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The relational responsibilities of scientists: (Re) considering science as a practice

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Abstract

Studies of science are increasingly drawing attention to the highly communal nature of research. Ethics, sociology, philosophy, and anthropology of science all emphasize the key role that collaborative actions play in the generation of scientific knowledge. Nonetheless, despite the increasing interest in these communal aspects of scientific research, studies on the relationships underpinning communality are commonly focused on the how the individual interacts with their peers and contributes to the epistemic activities of science. In contrast, there is little literature that broadens out the scope of this analysis to consider the multidimensional nature of these research relationships. In particular, little is said about how scientists mediate their social interactions with peers during daily laboratory research. Less, indeed, is said about the tradition of 'learning through example' that characterizes most in situ laboratory training.

All of these relational activities are of critical importance in sustaining and perpetuating the practice of science. It therefore becomes important to ask how we understand these relational activities directed towards building and sustaining relationships in different loci for the primary purpose of strengthening the practice of research and sustaining the traditions of scientific research. Moreover, it is vital to consider how discussions on responsibility may be cached out for individual scientists.

This article employs a virtue ethics approach to consider these issues. It begins by sketching out the plethora of different relationships present in daily laboratory practice using existing ethnographic studies. It then uses virtue ethics to identify specific responsibilities that individual scientists have in cultivating and safeguarding the development of these

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relationships. It concludes by suggesting ways in which these issues may be taken up in teaching responsible conduct to scientists.

Keywords
life sciences, pastoral care, relationships, responsible conduct, virtue ethics

Since its earliest conception, scientific research has been understood as a collegial and collaborative process. Scholars in many different fields – including Merton (1942), Kuhn (1970), and Latour and Woolgar (1979) – have highlighted the highly *communal* nature of scientific research. In recent years there has been an increasing interest in describing science as a *practice* (such as Hicks and Stapleford, 2016), using the work of Alasdair MacIntyre to denote a 'complex, collaborative, socially organized, goal-oriented, sustained activity' (MacIntyre, 1984: 187).

Despite the increasing interest in depictions of science as a communal endeavor, the role of the individual scientist within this communal activity is often highly specific and selective. Life science ethics – and indeed much of the philosophy of science – continues to focus on the individual activities directed towards the internal good of research data and telos of the knowledge creation. Thus, the majority of discussions focus on the epistemic activities relating to data production and dissemination – in effect, how the individual contributes to the epistemic aims of scientific research.

This article contends that this position is limiting for two important reasons. First, the epistemic activities of scientific research cannot be fully discussed without acknowledging the highly social processes of laboratory practices. An increasing amount of ethnographic studies of daily laboratory practice draw attention to the highly *relational* nature of scientific research and daily laboratory life. Moreover, scientists continually mediate their social relations with colleagues and peers, critically examine their research activities and outputs, and provide personal support and development to students and peers.

Second, it is important to recognize that the vast majority of pedagogy and continuous professional development after undergraduate education occurs via informal knowledge exchange activities within the laboratory – in effect, 'learning via example'. In this way, the social relationships between mentor and learner become of incredible importance and critical to epistemic success.

All of these relational activities are of critical importance in sustaining and perpetuating the practice of science, but are distinct from the data-related internal goods highlighted above. Indeed, these relational activities emphasize the dependency of modern scientific research on effective and sustainable interpersonal relationships. Thus, it becomes important to ask: how do we understand these relational activities directed towards building and sustaining relationships in different loci for the primary purpose of strengthening the practice of research and sustaining the traditions of scientific research?

In this article I consider these relational aspects of the practice of science in more detail – and how they may be thought of in terms of life science ethics. I begin by examining current ethnographies to elaborate on these relational activities. I then go on to critically engaging with a MacIntyrian framework of practices to highlight the limitations of the current framing of science as a practice. Using an expanded interpretation of *communal practices* informed by Larry May's work on collective responsibility, I then go on to discuss how these relational aspects of the practice of science may be cached out in terms of individual responsibility, and identify specific virtues that may be cultivated in order to appropriately address these relational responsibilities.

The relational nature of scientific practice

As mentioned above, *communality* has long been recognized to be a cornerstone of scientific research. Openness of data and methods, sharing of data and samples, and collaboration are crucial to the advancement of research. The recognition of this importance has characterized the way in which the norms of science are discussed (Merton, 1942), how codes of conduct are structured (Shamoo and Resnik, 2015), and the expectations arising from policy and funding requirements.[1] Thus, individual scientists are increasingly recognized as having commitments to communality that are often cached out in terms of their shepherding of resources – data, samples, and equipment. Indeed, particularly in the discussions surrounding the Open Data movement, the promotion of sharing to promote the common good – for the advancement of science and for public benefit – is particularly evident (Panton Principles: Murray-Rust et al., 2010).

As the enactment of communality and the exchanging of resources involves interpersonal exchanges, there has been considerable effort in recent years to characterize and understand the nature of these relationships. For example, there have been many studies examining how interpersonal relationships are involved in collaboration (Latour and Woolgar, 1979), networking (Bijker et al., 2012), data sharing (Research Information Network, 2009), and so forth. How these relationships contribute to the perpetuation of science continues to be discussed.

