# Chapter 5

# THE STRUCTURE OF VALUES IN SCIENCE

EVEN WHEN MAKING EMPIRICAL CLAIMS, scientists have the same moral responsibilities as the general population to consider the consequences of error. This apparently unremarkable statement has some remarkable implications. It means that scientists should consider the potential social and ethical consequences of error in their work, that they should weigh the importance of those consequences, and that they should set burdens of proof accordingly. Social and ethical values are needed to make these judgments, not just as a matter of an accurate description of scientific practice, but as part of an ideal for scientific reasoning. Thus, the value-free ideal for science is a bad ideal. However, simply discarding the ideal is insufficient. Although scientists need to consider values when doing science, there must be constraints on how values are considered, on what role they play in the reasoning process. For example, simply because a scientist values (or would prefer) a particular outcome of a study does not mean the scientist's preference should be taken as a reason in itself to accept the outcome. Values are not evidence; wishing does not make it so. There must be some important limits to the roles values play in science.

To find these limits, it is time to explore and map the territory of values in science. This will allow me to articulate a new ideal for values in science, a revised understanding of how values *should* play a role in science and of what the structure of values in science *should* be. I will argue that in general there are two roles for values in scientific reasoning: a direct role and an indirect role. The distinction between these two roles is crucial. While values can play an indirect role throughout the scientific process, values should play a direct role only for certain kinds of decisions in science. This distinction between direct and indirect roles allows for a better understanding of the place of values in science—values of any kind, whether cognitive, ethical, or social. The crucial normative boundary is to be found not among the kinds of values scientists should or should not consider (as the traditional value-free ideal holds), but among the particular roles for values in the reasoning process. The new ideal that rests on this distinction in roles holds for all kinds of scientific reasoning, not just science in the policy process, although the practical import of the ideal may be most pronounced for policy-relevant science.

In order to map the values in science terrain, we need to consider the function of values throughout the scientific research process. The schema of the research process I use in this chapter is admittedly idealized, but it should be both familiar and a sufficient approximation. The first step in any research endeavor is deciding which questions to pursue, which research problems to tackle. This decision ranges from the rather vague ("I think I'll look here") to the very precise (a particular approach to a very well-defined problem). Regardless, a decision, a judgment, must be made to get the process started. Then the researcher must select a particular methodology in order to tackle the problem. This decision is often closely tied to the choice to pursue a particular problem, but in many cases it is not. These decisions are often under constraints of ethical acceptability, resource limitations, and skill sets. And if institutional review boards are overseeing methodological choices, these decisions can take place over a protracted period of time. Methodological choices also profoundly shape where one looks for evidence.

Once the researcher embarks upon a chosen methodology, he or she must decide how to interpret events in the study in order to record them as data. In many cases, this is a straightforward decision with little need for judgment. However, judgment may be called for on whether a particular event occurred within the framework of the methodological protocol (was the equipment working properly?), or judgment may be needed in how to best characterize an ambiguous event. Once the researcher has collected the data, he or she must interpret it and draw conclusions. The scientist must ultimately decide whether the data support the hypothesis, and whether to accept or reject a theory based on the evidence. This process is mimicked in the papers published by scientists, and thus provides a useful heuristic for understanding the scientific process. These decision points may not be so orderly or neat in actual practice, but we can generally recognize where in actual practice a decision made by a scientist would be situated in this idealized process. I will use this schema of the research process to explicate where values should play which kind of role.

Before delving further into the *roles* values play in science, we should first examine whether clear distinctions can be made among the *kinds* of values potentially relevant to science. The value-free ideal rests on at least one distinction for values in science, between acceptable and unacceptable values. Acceptable values became known as "epistemic," meaning related to knowledge, whereas the rest became known as "nonepistemic," a catch-all category that includes social, ethical, and other values—all the "forbidden" values. If this distinction fails, not only is there another reason to reject the value-free ideal (for one of its foundational distinctions is faulty), but also one should not rely upon that distinction in forging a new ideal.

