MICHAEL J. REISS

THINKING LIKE A FOX

Queering the Science Classroom When Teaching About Sex and Sexuality

The fragment attributed to the ancient Greek philosopher Archilochus—πόλλ' οἶδ' ἀλώπηξ, ἀλλ' ἐχῖνος ἓν μέγα (the fox knows many things, but the hedgehog knows one big thing)—is well known. Isaiah Berlin (1953) developed this fragment into an argument in an essay in which he divides intellectuals and authors into two categories: hedgehogs, such as Plato, Dostoevsky, and Nietzsche, who see the world through a single lens; and foxes, such as Aristotle, Shakespeare, and Goethe, who draw on a range of ways of understanding the world.

My own intellectual journey has been from the position of a hedgehog—my doctorate was in applied mathematics and my first academic book consisted of exploring the implications of a single equation ($dM/dt = k_2M^b - k_1M^a$) for the growth and reproduction of organisms (Reiss, 1989)—to one of a fox, largely on the grounds that education is a complex field rather than a single discipline, and it is therefore rare that there is a single, widely agreed framework within which people agree that educational questions can be asked and answers proposed.

In this chapter, I therefore, as befits a fox, look at a single question from a number of viewpoints. Encouragingly, my conclusion will be that we obtain not dissimilar answers whichever of these viewpoints we adopt. This therefore suggests that a way forward can be proposed, a way forward that can, by a sort of epistemological triangulation, be more robustly defended than would be the case if I had behaved as a hedgehog and, to mix metaphors, put all my eggs into one basket (both hedgehogs and foxes do eat eggs).

Of course, too great a convergence would be suspicious—just as we would be suspicious if the readings of the height of a mountain were too similar, which would suggest that our measurements were not independent or even that they had been "fixed"; queer theory is obviously suspicious of things that are fixed! And so should science be too. Scientific advancements are always on the edge and messy; the temptation is to strive too hard to make sense of them either at the time, for example by omitting data that "don't fit," or in retrospect, as Foucault (1969/1972) argues in his critique of the way that neat histories are produced.

The question I will address is How should we teach about sex and sexuality in school science? The topics of sex and sexuality are, of course, only a small part of the typical school science curriculum. Nevertheless, it is obvious, given the historical roots of queer theory, its ongoing interest in sexualities, and the continued need for it to tackle heteronormativity (Holland, Ramazanoglu, Sharpe, & Thomson, 1998), that queer approaches to science education will have something to say about sex and

W. Letts, & S. Fifield (Eds.), STEM of Desire: Queer Theories and Science Education, 255–267. 2019
Brill | Sense, Leiden. DOI: 10.1163/9789004331068_015

sexuality, though it is, again, obvious that queer approaches to science education are not restricted to such topics (as other chapters in this book indicate). As Giffney (2009) points out, "*queer* loosely describes a diverse, often conflicting set of interdisciplinary approaches to desire, subjectivity, identity, relationality, ethics, and norms" (p. 2, italics added). However, what is not so obvious about how we should teach about sex and sexuality is that, as I shall argue, one reaches similar answers whichever of the following frameworks one adopts:

- The science curriculum should promote human flourishing.
- The science curriculum should enable students to acquire powerful knowledge.
- The science curriculum should advance social justice.

Important as out-of-school settings are, I focus on schools for reasons of both pragmatism and equity: some 95% of each cohort of students between the ages of about 5 and about 16 attend schools in many countries (others are home-schooled, truant, absent because of bullying, unwell, or in various nonschool institutions). Schools are therefore the easiest route by which educators can reach the overwhelming majority of young people in this age group; other routes (e.g. museums and online) while important do not have the coverage of each cohort that schools do. At the same time, education in out-of-school settings (e.g., http://www.wellcomecollection.org/exhibitions/institute-sexology) can play an important role in disturbing the conventional school curriculum, and schools can, and should, avail themselves of such opportunities.

THE SCIENCE CURRICULUM SHOULD PROMOTE HUMAN FLOURISHING

There are a number of ways in which curricula can be developed. National curricula, especially at high school level, typically start with a list of subjects: mathematics, the predominant language, science, and so on. Aside from minor skirmishes (for example, over citizenship, drama, geography, and dance) they take for granted a dozen or so discrete school subjects and the knowledge they entail. There is a general implicit presumption that agreement exists as to the purpose of school education, without these purposes being spelt out and examined in any depth, and that the way to construct a curriculum is to start with familiar subjects.