The increasing focus on the interpersonal relationships mediating scientific progress has emphasized that scientific research is a highly interactive practice, and the scientific community as individuals bound together by the sharing activities necessary for epistemic activities. It is clear from the analysis of these studies that science cannot be done in isolation. Nonetheless, although the responsibilities that scientists have to their own data and research activities are necessary, they are not sufficient in and of themselves.

The focus on these extra-laboratory – and resource-focused – relationships often directs attention away from other relationships that are fundamental to science as a practice. In a recent analysis of life science codes of conduct, Shamoo and Resnik (2015) identified two key areas that relate to interpersonal relational activities, namely the mentoring and working with colleagues. They define 'responsibility for future generations (mentoring)' as the duty to 'help educate, mentor and advise students. Promote their welfare and allow them to make their own decisions'. Similarly, 'respect for colleagues' includes respecting them and 'treat(ing) them fairly'.

Within these codes of conduct – and within life science ethics more generally – these responsibilities are left characteristically vague – largely because of the principle-based approach that dominates science ethics discourse (Resnik, 2012).[2] Similarly, few studies have set out to examine intra-laboratory collegial relationships systematically. Nonetheless, the increasing amount of ethnographic research that has been carried out in scientific laboratories offers important insight into these interpersonal relationships. Researchers such as Latour and Woolgar (1979), Goodfield (1981), and Traweek (1992), to name a few, have all produced detailed accounts of daily research practices that highlight the highly communal – and often chaotic – nature of daily experimental research. Similarly, sociologists of science, such as Harry Collins (2014), have highlighted the social aspects of how scientists generate, perpetuate, and judge the data arising from experimentation. From such accounts it is possible to shine a spotlight on these intra-laboratory relationships.

What is particularly evident from these studies is not only the highly personal and contextual nature of these intra-laboratory relationships, but also the wide range of interpersonal relationships necessary for successful science. These various types of activities are described in the sub-headings below.

Fostering tacit knowledge and environments of pedagogy

The work of Harry Collins and his colleagues has brought the importance of *tacit knowledge* in scientific research to the forefront of discussions on science.[3] Contrary to traditional interpretations of scientific practices that emphasized the reproducibility and universalness of research methodologies, *tacit knowledge* draws attention to the skill required of the individual operator. This emphasizes to the 'physicalness' of conducting research methodologies that requires a high level of sensitivity and training. Importantly, the tacit nature of this knowledge highlights the difficult of transmitting this knowledge through traditional modes of knowledge dissemination. Rather, tacit knowledge (and tacit ability) come through learning via example and through repetitive 'doing'. This is evident in the extended quote from Collins' book (2014), *Are We All Scientific Experts Now?*

> But experiments and observations are extremely difficult. When high-school students first look down a microscope at some pond-water, they see a mess; they do not observe the algae and the protozoa without being shown what to see. And when school students do experiments in the classroom they mostly fail until they are shown exactly how to get the right result. Exactly the same goes for professional scientists in the laboratory. It is easy to read the after-the-fact description of an experiment, but actually carrying out a similar experiment to the point of success is extraordinarily difficult – it is a matter of skilled manipulation and, usually, a lot of luck.
>
> I had shown that scientists trying to build a new kind of laser – the TEA-laser – always failed unless they spent time in the company of a successful scientist; they had to pick up the knack of building it, a knack which neither party fully understood. This kind of invisible knack is known as "tacit knowledge": it comprises the things we know but cannot say. (Collins, 2014: 31)

The fostering of tacit knowledge is, unsurprisingly, embedded within the fabric of scientific research. The traditions of science pedagogy strongly prioritize 'learning through example' in all instances after undergraduate training. Scientists learn their trade 'at the bench', being taught experimental procedures, laboratory conduct, and general behavioral norms from peers and mentors. The willingness to assist in these training and teaching activities are an unwritten expectation of any scientist, and crucial to the success of any laboratory.

Such studies highlight a key sphere of intra-laboratory relationships concerned with teaching and learning via example. It is important to note that for this type of informal learning to be effective, a relationship must be established in which the student feels comfortable to question, and the teacher comfortable to correct. In effect, learning via example is only optimal if there is a relationship between learner and teacher and an environment that supports the learning engagement.

The recognition of the *tacitness* of scientific experimentation should also draw attention to an often overlooked aspect of learning via example: that routines in the laboratory are personally constructed and personally perpetuated (Bezuidenhout, 2015). Individuals within the learning via example relationship thus also have additional responsibilities regarding the *content* that they perpetuate. Indeed, ethics literature abounds with studies relating to the perpetuation of bad habits or unethical behavior (such as Christakis, 1992), and it is important that individuals in informal teaching roles recognize the critical role they play in the perpetuation of traditions of research practices.