In recent examinations of values in science, the divisions have become more complex, and, upon closer examination, simple distinctions are less tenable. If we cannot rely upon definitively demarcated categories of values, it becomes all the more important that we keep clear the *role* of the values in our empirical reasoning, making sure that they are constrained to legitimate roles. In addition, without the dichotomy between epistemic and nonepistemic values, we can better understand the tensions involved in weighing various kinds of values in any given scientific judgment, for example, when cognitive and ethical values conflict. A topography of values, with continuities among categories rather than cleanly demarcated categories, can help to organize the kinds of values involved.

## The Topology of Values in Science

Central to the current value-free ideal, the 1950s debate about values in science (discussed in chapter 3) introduced a demarcation in the types of values that could influence science. "Epistemic values" were thought to be those that related directly to knowledge and could be differentiated from nonepistemic values such as social and ethical values. Traditional examples of epistemic values included predictive accuracy, explanatory power, scope, simplicity (or "economy"), and so forth.[1] Under the value-free ideal, these values were sharply demarcated from social and ethical values, such as concern for human life, reduction of suffering, political freedoms, and social mores.

The clear demarcation between epistemic (acceptable) and nonepistemic (unacceptable) values is crucial for the value-free ideal. Philosophers of science, even while presuming the isolation of science from society, have understood the endemic need for judgment in science. Scientists often disagree over which theory is preferable in accounting for the same available evidence. So even with an isolated science, there is a need for some value judgments in science. Philosophers have thus attempted to make a distinction between the kinds of values proper to scientific judgment and the kinds of values thought to threaten the value-free ideal. As Levi (1960, 1962) argued, and most philosophers came to agree, only values that were part of the "canon of scientific reasoning" should be used, that is, only epistemic values were legitimate when assessing the strength of evidence in relation to theory. However, the reasons for such an isolated science were neither fully articulated nor well supported. Indeed, as I argue in chapter 4, such scientific isolation from moral responsibility was unwarranted and undesirable. Even so, it is not clear that the initial distinction between epistemic and nonepistemic values was a viable one.[2] If this distinction fails, the value-free ideal is untenable, the arguments of the previous chapter aside.

The main argument for the porousness (and thus failure) of the epistemic/nonepistemic distinction is that epistemic values end up reflecting the nonepistemic values of the day. For example, Phyllis Rooney (1992, 16) observes that Ernan McMullin, a staunch defender of the distinction, allowed an acceptable role for "nonstandard epistemic values," such as metaphysical presuppositions or theological beliefs. An example of this, Rooney notes, would be the theological views on the role of randomness in the universe that underlay the Bohr-Einstein debate. The social or cultural values that shaped Bohr's or Einstein's theological views then acted as guides for epistemic choice, thus operating as epistemic values. Such nonstandard epistemic values have deeply influenced the direction of scientific thought, but they also often reflected social values, Rooney suggests, thus smuggling the nonepistemic values through the boundary. Similar issues arise in scientific studies of gender, where socially desired biological determinism appears within scientific research in the form of simplicity, a supposedly acceptable and pure epistemic value (Rooney 1992, 18). Thus, the "'non-epistemic' [becomes] encoded into the constitutive [that is, epistemic] features of specific theories" (ibid., 20). The boundary looks quite permeable in this light, unable to bear the weight of keeping the undesirable values out of science.

Helen Longino (1996) makes a similar point. She first provides examinations of the standard epistemic values, such as accuracy, consistency, simplicity, scope, and fruitfulness (41–44). Then in contrast, she suggests some alternative epistemic virtues arising from feminist critiques of science, such as novelty, applicability, and ontological heterogeneity (45–50). With two competing sets of epistemic values in hand, Longino both undermines the apparent political neutrality of the standard set of epistemic values and raises the question of whether a clear dichotomy can be made between internal acceptable and external unacceptable values.

Even Hugh Lacey, another defender of the acceptable versus unacceptable values in science distinction, has difficulty maintaining a firm boundary. In his discussion of Longino's work, he writes,

> Longino maintains that a cognitive [that is, epistemic] value such as empirical adequacy, does not have "a solely epistemic or cognitive basis." I concur: since adopting a strategy

> is partly rationalized in view of its mutually reinforcing interactions with certain social values, values contribute to some extent to the interpretation of empirical adequacy that one brings to bear on one's hypotheses. (Lacey 1999, 221)

How one can maintain the dichotomy of values needed to support the traditional value-free theses is unclear in the face of these concerns. If social (nonepistemic) values shape the instantiation of epistemic values, then social values are influencing science through epistemic values.[3] Under the burden of these arguments, the strict demarcation between epistemic and nonepistemic values no longer seems viable. Without such a demarcation, the dichotomy between acceptable and unacceptable values in science fails. In the absence of such a dichotomy, a more nuanced topography of values in science is both possible and desirable.