An alternative to starting with subjects is to start further back, with aims (Reiss & White, 2013). Education has had diverse aims over the years. As Harris (1999) has put it:

> In the very first lecture of every course I give, I stress that 'education' is a changing, contested and often highly personalised, historically and politically constructed concept. To illustrate this I read a few dictionary definitions of 'education', as well as a selected set of stated 'aims of education'. When students hear that D. H. Lawrence claimed education should aim to 'lead out the individual nature in every man and woman to its true fullness', that for Rousseau the aim of education was 'to come into accord with teaching of nature', that R. M. Hutchins saw the aim of education as 'cultivation of the intellect', that A. S. Neill believed the aim of education should be to 'make people happier, more secure, less neurotic, less prejudiced', and that John

> Locke claimed 'education must aim at virtue and teach man to deny his desires, inclinations and appetite, and follow as reason directs'; hopefully the penny has dropped. (p. 1)

Nevertheless, within even the examples that Harris cites, chosen to represent their diversity, we can see two broad groupings. First, those where the intention is to develop the individual for her/his own benefit; secondly, where the intention is to develop individuals so that they collectively contribute to making the world a better place. John White and I (Reiss & White, 2013) contend that there should be two fundamental aims of school education, namely to enable each learner to lead a life that is personally flourishing and to contribute to building up societies (whether at the local or global level) that enable others to do so too.

The idea that humans should lead flourishing lives is among the longest established of ethical principles, one that is emphasised by Aristotle in his *Nicomachean Ethics*. There are many analyses as to what precisely constitutes a flourishing life. A hedonist sees it in terms of maximising pleasurable feelings and minimising painful ones. Related to this, a person may wish to maximise their wealth, fame, consumption or, more generally, to satisfy their principal desires, whatever these may be. Admittedly, there are difficulties with all these accounts (White, 2011). For example, a problem with desire satisfaction is that it allows ways of life that virtually all of us would deny were flourishing, a life mainly devoted to drinking very large amounts of alcohol, for instance.

A life filled with whole-hearted and successful involvement in more worthwhile pursuits—significant relationships, meaningful work, and other activities we find satisfying—is on a different plane. Virtually all of us would rate it fulfilling. At the same time, nearly all of us in a modern society presume it is largely up to each of us to choose the mix of relationships and activities that best suits us (certain family obligations are generally excepted from this generalisation, though less than in the past). A central aim of the school should therefore be to prepare students for lives of autonomous, whole-hearted, and successful engagement in worthwhile relationships, activities, and experiences.

Such an aim is facilitated by a much richer, less binary account of sex and gender than is usually presented in science lessons. I shall have more to say about this in the rest of this chapter, but the key point here is that by queering the way we teach about sex and sexualities in school science we can provide a curriculum and a pedagogy more appropriate for *all* students. This claim may appear counterintuitive. While queer approaches may evidently help LGBTQI youth, aren't they counterproductive for dyed-in-the-wool heteronormative or heterosexist youths? Aware that I may be accused of a Panglossian tendency, I think not. My argument is that the truth(s) will out and queer approaches to sex and sexuality are closer to these truths than the conventional, out-dated fodder all too typically served up in bland science textbooks and standardised approaches to teaching human reproduction. Queer teaching is simply better science teaching—a point made by Luhmann (1998) and Lemke (2011), with Jay Lemke arguing that at least one meaning of queer approaches is to live up to science's own professed epistemic virtues better than science education usually does.

THE SCIENCE CURRICULUM SHOULD ENABLE STUDENTS TO ACQUIRE POWERFUL KNOWLEDGE

While historians tell us that what scientists study changes over time, there are reasonable consistencies. Science is concerned with the natural world and with certain elements of the manufactured world—so that, for example, the laws of gravity apply as much to artificial satellites as they do to planets and stars. Furthermore, as important as the scope of science is the way that science is undertaken. Fundamentally, science is about the building up of knowledge that is derived *empirically* and gives rise to *testable* models of the world.

This means, for instance, that scientific knowledge is distinct from mathematical knowledge (though there can be overlaps, as is the case with applied mathematics and theoretical physics). Mathematical knowledge about, for example, the characteristics of polynomial equations is not obtained by setting off into the field or the laboratory to isolate examples of polynomial equations that can be purified and then investigated. Equally, scientific knowledge about, for example, the causative agents of infectious diseases is not obtained by sitting in arm chairs attempting to find the solutions to the problems that worried Pasteur and Koch.