Providing pastoral care and a supportive social environment

Laboratories are not just environments that support learning via example, but they are also social spaces in which highly disparate personalities work in very close proximity – and whose research relies on working successfully together. Consequentially, how individual scientists contribute – or detract from – the communal laboratory culture and society is of critical importance to the general productivity of the research group. Below is an excerpt from an ethnography by Goodfield in which she describes her visit to a highly productive and successful laboratory. In particular, she notes that the *social relations* between individuals were highly successfully established and curated, which led to a very dynamic working environment:

> With everyone shaking down so well, the lab rapidly developed its collective sense of humor, an indispensable factor. Soon the newcomers were spending much of their free time together, and by December, when the wheels of the lab were running smoothly and the work was pouring in, they were all there working away most evenings. But Friday evening generally found them and their families in each other's apartments, eating, drinking, and discussing science in an entirely irreverent fashion. This proved to be a healthy attitude in the year that followed. (Goodfield, 1981: 103)

In addition to establishing and curating successful social relations, it is possible to suggest that scientists also have more extensive pastoral roles with regard to students and peers. Indeed, it is possible to argue for the importance of *community reflection* within scientific laboratories to assist individual scientists in identifying whether careers as bench researchers were truly their calling.[4] As a result, scientists – both individually and as a community – must cultivate constructively critical relationships that allow them to question whether their students and peers are truly suited to laboratory research, or whether their talents are better applied in other contexts.

An example of such behavior is evident from another passage from Goodfield's ethnography where she describes the interaction between a mentor (Dr Vera) and student (Anna). Dr Vera, observing that Anna had not been particularly productive or seemingly happy, suggested that she might prefer to return to her native Portugal rather than stay in a position that was not suited to her:

> She may have been furiously angry when at the end of June Dr Vera suggested that she might like to go home, but she says now that it was the best thing that ever happened to the "nice little Portuguese girl." … Dr Vera went on holiday. By the time she came back Anna had recovered her poise and was able to thank Dr Vera for "the shake", which so far as she was concerned had done two things: First, it had shown her that she could, and must, plan experiments and do them, and second, that she really did have genuine scientific questions – that she hadn't just been sitting here like a dummy. (Goodfield, 1981: 26)

Dr Vera's concern was well-intentioned and based on her relationship with Anna, but also well-founded as it was evident (in retrospect) that what Anna was missing was a belief in herself and her calling. Without Dr Vera's intervention it is possible that this belief in her calling as a scientist might have gone unrecognized.

Monitoring and mediating those around

Another key relational aspect of scientific research relates to the ability of individuals to inspire colleagues, but also to be engaged enough in their work to monitor and mediate their interactions within the laboratory. In this role, scientists function not only as inspirations and catalyzers of research projects, but also as gatekeepers of unrestricted experimentation, whistleblowers, and enforcers of norms and rules.

These roles are best understood through ethnographic quotes. Traweek, in her ethnography of high-energy physics, identified certain scientists she termed 'accelerators', who were highly productive through their ability to establish and mediate relationships with their peers. She says:

> [a]ccelerators come into being because of the vision, creativity, and tenacity of an individual who can gather about him a team of gifted people whose work he detects and coordinates by means of his example, will, and – some would say – whim. (Traweek, 1992: 101)

It is thus through their interpersonal relationships that the accelerator is able to catalyze the research around them and facilitate a creative environment of productive research.

In addition to these inspirational roles, researchers also have to play the role of gatekeepers. The structure of science is such that individual researchers will continually be engaged in the research of their peers and students. Establishing relationships through which creativity, hunches, and whims can be understood, evaluated, and supported is thus of critical importance. Goodfield describes such a relationship, saying:

> [w]e were just jumping from here to there. But I was amazed that each time she came in with an idea, I was able to see exactly what she was thinking and where this might fit in the overall picture. So she was able to convince me very easily that she could do something with the data. Then I said, 'By all means, go right ahead'. (Goodfield, 1981: 110)

Putting relationships in the foreground

These ethnographies – and the related STS literature – all highlight that membership to the scientific community requires a plethora of activities relating to the establishment, maintenance, and perpetuation of relationships critical for the group identity and goals. Moreover, it involves activities directed at ensuring the creation and perpetuation of environments in which other individuals can flourish. In particular, these relate to the pedagogy and learning from example, to the establishment and perpetuation of positive working and learning environments, and the positively critical role that each scientist has in monitoring, scrutinizing, and reflecting on the work practices and products of those directly around him.

The importance of these relationships should come as no surprise to scientists – or to those who study science. Indeed, although there has been some discussion about the social nature of science in relation to research ethics and responsible conduct of research (Shamoo and Resnik, 2015), little is said about the responsibilities that scientists have to establishing, cultivating, and sustaining these relationships. For instance, Shamoo and Resnik (2015) highlighted principles such as honesty, objectivity, integrity, carefulness, openness, respect for intellectual property, confidentiality, and responsible publication. All of these, it should be noted, related closely to the production and dissemination of data. In contrast, care, affability, and empathy – aspects crucial in nurturing relationships – were absent.

What is also evident from the principles highlighted above is that, although they are undoubtedly involved in the mediation of resource exchanges, in and of themselves they do not contribute to the establishment of the rich and reciprocal relationships described in the ethnographies above. Indeed, without the reflexivity and empathy inherent in expanded definitions of care relationships,[5] such discussions are very difficult. These codes of conduct – and indeed, much of the STS literature – thus represents these relationships as individualistic[6] and transactional.

