatible with Europe’s top values, needs, and expectations. The development of the VW TDI diesel was thus a textbook example of a R&I endeavor that was procedurally and substantively irresponsible, hence not RRI.

²⁰ See https://media-bell-labs-com.s3.amazonaws.com/pages/20170403_1709/misconduct-review-report-lucent.pdf.

²¹ <http://news.mit.edu/2017/volkswagen-emissions-premature-deaths-europe-0303>.

The particulars of this example aside, important general questions about innovation and responsibility remain to be answered, including:

- How exactly should the innovation stage of R&I endeavor be conceptualized?
- What are its constituent phases?
- Are the phases the same for all kinds of innovations?
- Are some phases of the innovation stage for physical designed products and systems not applicable to life-science products, such as drugs and genetically edited organisms?
- Are some phases of the innovation stage for life-science products not applicable to physically designed objects or systems?
- What ethical issues and responsibilities are incumbent upon practitioners navigating each of the life-science innovation phases?

Answering these questions will help clarify the concept of responsible research and innovation. Identifying the phases of the innovation stage and their respective responsibilities could be a worthwhile topic for the projected CCC minicourse on ethics and cellular engineering.

B. The Diversity of Lab-Director Responses

The interviewed lab directors offered partially overlapping, partially divergent accounts of what RRI means to them. Their notions of RRI often

appeared little different than conceptions of RCR. However, in this writer's view, these seemingly disconcerting facts are not a cause for serious concern. It would be naïve to expect a group of researchers in different fields of the life sciences to give identical or strongly convergent definitions or characterizations of RCR, much less of such an inchoate concept as RRI. In fact, one noteworthy 'finding' of this study is precisely **the diversity of practices cited as reflecting lab-director understandings of RRI, and the variety of real-life examples given of RRI or RRI-related thinking and practice.**

No specific definition of RRI is likely to command the support of all or most R&I practitioners, including those who work on synthetic biology and cellular engineering. However, such practitioners can enrich their conceptions of RRI by familiarizing themselves with the range of practices lab directors have introduced and institutionalized in their labs to foster responsible conduct of research. Doing so would set the stage for taking the next step: thinking carefully and comprehensively about the innovation stage of R&I endeavor, one in which some of them may eventually become active, e.g., as entrepreneurs in life-science startups. The articulation of a robust notion of RRI and the elaboration of phase-specific ethical

responsibilities that arise in the innovation stage are tasks that merit serious attention going forward.²²

²² The fact that responsibilities related to phases of the innovation stage of R&I endeavors have yet to be well studied, parallels the fact that the literature on ethical issues in engineering has had little to say to date about ethical issues that arise in the entrepreneurial phase of engineering activity.