Similarly, scientific knowledge can be distinguished from aesthetic knowledge, from literary knowledge, from normative knowledge, and from a number of other knowledges. To say a bit more about just one of these, namely normative knowledge, science is fundamentally concerned with how things are rather than with how they should be. So, there is a science of gunpowder and in vitro fertilisation without science telling us whether warfare and test-tube births are good or bad (Reiss, 2015). Of course, science plays a role in telling us whether such things are good or bad—any utilitarian approach to ethics relies on a detailed, accurate, and thorough knowledge of the consequences of human actions; but there are aspects of moral philosophy that cannot be reduced to science, as has been appreciated at least since David Hume made his famous is/ought distinction.

At the same time, to return to the example of in vitro fertilisation, the science around this reproductive technology is made possible in part by all sorts of decisions and resource allocations that define it as a good and worthy thing to know about. Science serves as a culturally validating force—because it is so in science lends credence and credibility to phenomena, making them seem *right*. Furthermore, the existence of new technologies, informed by science, alters the way we see ourselves and so affects our hopes and our behaviours. The promises of in vitro fertilisation can profoundly affect human aspirations.

Scientific knowledge is therefore powerful and pervasive but it is not all powerful. To think otherwise is to be guilty of scientism. The argument that schooling should enable learners to obtain the sort of powerful knowledge that they would otherwise be unlikely to acquire (e.g., from their families or from listening to television) has received a sustained defence in recent years from the writings of Michael Young (e.g., Young, 2008). My point is that queer approaches to scientific knowledge, precisely by troubling what otherwise would remain unwarranted presumptions about how humans exist and behave, provide access to more powerful knowledge that would otherwise be the case.

Consider how sex is typically presented in school science classrooms. School biology typically examines issues of sex through the lens of reproduction (Reiss, 2007a). This immediately tends to presume heterosexuality. Biology is all too often assumed to be a neutral subject, so that many biology teachers in schools continue to teach gender and sex as unquestioned fact. In particular, differences between females and males are often presented as clear-cut and inevitable, and the study of school biology textbooks shows that they are often sexist and typically ignore lesbian and gay issues (Bazzul & Sykes, 2011; Reiss, 1998; Snyder & Broadway, 2004). For example, biology textbooks in England for 14- to 16-year-olds often omit all mention of the clitoris and, when they do refer to it, frequently talk of it in a belittling way as the female's equivalent of a penis. Males are rendered visible, females less so; and the female exists by virtue of comparison with the male. When the possibility of being gay or lesbian is addressed (the furthest that school biology textbooks ever get from heteronormativity), the impression is generally given that this is a sort of second-best option which the reader may well grow out of.

However, closer examination of sex in human biology provides plenty of space for critical reflection and allows for a richer understanding of what it is to be a sexual person. Emily Martin (1991) has shown that while menstruation is viewed in scientific textbooks as a failure (you should have got pregnant), sperm maturation is viewed as a wonderful achievement in which countless millions of sperm are manufactured each day. Furthermore, sperm are viewed as active and streamlined, whereas the egg is large and passive and just drifts along or sits there waiting. It was back in 1948 that Ruth Herschberger argued that the female reproductive organs (it is difficult in the scientific discourse around sex to avoid referring to reproduction) are viewed as somehow being less autonomous than those of the male. The way the egg is portrayed in science textbooks has been likened to that of the fairy tale *Sleeping Beauty*, in which a dormant, virginal bride awaits a man's magic kiss. However, for well over a decade biologists have seen both egg and sperm as active partners. Just as sperm seek out the egg, so the vagina discriminates between sperm, and the egg seeks out sperm to catch. Nevertheless, as Martin points out, even when acknowledged, such biological equality is still generally described in a language that gives precedence to the sperm. When the egg is presented in an active role, the image is one of a dangerous aggressor "rather like a spider lying in wait in her web" (Martin, 1991, p. 498).

Social historical research on sex hormones has also shown how the way that such hormones are presented in textbooks and scientific papers gives messages that go well beyond what the data indicate. Despite the fact that it has been known since the 1920s that each sex contains the "other's" hormone—so males contain oestrogen and females testosterone—school textbooks typically ignore both this fact and the close chemical similarity between oestrogen and testosterone (Roberts, 2002). Indeed, a different reading of the data to that usually presented in school textbooks—but one more in line with the scientific evidence about the working of sex hormones—is that conventional understandings of femaleness and maleness lie on a continuum. Such a model of the consequences of the actions of the sex hormones became common among endocrinologists in the 1940s.