Current approaches to life science ethics thus leave discussions on the relational aspects of science at an impasse. Even specifically highlighting relational duties such as the ‘responsibility for future generations (mentoring)’ and the ‘respect for colleagues’ (Shamoo and Resnik, 2015) give little insight into how to establish, curate, and perpetuate the highly personal, complex, and contextual nature of these relationships. Moreover, it offers no way through which to discuss potential complications, such as a lack of complete autonomy amongst individuals or the absence of environments that support productive relationships. In the remainder of the article I discuss a potential way in which these relationships – and the responsibilities associated with them – can be gainfully explored through virtue ethics.

Caching out relational responsibilities

The ethnographic research above highlights the critical importance of the relational aspects of scientific research. Without ‘hands on’ pedagogy, peer-learning, and monitoring it is unlikely that scientific research can progress in its current form. It stands to reason that individual researchers thus have responsibilities to engage in these relational activities through their membership to the *practice* of science.[7]

So, how can such responsibilities be effectively discussed? As highlighted above, discussing these relationships in the context of the life sciences is difficult. Even within a definition of science as a communal practice – thus, a ‘complex, collaborative, socially organized, goal-oriented, sustained activity’ (MacIntyre, 1984: 187) – framing these responsibilities is difficult. These difficulties relate to problems of definition (in how science as a *practice* is defined and in how the 'community of scientists' is defined) as well as ontological problems (in how the internal goods and telos of science are understood).

It is tempting – similarly to deontological discussions on the life sciences – to portray the individual scientist as an autonomous entity who mediates and manages their membership to the community of scientists. This results in the focus of discussions being predominantly on how individual scientists flourish *qua* scientists as well as *qua* humans. Such portrayals do not reflect the relational aspects of research discussed above. Indeed, what follows on from these portrayals is an impression of *mediated* communality, instead of essential communality – a situation in which scientists cannot exist without the relations between researchers.

In trying to effectively cache out this notion of *essential relations*, it is helpful to turn to discussions on collective responsibility – in particular, the work of Larry May. He suggested an understanding of groups that lies towards the middle of this continuum between the idea of a group as a homogenous entity, and that of being a collection of specific individuals. May's theory of collective responsibility hinges on the notion that an action was legitimately collective if the individuals in question are related to each other so as to enable each to act in ways that they could not manage on their own. Furthermore, that some individuals are authorized to represent their own actions as the actions of the group as a whole (May, 1987: 55).

According to May, relationships and social structures are important, and group intentions arise out of the relationships between particular members of a group rather than from one group member. The common moral element allows making decisions self-consciously. Through this, each member of the group comes to have the same intention, either reflectively or pre-reflectively (shared interests and attitudes, solidarity) (May, 1987: 64). May goes further to suggest that collective responsibility needs to consider that individuals are embedded in a 'web of commitment' which provides multiple (perhaps even conflicting) commitments (May, 1996), resulting in responsibilities being reformulated as 'legitimate negotiated compromises'.

This approach suggests three important considerations for discussions on collectives in science. The first consideration is that membership to the collective of science should be viewed as a conglomerate collectivity (French, 1984), in that the conglomerate is an organization of individuals such that its identity is not exhausted by the conjunction of identities of the persons in the organization (in contrast to aggregate collectives). The second is that within the collective each individual has multiple roles – indeed, a 'web of commitment' – that operates on many different levels. Thirdly, as emphasized by May, is the social element that is part of the binding force of the group in the form of social structures or social subscription.

Using May's understanding of 'webs of commitment' within the framework of *practices* also assists in unpacking some of the problems relating to the definition of internal goods and the telos of science. MacIntyre defined a good as: 'something we judge to be worthwhile to have, achieve, attend to, or participate in. As such, goods are what provide us with reasons for acting' (MacIntyre, 1999: 64, as quoted in Higgins, 2011: 239). In effect, the internal goods of a practice are oriented towards its telos and are 'characteristic objects of human desire' (MacIntyre, 2007 [1981: 196]).

As the majority of discussions on life science ethics have focused on the *epistemic* nature of science, and the duties that individual scientists have towards data production and the perpetuation of research programs, the telos of science is often similarly equated to these activities. Defining the telos of science in terms of knowledge production thus makes it very difficult to talk about the *relational aspects* of the practice as they do not directly contribute to data production.

Instead, if the telos of science is expanded to include the *essentially communal* nature of knowledge production – indeed, as a defining characteristic of science in contrast to other forms of knowledge production – the perpetuation and maintenance of the *communal* aspects of the practice become internal goods worthy of desiring. Thus, the establishment and perpetuation of the relational aspects of the practice of science become internal goods for individual researchers.

These relational aspects of the scientific practice thus become ethical issues for the practice, and not just issues relating to cultural traditions or personal flourishing. Thus, relational aspects of science as internal goods may be understood as the 'partial realization of the excellence definitive of a particular practice' (Higgins, 2011: 246) in and of themselves. This offers a nuanced view of traditional interpretations of internal goods that locate the yields of internal goods in the work or performance, or in the character of the practitioner. Achieving these relational internal goods transforms not only the practitioner, but also those who are the object of the practice. Thus, the stabilization of the practice of science through the fostering of collegial, conscientious, and responsible colleagues is both an individual and a collective responsibility of all scientists.

Unpacking relational responsibilities

The discussion above makes a clear case for the importance of the relational aspects of the scientific practice, and highlights the responsibility that individual scientists have towards cultivating and curating these interactions. As mentioned above, although codes of conduct and other deontologically-oriented ethics discussions do recognize these relational responsibilities, little is explicitly said about how these relationships can be established or perpetuated owing to their highly contextual nature and the difficulties this poses for deontology. In contrast, discussions on *practices* necessarily lead us to virtue ethics, and to possible solutions to the stalemate currently existing within life science ethics.

In recent years there has been an increased interest in the use of virtue ethics for understanding scientific research and integrity. An increasing number of authors, such as MacFarlane (2008), have compiled lists of scientific virtues as alternatives to principle-based research ethics approaches. Other authors, such as Resnik (2012), suggest that virtue ethics can serve as a complementary strand to traditional principle-based approaches and strengthen current research ethics discussions. It is important to recognize, however, that even with this resurgence of interest in virtue ethics, current discussions on scientific virtues continue to be epistemically-focused, and often are driven by the responsibilities that scientists have to their data.

In contrast, by identifying relational aspects of science as internal goods to be cultivated provides scientists not only with specific intermediary teloi to strive towards, but also a pathway to reach them through the cultivation of specific virtues. The use of virtue ethics also opens up discussions on relational responsibilities to include dimensions not currently covered in codes of conduct and other life science ethics. Although it is obvious that the scientist must engage in key practices integral to the communal practice of science, including openness, mentoring, and so forth, the scientist must also actively act as an exemplar of good practice in the laboratory, so that they may serve to inspire good practice in others. This includes the manner in which they conduct their daily routine behaviors – including how they are constructed, enacted, and perpetuated.[8] Moreover, a third area of responsibility that becomes evident from the ethnographic data on laboratory practices is to *facilitate exemplary behavior in others*. This relates to the responsibility of creating and maintaining environments that facilitate the acquisition of virtues and the enactment of virtuous behavior *in others*. The individual thus has specific responsibilities towards creating environments that allow others to flourish.

By re-examining the relational aspects of scientific research described in the ethnographic section above, it is possible that the cultivation of the following traits – and the virtues that are associated with them – may be primary responsibilities for any scientist. Indeed, by activating virtuous behavior in the cultivation of interpersonal relationships, scientists are able to foster the nurturing and empathy that enables their peers – and thus their discipline – to flourish. Ways in which this can be achieved are briefly discussed below.

Critical reflexivity

Examining tacit knowledge and the routines of daily research in detail highlights a key aspect that is often overlooked: that these routines have, in themselves, a social component. Indeed, a careful analysis of routine behaviors in laboratories highlights that the translation of a written method or behavior into a contextually embedded practice has a degree of personal decision-making and is influenced by the social and physical context in which the activity takes place (Bezuidenhout, 2012, 2015).

Thus, routines in the laboratory carry with themselves a type of 'embedded ethics' that may foster or detract from the acquisition of virtues because of the way they were constructed and implemented. For example, taking shortcuts in waste separation and processing, although theoretically justifiable in terms of time, finances, utility and so forth, may ultimately undermine the ethical development of scientists and cause them to distance themselves from discussions on responsible conduct of research. This may lead to ethical erosion (Bezuidenhout, 2012).

Recognizing the link between routine behaviors, tacit knowledge, and ethical development is thus of importance for any scientist. In their own work it is important that they foster critical self-evaluation to ensure that their daily routine and research practices are of a high ethical standard. Moreover, and of importance to this article, it is also of vital importance that this critical reflexivity is extended to the routines that they *teach others in the laboratory*.

As the vast majority of the working practices of individual scientists are learnt from peers and mentors in situ, there is a possibility that poor practices may be transmitted through these relational 'learning via example' interactions. Scientists in the role of teachers thus play a vital role in establishing and perpetuating – or undermining – the establishment of ethical working practices in their peers and students. In the role of teachers, they thus have a strong responsibility to ensure that the routines and practices they teach are ethically sound and lead to the development of virtues in the student.

Traits that are obviously desirable to strengthen such relations are a strong grounding in ethics, but also an ability to critically apply this knowledge to an analysis of the routines of research. In this way, an insight into how routine behavior influences ethical development is key. Virtues associated with the cultivation of these traits would relate to foresight – as the ability to plan ahead and anticipate the possibilities that inform one's present action. Cultivating the virtues of memory, synesis, and reasoning is also of considerable importance, as these virtues will assist the scientist in understanding the embedded ethics of the routines they perpetuate.

Commitment to personal development

Related to the teaching of routines is, of course, a need for an explicit commitment to developing peers and students through teaching and support (Bezuidenhout and Warne, forthcoming). As mentioned earlier in the article, the role of the *educator* in the 'learning via example' relationship is rarely unpacked. It is thus important to recognize that the educator not only has the responsibility to ensure that the correct content has been transmitted, but also that the environment in which individuals are learning is supportive and fosters excellence.