While this model can lead to an essentialist understanding of sexuality and sexual orientation—and it correlated with a rise in the number of studies of the presumed femininity of gay men (Oudshoorn, 1994)—it can also be seen as allowing a far more fluid understanding of sexuality, accommodating, for example, some forms of intersexuality (cf. Callahan, 2009). The principle of intersexuality dates largely from Magnus Hirschfeld's pioneering work in the first three decades of the 20th century on sexual difference. By rejecting the discrete categories of male and female, arguing instead that each of us is on a continuum, Hirschfeld radically deconstructed the sexual binary (Bauer, 2003). One of the things good teaching can help students to appreciate is the way in which males and females are pressured, respectively, to perform maleness and femaleness, discourses that are structured largely in opposition to each other (cf. Butler, 1990; Martino & Pallotta-Chiarolli, 2005). My experience of teaching a nonbinary version of human sex to school students is that many of them find it fascinating; it can help them to see the world, and themselves, in a new light. Indeed, enabling students to see classifications that relate to gender, sex, and sexuality more fluidly has the potential to lead students to question, even disrupt, other rigid typologies, facilitating the beginnings of an intersectional analysis.

Biological indicators of sexual orientation have long been sought and continue to fascinate commentators, attracting some and worrying others in the gay and lesbian communities. Hardly a month goes by without a report of some such biological indicator. Precisely which indicator is flavour of the month (a hormone, a gene, parental upbringing, relative finger length, etc.) may tell us more about research fashions and the power of statistical analysis than much else. Around the middle of the 20th century, hormones were widely thought to be all powerful and responsible for our sexuality. Towards the end of the 20th century the focus shifted to genes. Genes are responsible for the chemicals, including hormones, made in the body, and a reductionist perspective sees them as determining not just sex and sexuality but almost all of what it is to be ourselves.

Much of the literature about the "causes" of sexuality concentrates on gayness, though Lynda Birke, a biologist as well as a feminist and a lesbian, provides a valuable review about lesbianism and notes that she has "spent much time and energy refuting the allegations that any social categories (of gender, race or sexuality) are fixed by biology" (Birke, 1997, p. 58). However, as Birke points out, there are, of course, several reasons for hesitating in rejecting entirely biological notions of sexual orientation. For one thing, some have used such notions politically to argue for gay rights (though this approach is hotly contested—see Schüklenk & Brookey, 1998); more prosaically, it may well yet turn out that there are biological bases to at least some people's sexuality.

All of which leads us on to how might biology be taught better in schools? Much biology teaching is focused around the use of textbooks, yet "teachers can read subtextually and resistantly and can help their students to do likewise. Too rarely are students encouraged to critique their science textbooks; too often are textbooks used as if they contained only unquestionable truths" (Reiss, 1998, p. 148). This is a simple message but one that provides a teacher—and her/his students—with a

powerful tool, for it avoids buying into the general assumption of teacher as the expert repository of facts, instead sitting more comfortably with critical and emancipatory understandings of education. This can be more satisfying for teacher and students alike, and fits well with an information society which provides students with plenty of opportunities to obtain many of the facts they want/need to know at the right pace for themselves.

A fuller account of what biology teachers can do is provided by Anne-Marie Scholer (2002) in her description of her teaching programme for a two-semester intermediate-level college course in anatomy and physiology, required for first-year students in nursing, athletic training, and physical therapy majors. Scholer begins with the idea that male/female is not a dichotomy. Here she draws on the various causes of indeterminate sex in humans, the sex hormone story outlined above, the existence of breast cancer in men, and transgender. As she says, "While the foregoing material is undoubtedly familiar to individuals in the fields of sexuality education, it is quite new to most of my students and peers. I have found such examples to work well in class, creating vocal displays of cognitive dissonance" (Scholer, 2002, p. 78). As every teacher knows, cognitive dissonance, if well handled, can be a powerful incentive to learning. (Handled badly it can merely reinforce prejudice or be rejected as confusing.) Scholer goes on to challenge the prevailing stereotype of eggs as passive objects, to discuss how sex is not just anatomy and hormones, to avoid heteronormativity, and generally to "create an inclusive environment in my classroom" (p. 82).