'Learning via example' is most effective when relationships are created that inspire and support, and in which the student feels able to ask questions or admit mistakes. Students will also be more likely to flourish if they are praised for their endeavors. This is evident from more general pedagogical and psychological literature (Allen and Eby, 2010). Educators within these informal teaching relationships must thus not only prioritize the student's learning, but also ensure that this learning occurs in an environment that supports it.

Key traits for such educators that would support these relations would include being caring, supportive, and inspirational. A virtue that would be key in the cultivation of these traits would include rhetoric – the art of persuasion. Moreover, those virtues associated with justice – magnificence, magnanimity, patience, and perseverance – would also be key in being an inspirational and engaged educator. Of key importance is the personal commitment to excellence and to nurturing excellence in those around oneself.

Pastoral sensitivity

In addition to the teaching relationships that scientists cultivate with their peers and students, working within a laboratory requires numerous other social relationships. These include relationships of support, of nurturing, and of care that are commonly associated with pastoral care (Slade, 1991). In the highly social and communal environment of the laboratory, within their 'webs of commitment', individual scientists have the responsibility to recognize the emotional dimensions of their peers and students and to safeguard their emotional well-being. This responsibility, it is important to recognize, extends beyond their roles *qua* scientists into their extra-laboratory lives.

Of particular importance in fostering these relationships is an ability to empathize with others and to care. This is not to suggest that every relationship will be a friendship, but rather that each relationship is based on respect, recognition, and care.[9] The primary virtue motivating such relationships is, of course, love – defined as desiring and seeking the good of others.

Establishing relationships that assist individuals to flourish would also be strengthened by the cultivation of virtues such as liberality (generosity – with time, as well as resources), affability/friendliness, patience, and perseverance. Acumen – particularly social acumen – would also be of considerable importance in establishing connections and discovering innovative ways to foster relations. In effect, it is critical that scientists cultivate empathy that facilitates their care for their peers not only as colleagues, but also as individuals and highly complex humans.

Willingness to intercede

Relating to the importance of pastoral sensitivity is a corresponding need to safeguard the environment that supports the establishment of relationships of love. In order for individuals to flourish, it is necessary that the laboratory environment is structured in support. Individual scientists, when engaging with relational responsibilities, thus also have a duty to intercede when the environment undermines flourishing. This duty could be activated in a number of different areas – in the perpetuation of inappropriate behaviors through routines, in the undermining of pastoral support, in the willful thwarting of regulatory requirements, and in general misconduct.

Scientists thus have strong relational responsibility to critically survey their surroundings, but also to intervene when problems are identified. Traits associated with the cultivation of this relationship would include a courage of convictions and an ability to deftly manage difficult situations. Virtues that would assist in the cultivation of these traits would include vengeance, as the ability to hold others accountable to the relevant norms and laws for their own good and for the good of the community. It would also require synesis (as good council) and gnome (as council for things in exception to the law).

Prioritization of community

By using the work of Larry May to add to MacIntyre's framework of *practices* I draw attention to the conglomerate nature of the scientific community – that the community cannot solely be understood as a sum of its aggregate parts. This places an additional set of relational responsibilities on individual scientists, as they have responsibilities for the maintenance of the community and the perpetuation of its values and priorities in a way that supersedes their own interests.[10]

By identifying themselves as scientists, individuals thus have important duties relating to the perpetuation of science as a whole. In so doing, they must necessarily cultivate a (one-sided) relationship that is based on piety and observance. This will foster behavior that correctly gives honor to those to whom individuals are indebted, and to those who deserve it. The relationship would also be strengthened by the cultivation of gratitude towards those who contributed to individual development and well-being.

Cultivating phronesis

Although it is possible to cache out these different areas of relational responsibilities, it is of course unlikely that these roles will be discrete and contained. The cultivation of virtues towards the internal good of virtuous relationships is, of course, also a discussion of the cultivation of phronesis. Zagzebski (1996) suggests that phronesis – or practical wisdom – is necessary to coordinate various virtues into a single line of action or a line of thought leading up to an act, in the first case, or a belief, in the second. Indeed, as MacIntyre suggests,

> without it (phronesis) … one cannot be virtuous … A man may have excellent principles, but not act on them … the virtue which is manifested in acting so that one's adherence to other virtues is exemplified in one's actions. (MacIntyre, 1966: 74)

The concept of *phronesis* was introduced in Aristotle's *Nichomachean Ethics*, where it was defined as 'a state of grasping the truth, involving reason, concerned with action about things that are good or bad for a human being' Aristotle (1999: 89).[11] Recently, phronesis has been interpreted in a number of different ways; however, all these definitions are united by a focus on deliberation and deliberative strategies (Noel, 1999). Thus, the concept of phronesis may be broadly defined as 'knowing how to apply general principles in particular situations … it is the ability to act so that the principle will take a concrete form' (MacIntyre, 1966: 74). It is particularly through the cultivation of phronesis that scientists will be able to balance the duties of empathy and nurturing with the other activities necessary for effective science – competition, disinterestedness,[12] and the objective and critical evaluation of students/trainees. Indeed, the habitual enactment of virtuous behavior that is mediated by phronesis is key for scientists to navigate the many dimensions of socially responsible science (Resnik and Elliott, 2016).

The cultivation of virtues that are instrumental in the perfection of relational responsibilities is thus dependent on the cultivation of phronesis, as only through phronesis do individuals develop a capacity to recognize some features of a situation as more important than others, and to identify what is relevant in any given action. It is important to note that this recognition is motivated by rational choice, and not by innate tendencies. Phronesis is 'deliberative and takes into account local circumstances, it weighs trade-offs, it is riddled with uncertainties, it depends on judgments, profits from wisdom, addresses particulars, deals with contingencies, is iterative, and shifts aims in process when necessary' (Eisner, 2002: 375). Thus, phronesis enables individuals to arrive at good – but imperfect – decisions with respect to particular circumstances by exercising a capacity to recognize, in any particular situation, those features of it that are morally salient (Hursthouse, 2013).

The acquisition of practical wisdom is a continuous process that comes with the experience of life. These aspects, as mentioned by Rosalind Hursthouse,

> coalesce in the description of the practically wise as those who understand what is truly worthwhile, truly important, and thereby truly advantageous in life, who know, in short, how to live well … [who] have a true grasp of eudaimonia ["flourishing"]. (Hursthouse, 2013)

Current educational theory has examined phronesis in relation to improving teacher performance (Eisner, 2002; Halverson, 2004), and it has been shown to be of crucial importance. How it is similarly fostered in students remains to be examined.

Concluding comments

MacIntyre defined a *practice* as:

> any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of, that form of the activity, with the result that human powers to achieve excellence and human conceptions of the ends and good involved are systematically ended. (MacIntyre, 1984: 187)

Although this is an effective definition of scientific research, it is also important to recognize what remains largely unsaid: '[that] the practice of science itself is an art pervaded by passion, dependent upon imagination, filled with uncertainty, and often motivated by the challenge and joy of the journey. It is not the application of sanitized routines that teachers were too used to as a way to carry on in the classroom' (Eisner, 2002: 379). Science is a collaborative and creative process.

By focusing on the relational nature of the practice of science it is possible to highlight a range of responsibilities that individual scientists have to the curation and promotion of the social aspects of scientific research. These responsibilities, as they are highly contextual and interpersonal, are often overlooked in deontological discussions about life science ethics and are rarely explicitly cached out in codes of conduct, policy, or educational resources. Nonetheless, a virtue ethics approach allows these issues to be gainfully spotlighted and discussed. By focusing on the virtues necessary to sustain relationships in the different spheres it is possible not only to discuss how to foster such behaviors amongst scientists, but also how to identify problems and misconduct.

Virtue ethics is often criticized for being difficult to teach via formal instruction, as it is highly contextual. Nonetheless, this criticism may also serve as a strength, and it is also possible to suggest that virtue ethics is well-suited to the informal instruction that occurs within laboratories (Resnik, 2012). Indeed, virtue ethics offers an important means of discussing the interpersonal relationships necessary for the flourishing of science practices, thus augmenting current principle-based science ethics discourse. Offering a viable virtue ethics framework through which to engage with these practices, however, is a necessary step towards explicitly endorsing, supporting, and fostering in a more consistent and coherent fashion.

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Notes

1. Examples could include the Wellcome Trust data sharing policy (https://wellcome.ac.uk/funding/managing-grant/policy-data-management-and-sharing), the National Academies of Sciences (2012) policy document *On Being a Scientist*, and the Panton Principles of data sharing (www.pantonprinciples.org).
2. Resnik (2012: 329) goes on to say that 'ethics guidelines and codes of conduct adopted by professional associations are usually framed in terms of rules, duties or responsibilities'. This approach has regularly been criticized for being 'de-contextual' and not providing adequate guidance for decision-making when the principles conflict.
3. The *tacitness* of scientific experimentation is increasingly recognized as paramount. Not only has this recognition shaped subsequent discussions on the sociology of science, but its importance is also increasingly evident in discussions within the scientific community. As concerns about the reproducibility of research and the reliability of data continue to grow, there has been a growing interest in extended methodologies, video recordings of experimental procedures, and student placements. All of these strongly acknowledge the importance of accessing the tacit elements of the experimental system.
4. This is the topic of a forthcoming article by Bezuidenhout and Warne.
5. In this I refer to the field of care ethics and its proponents, such as Nel Noddings, Michael Slote, and Chris Castmans. I also refer to the work of Emanmuel Levinas (1961) – particularly his work on the concept of 'the Other'.
6. As the vast majority of life science ethics discourse – and, of course the codes of conduct – are deontologically-framed, it is unsurprising that the responsibilities are represented as highly individualistic.
7. MacIntyre defined a practice as 'any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of, that form of the activity, with the result that human powers to achieve excellence and human conceptions of the ends and good involved are systematically ended' (MacIntyre, 1984: 187).
8. Science scholars – and indeed scientists themselves – have long cleaved to the dominant representation of scientific practices as standardized, reproducible, and global.
9. See note 4.
10. This responsibility may also be thought of in terms of 'Ubuntu' – the African philosophy that proposes that individual humanity is found through membership in a community, and that the good of the community supersedes individual desires.
11. Aristotle distinguished phronesis from other types of wisdom, namely *episteme, techne*, and *phantasia*. Episteme, for instance, represents expert, propositional knowledge that is taken as true, whereas techne refers to the knowledge that assists individuals in attaining a given end (Birmingham, 2004).
12. I use competition and disinterestedness in the Mertonian sense (Merton, 1942).