There may be some who think that school and college biology is not an important battle ground, even that to fight discrimination and injustice on this front is to risk allowing the discourse to be predetermined by the other side. However, as Mariamne Whatley pointed out in a chapter in Debbie Epstein's and James Sears's *A Dangerous Knowing*, "Using science to attack comprehensive sexuality education and to support abstinence-only education is one strategy being used currently" (Whatley, 1999, p. 238).

Similarly, Will Letts (2001) has explored how school science structures and is structured by norms of heterosexual masculinity. Letts's work is particularly valuable as he focuses on classroom examples of primary school science—when some might assume that at this age science is fairly neutral (see the work of the No Outsiders project in DePalma & Atkinson, 2009). He argues that science, including school science, functions as a grand narrative that seduces students and teachers; he concludes:

> As a plan of action, I advocate that school science becomes an active and generative site for critical science literacy. The words 'science literacy' in this phrase are intended quite differently than popular utterances of them have come to mean. 'Science literacy' does not simply mean an intake and consumption of science texts and 'facts', either purposefully or through acts of seduction. I am using critical science literacy to denote something akin to critical media literacy. (p. 270)

A school science classroom for critical science literacy, at any age, would be one in which the traditional virtues of science—its open-mindedness and refusal to accept tradition on trust—were more widely (and reflexively) applied. It would allow young people to think about themselves and their sexuality more meaningfully. It would help those uncomfortable with traditional descriptions of masculinity and femininity to realise that they are not alone in their rejection of such simple dichotomies. All this can be achieved without harming those students who are comfortable with such conventional descriptions. Sadly, such classrooms are still rare. In the long run, such teaching, idealistic though this may sound to some, would contribute to making the world a better place both overall and for the many individuals who otherwise feel or find that they don't fit. (But note, Britzman [1995] points out that attempts to improve things for those who are excluded can often get it wrong, as when the inclusion of gay and lesbian studies in the curriculum causes the very exclusions it is meant to cure.)

THE SCIENCE CURRICULUM SHOULD ADVANCE SOCIAL JUSTICE

The first section of this chapter argued that schooling should enable human flourishing, both individually and collectively. The second section argued that schooling should give students access to powerful knowledge to which they otherwise would lack access, and then applied this dictum to teaching about sex and sexuality in the science classroom. This section begins from an oft-asked question, namely what the aims of school science education should be, and explores the implications of possible answers.

I have argued for a number of years that science education as currently undertaken in schools is generally too narrow in its conceptualisation, its aims, its curriculum, its teaching, and its assessment, and that this is a major reason why it fails to engage many young people (Reiss, 1993).

Before designing a school science curriculum, one needs to determine its aims. Many aims for school science education have been proposed (e.g., Reiss, 2007b), though these are often implicit. A frequent aim of science courses has been to provide a preparatory education for the small proportion of individuals who will become future scientists (in the commonly understood sense as employed professionals). This aim has been widely critiqued on democratic grounds (e.g., Millar & Osborne, 1998). After all, what of the great majority of school students who will not become such scientists?

Another aim is to enable "scientific literacy." Although there has been a long-running debate as to the meaning of the term (e.g., Miller, 1983), generally, scientific literacy is seen as a vehicle to help tomorrow's adults to understand scientific issues (Gräber & Bolte, 1997). The basic notion is that science education should aim to enhance understanding of key ideas about the nature and practice of science as well as some of the central conclusions reached by science. Perhaps to be included within this category is the argument that to be an educated person in the 21st century is to understand something of science (e.g., Shamos, 1995). This is the "science as

culture" argument; that science is as worth studying *in itself* as are, for example, literature and the arts.

A further aim is that many science courses hope that, as a result of what is learnt, students both now and in the future as adults will be able to gain *practical* benefit from it. At its most straightforward this might be by entering paid employment that draws on what they have learnt in science. Although, as noted above, most students do not enter such careers, they too may still benefit individually from their school science. For example, in most science courses, in countries round the world, it has long been accepted that one of the justifications for the inclusion of certain topics is that knowledge and understanding of them can promote human health. Such topics may include infectious diseases, diet, reproduction and contraception, exercise, and the use of drugs (including smoking and alcohol).

Another, more mundane, way in which school science might help individual advancement is by providing what I have termed *science education for consumerism* (Reiss, 2007b). This is the hope that school science education might, for example, help us choose the most appropriate technological goods (Is it worth my paying x% more for a washing machine that uses y% less hot water?) or make broad decisions, for instance about climate change, on narrow criteria (Where should I live so as to minimise problems with rising sea levels or extreme weather events?). This is a subset of the more general and long-established argument that science education should be for public understanding (American Association for the Advancement of Science, 1990; Millar, 1996).

A further aim of school science education is that it should be for citizenship (Jenkins, 1999). A "weak" version of this consists of learning what a democracy is and the place that science plays in being an engaged citizen. A "strong" version entails using such knowledge to bring about desirable change. This is closely allied to claims that the aim of school science education should be to effect social justice or sociopolitical action (e.g., Calabrese Barton, 2001; Carter, 2005; Hodson, 2009). Calabrese Barton draws on feminist approaches to show that many of the students with whom she and her colleagues work, whilst seen in school as poor attainers in science, are actually perfectly capable of high quality science work provided they are given real choice in the science they work at.

It is evident that there are currently diverse aims for school science education. That science education should help advance social justice seems an aim that is worth arguing for. Science is so powerful a discourse that it has too often been used to marginalise and oppress others, those who do not fit into the mainstream, the majority. Stephen J. Gould (1981) pointed out how supposedly objective measures undertaken by the most reputable scientists were used by them and others to reinforce gender, racial, and class stereotypes.

It can be difficult for any of us, scientists or not, to ensure that our work is not overly influenced by the cultural presumptions of the society in which we live—structures are important. One approach that can be useful is that advocated by Rawls (1971) in his *A Theory of Justice*. Rawls argued that we should live as if behind a veil of ignorance, i.e. that societal decisions should be made as if each of us did not know our own circumstances. The great advantage of this imaginative approach is

that it puts us in the shoes of others and can help to make discrimination against minorities less likely. Rawls goes on to argue that matters should be arranged so that (a) each person has the most extensive liberty compatible with the liberty of others and (b) social and economic inequalities benefit the least advantaged members of society.

Rawls's arguments not only help us to consider how science might be more justly presented; they also have implications for such repeatedly contested matters as same-sex couples at high school proms and cases of students being omitted from yearbooks because of pregnancy or what a school deems to be inappropriate dress (the word has a pleasing ambiguity), e.g. young women not being allowed to wear a tux(edo) or a button-down shirt and tie.

CONCLUSIONS

Much of the early literature that addressed gay, lesbian, and queer issues in schooling (e.g., Garber, 1994; Unks, 1995) paid little or no attention to science. The more recent emphasis on queering school science (e.g., Fifield & Letts, 2014; this volume) is therefore to be welcomed. Around the world, a common argument in favour of science enjoying its privileged place in the curriculum is that a country needs large numbers of people to choose careers in science and related fields (e.g., engineering). This neoliberal argument is not to be ignored; human flourishing is helped (think of advances in medicine, transport, and communications) by scientific advances. Yet, there should be more to school science than its role in providing the next generation of scientists. In this chapter I argue that three different approaches to determining what might be in the science curriculum when teaching about sex and sexuality—a curriculum for human flourishing, a curriculum for powerful knowledge, and a curriculum for social justice—all conclude that conventional teaching about human sex and sexuality falls short.

Queer approaches to teaching these topics can aid human flourishing, enable students to gain more powerful knowledge, and address social injustices. Crucially, for those who believe that school science is an uncontested arena that should stick to solid and well-established science, it is increasingly the case that conventional teaching about human sex and sexuality is poor science. I am well aware that there will be some who think it overoptimistic to presume that science teaching can help when teaching about sex and sexuality, given how contentious these issues are in many countries (e.g., Irvine, 2002). However, science occupies a central space on the school timetable and may be able to achieve things more difficult to achieve through less powerful subjects.

Finally, what of those who maintain that the approach for which I have been arguing runs counter to how they see reality, for instance because of their understanding of the teaching of religion? Three main responses can be made. First, when religion is included in the school curriculum this does not mean that it should trump all other considerations (Reiss, 2012). Secondly, not all religions and not all interpretations of religion are conservative ones. Within Christianity, for example, a whole range of positions hold, from ones where scripture is read literally and non-

critically to ones where scripture, while still held in high esteem, is read more critically (Reiss, 2014). Hedgehogs and foxes again: There is more than one way of seeing and being in the world. Thirdly, and perhaps more mundanely, there may be circumstances when even someone convinced of the various benefits of queering the science classroom may feel that it would be wise to avoid too much usage of the word *queer* (which can act as a red rag to a bull) and simply concentrate on the argument that all one is concerned with is the provision of good quality science education. This need not be seen as a "cop out"; just as teaching in biology about "the problem of the species" (hybrids, ring species, etc.) need not be taken as an attack on the notion of "kinds" in the book of Genesis, so a richer, more nuanced, and I would argue more accurate, teaching about sex and sexuality need not be read as an attack on religious faith.