References

Allen TD and Eby LT (2010) *The Blackwell Handbook of Mentoring: A Multiple Perspectives Approach*. Chichester, UK: John Wiley & Sons Ltd.

Aristotle (1999) *Nichomachean Ethics* (Irwin T, trans.). Indianapolis, IN: Hackett.

Bezuidenhout L (2012) Research infrastructures, policies and the "web of prevention": The ethical implications of inadequate research environments. *Medicine, Conflict and Survival* 28(1): 19–30.

Bezuidenhout L (2015) Variations in scientific data production: What can we learn from #overlyhonestmethods? *Science and Engineering Ethics* 21(6): 1509–1523.

Bezuidenhout L and Warne N (forthcoming) Should we all be scientists? Re-thinking laboratory research as a calling. *Science and Engineering Ethics*.

Bijker WE, Hughes TP and Pinch T (eds) (2012) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge MA: MIT Press.

Birmingham C (2004) Phronesis: A model for pedagogical reflection. *Journal of Teacher Education* 55: 313–324.

Christakis NA (1992) Ethics are local: Engaging cross-cultural variation in the ethics for clinical research. *Social Science and Medicine* 35(9): 1079–1091.

Collins H (2014) *Are We All Scientific Experts Now?* Cambridge, UK: Polity Press.

Eisner EW (2002) From episteme to phronesis to artistry in the study and improvement of teaching. *Teaching and Teacher Education* 18: 375–385.

French P (1984) Collective and Corporate Responsibility. New York: Columbia University Press.

Goodfield J (1981) *An Imagined World: A Story of Scientific Discovery*. Ann Arbor, MI: The University of Michigan Press.

Halverson R (2004) Accessing, documenting, and communicating practical wisdom: The phronesis of school leadership practice. *American Journal of Education* 111: 90–121.

Hicks DJ and Stapleford TA (2016) The virtues of scientific practice: MacIntyre, virtue ethics, and the historiography of science. *Isis* 107(3): 449–472.

Higgins C (2011) *The Good Life of Teaching: Ethics of Professional Practice*. Chichester: Wiley-Blackwell.

Hursthouse R (2013) Virtue ethics. In: Zalta EN (ed.) *Stanford Encyclopedia of Philosophy*. Stanford, CA: Stanford University.

Kuhn T (1970) *The Structure of Scientific Revolutions*. Chicago, IL: Chicago University Press.

Latour B and Woolgar S (1979) *Laboratory Life*. Princeton, MA: Princeton University Press.

Levinas E (1961 [1969 tr.]) *Totality and Infinity*. Pittsburgh, PA: Duquesne University Press.

MacFarlane B (2008) *Researching with Integrity: The Ethics of Academic Inquiry*. New York, NY: Routledge.

MacIntyre A (1966) *A Short History of Ethics: A History of Moral Philosophy from the Homeric Age to the Twentieth Century*. New York, NY: McMillan.

MacIntyre AC (1984) *After Virtue: A Study in Moral Theory*. Notre Dame, IN: University of Notre Dame Press.

MacIntyre AC (1999) *Dependent Rational Animals: Why Human Beings Need Virtues*. Chicago, IL: Open Court Publishing.

MacIntyre AC (2007 [1981]) *After Virtue: A Study in Moral Theory* (3rd edn). Notre Dame: University of Notre Dame Press.

May L (1987) The Morality of Groups. Notre Dame: University of Notre Dame Press.

May L (1996) *The Socially Responsive Self*. Chicago, IL: University of Chicago Press.

Merton F (1942) *The Normative Structure of Science*. Chicago, IL: Chicago University Press.

Murray-Rust P, Neylon C, Pollock R and Wilbanks J (2010) *Principles for open data in science*. Available at: http://pantonprinciples.org/ (accessed 21 September 2016).

National Academies of Sciences (2012) *On Being a Scientist: A Guide to Responsible Conduct in Research* (3rd edn). Washington, DC: National Academies Press.

Noel J (1999) On the varieties of phronesis. *Educational Philosophy and Theory* 31(3): 273–288.

Research Information Network (2009) *Patterns of Information Use and Exchange: Case Studies of Researchers in the Life Sciences*. London, UK: Research Information Network.

Resnik D (2012) Ethical virtues in scientific research. *Accountability in Research* 19(6): 329–343.

Resnik D and Elliott K (2016) The ethical challenges of socially responsible science. *Accountability in Research* 23(1): 31–46.

Shamoo A and Resnik D (2015) *Responsible Conduct of Research* (3rd edn). New York, NY: Oxford University Press.

Slade T (1991) Changing pastoral roles: A case of overloading? *Pastoral Care in Education* 9(4): 45–46.

Traweek S (1992) *Beamtimes and Lifetimes: The World of High Energy Physics*. Cambridge, MA: Harvard University Press.

Zagzebski LT (1996) *Virtues of the Mind: An Inquiry into the Nature of Virtue and the Ethical Foundations of Knowledge*. Cambridge, UK: Cambridge University Press.