REFERENCES

American Association for the Advancement of Science. (1990). *Science for all Americans: Project 2061*. New York, NY: Oxford University Press.

Bauer, J. E. (2003, October). *Magnus Hirschfeld's doctrine of sexual intermediaries and the transgender politics of identity*. Paper presented at the meeting of Past and Present of Radical Sexual Politics, Amsterdam. Retrieved from http://www.iisg.nl/womhist/radsexpol.html#papers

Bazzul, J., & Sykes, H. (2011). The secret identity of a biology textbook: straight and naturally sexed. *Cultural Studies of Science Education, 6*, 265–286.

Berlin, I. (1953). *The hedgehog and the fox: An essay on Tolstoy's view of history*. London: Weidenfeld & Nicolson.

Birke, L. (1997). Born queer? Lesbians interrogate biology. In G. Griffin, & S. Andermahr (Eds.), *Straight studies modified: Lesbian interventions in the academy* (pp. 57–70). London: Cassell.

Britzman, D. P. (1995). Is there a queer pedagogy? Or, stop reading straight. *Educational Theory, 45*, 151–165.

Butler, J. (1990). *Gender trouble: Feminism and the subversion of identity*. New York, NY: Routledge.

Calabrese Barton, A. (2001). Science education in urban settings: Seeking new ways of praxis through critical ethnography. *Journal of Research in Science Teaching, 38*, 899–917.

Callahan, G. N. (2009). *Between XX and XY: Intersexuality and the myth of two sexes*. Chicago, IL: Chicago Review Press.

Carter, L. (2005). Globalisation and science education: rethinking science education reforms. *Journal of Research in Science Teaching, 42*, 561–580.

DePalma, R., & Atkinson, E. (Eds.). (2009). *Interrogating heteronormativity in primary schools: The No Outsiders project*. Stoke on Trent: Trentham Books.

Fifield, S. & Letts, W. (2014). [Re]considering queer theories and science education. *Cultural Studies of Science Education, 9*, 393–407.

Foucault, M. (1969/1972). *The archaeology of knowledge*. London: Tavistock.

Garber, L. (Ed.). (1994). *Tilting the tower: Lesbians teaching queer subjects*. New York, NY: Routledge.

Giffney, N. (2009). Introduction: the 'q' word. In N. Giffney, & M. O'Rourke (Eds.), *The Ashgate research companion to queer theory* (pp. 1–13). Burlington, VT: Ashgate.

Gould, S. J. (1981). *The mismeasure of man*. New York, NY: W. W. Norton.

Gräber, W., & Bolte, C. (Eds.). (1997). *Scientific literacy: An international symposium IPN 154*. Kiel: Institut für die Pädagogik der Naturwissenschaften an der Universitatät Kiel.

Harris, K. (1999). Aims! Whose aims? In R. Marples (Ed.), *The aims of education* (pp. 1–13). London: Routledge.

Hodson, D. (2009). *Teaching and learning about science: Language, theory, methods, history, traditions and values*. Rotterdam: Sense Publishers.

Holland, J., Ramazanoglu, C., Sharpe, S., & Thomson. R. (1998). *The male in the head: Young people, heterosexuality and power*. London: Tufnell Press.

Irvine, J. M. (2002). *Talk about sex: The battles over sex education in the United States*. Berkeley, CA: University of California Press.

Jenkins, E. W. (1999). School science, citizenship and the public understanding of science. *International Journal of Science Education*, *21*, 703–710.

Lemke, J. (2011). The secret identity of science education: masculine and politically conservative? *Cultural Studies of Science Education, 6*, 287–292.

Letts, W. (2001). When science is strangely alluring: Interrogating the masculinist and heteronormative nature of primary school science. *Gender and Education*, *13*, 261–274.

Luhmann, S. (1998). Queering/querying pedagogy? Or, pedagogy is a pretty queer thing. In W. Pinar (Ed.), *Queer theory in education* (pp. 141–155). Mahwah, NJ: Lawrence Erlbaum.

Martin, E. (1991). The egg and the sperm: How science has constructed a romance based on stereotypical male-female roles. *Signs: Journal of Women in Culture and Society*, *16*, 485–501.

Martino, W., & Pallotta-Chiarolli, M. (2005). *Being normal is the only way to be: Adolescent perspectives on gender and school*. Sydney: University of New South Wales Press.

Millar, R. (1996). Towards a science curriculum for public understanding. *School Science Review*, *77*(280), 7–18.

Millar, R., & Osborne, J. (Eds.) (1998). *Beyond 2000: Science education for the future*. London: Nuffield Foundation.

Miller, J. (1983). Scientific literacy: A conceptual and empirical review. *Daedalus*, *112*(2), 29–48.

Oudshoorn, N. (1994). *Beyond the natural body: An archeology of sex hormones*. London: Routledge.

Rawls, J. (1971). *A theory of justice*. Cambridge, MA: Harvard University Press.

Reiss, M. J. (1989). *The allometry of growth and reproduction*. Cambridge: Cambridge University Press.

Reiss, M. J. (1993). *Science education for a pluralist society*. Milton Keynes: Open University Press.

Reiss, M. J. (1998). The representation of human sexuality in some science textbooks for 14-16 year-olds. *Research in Science & Technological Education*, *16*, 137–149.

Reiss, M. (2007a). Representing the world: difference and science education. In M. Reiss, R. DePalma, & E. Atkinson (Eds.), *Marginality and difference in education and beyond* (pp. 61–72). Stoke-on-Trent: Trentham.

Reiss, M. J. (2007b). What should be the aim(s) of school science education? In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The re-emergence of values in science education* (pp. 13–28). Rotterdam: Sense Publishers.

Reiss, M. J. (2012). What should be the role of religion in science education and bioethics? In S. A. Øyen, T. Lund-Olsen, & N. S. Vaage (Eds.), *Sacred science? On science and its interrelations with religious worldviews* (pp. 127–139). Wageningen: Wageningen Academic Publishers.

Reiss, M. J. (2014). Sex education and science education in faith-based schools. In J. D. Chapman, S. McNamara, M. J. Reiss, & Y. Waghid (Eds.), *International handbook of learning, teaching and leading in faith-based schools* (pp. 261–276). Dordrecht: Springer.

Reiss, M. J. (2015). The nature of science. In R. Toplis (Ed.), *Learning to teach science in the secondary school: A companion to school experience* (4th ed., pp. 66–76). London: Routledge, pp.66-76.

Reiss, M. J., & White, J. (2013). *An aims-based curriculum: The significance of human flourishing for schools*. London: IOE Press.

Roberts, C. (2002). 'A matter of embodied fact': Sex hormones and the history of bodies. *Feminist Theory*, *3*, 7–26.

Scholer, A.-M. (2002). Sexuality in the science classroom: One teacher's methods in a college biology course. *Sex Education*, *2*, 75–86.

Schüklenk, U., & Brookey, R. A. (1998). Biomedical research on sexual orientation: Researchers taking our chances in homophobic societies. *Journal of the Gay and Lesbian Medical Association*, *2*(2), 79–84.

Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick: Rutgers University Press.

Snyder, V. L., & Broadway, F. S. (2004). Queering high school biology textbooks. *Journal of Research in Science Teaching, 41*, 617–636.

Unks, G. (Ed.). (1995). *The gay teen: Educational practice and theory for lesbian, gay, and bisexual adolescents*. New York, NY: Routledge.

Whatley, M. H. (1999). The 'homosexual agenda' goes to school. In D. Epstein, & J. T. Sears (Eds.), *A dangerous knowing: Sexuality, pedagogy and popular culture* (pp. 229–241). London: Cassell.

White, J. (2011). *Exploring well-being in Schools: A guide to making children's lives more fulfilling*. London: Routledge.

Young, M. F. D. (2008). *Bring knowledge back in: From social constructivism to social realism in the sociology of education*. London: Routledge.

Michael J Reiss is professor of science education at the UCL Institute of Education, University College London (UK), and a Fellow of the Academy of Social Sciences. The former director of education at the Royal Society, he has written extensively about curricula, pedagogy, and assessment in science education and has directed a very large number of research, evaluation, and consultancy projects over the past 20 years funded by UK Research Councils, government departments, charities, and international agencies. He can be contacted at m.reiss@ucl.ac.uk