In developing such a topography, we should begin by examining the goals behind the stated values. With a clearer understanding of goals, we can have a clearer understanding of the types of values relevant to science. Having types of values does not commit one to strict demarcations, however. It is more useful to think about these values as spread out in a landscape, with different parts of the landscape focusing on different goals, rather than as segregated into camps. Areas of overlap and interaction are common. For example, how one interprets a cognitive value such as simplicity may well be influenced by socially structured aesthetic values, values that help one interpret and recognize simplicity. Or which theories seem more fruitful may have much to do with which lines of investigation are likely to receive the needed social resources. When one rejects the idea that there are kinds of values acceptable and unacceptable in science, the need for clearly differentiated categories dissolves, and interactions or tensions can be more readily noticed.

With such a fluid understanding of the categories, how should we understand the topography of values in science? What are the various goals relevant to science? For the remainder of this work, three categories of values will reflect the predominant concerns: ethical, social, and cognitive. (Aesthetic values are often also important in some areas of science, but tend to be less so for policy-relevant science.) I will argue that epistemic values, *distinguished from cognitive values,* should not be thought of as values at all, but rather as basic criteria that any scientific work must meet. The epistemic criteria are set by the very valuing of science itself, and thus establish the scope of science, rather than acting as values within science.

The first kind of value, ethical value, focuses on the good or the right. These values are particularly important when examining the consequences of error for the general public. Ethical values help us weigh whether potential benefits are worth potential harms, whether some harms are worth no price, and whether some harms are more egregious than others.[4] Examples of ethical values relevant to scientific research include the rights of human beings not to be used for experimentation without fully informed consent, the consideration of sentient beings for their pain, concern for the death and suffering of others, whether it is right to pursue research for new weapons of mass destruction, and whether an imposition of risk is ethically acceptable.

Closely related (but not identical) to ethical values are social values. Social values arise from what a particular society values, such as justice, privacy, freedom, social stability, or innovation. Often social values will overlap with ethical values. For example, the social concern one might express over poverty can be tied to issues of justice or to concern over the increased health risks borne by impoverished individuals. A scientist may research a particular area because of both an ethical concern and a social value that reinforces that concern, such as pursuing research on malaria because it is a dreadful disease affecting millions and the scientist wishes to reduce the suffering caused by it, *and* because the scientist shares the social concern over the justice of working on diseases that afflict an affluent few rather than diseases that cause excessive suffering among the impoverished many (Flory and Kitcher 2004). Nevertheless, some social values can be opposed to ethical values. For example, the social value of stability was antithetical to the ethical values underlying the push for desegregation and the civil rights movement. More recently, the social value of stability and the reinforcement of stereotypes undergirding that stability, are reflected in some scientific studies of race and IQ that seek to show that the current social order is naturally ordained in some way (Fancher 1985; Gould 1981). Such values run directly counter to ethical values focused on the rights and qualities of individuals as such.

Cognitive values make up another major grouping. By "cognitive values" I mean something more precise than the vague clumping of acceptable values in science central to the value-free ideal, often equated with epistemic values. Rather, I mean those aspects of scientific work that help one think through the evidential and inferential aspects of one's theories and data. Taking the label "cognitive" seriously, cognitive values embody the goal of assisting scientists with their cognition in science.

For example, simplicity is a cognitive value because complex theories are more difficult to work with, and the full implications of complex theories are harder to unpack. Explanatory power is a cognitive value because theories with more explanatory power have more implications than ones that do not, and thus lead to more avenues for further testing and exploration. (Explanatory theories structure our thinking in particular but clearly articulable ways, and this allows one to draw additional implications more readily.) Scope is a cognitive value because theories with broad scope apply to more empirical areas, thus helping scientists develop more avenues for testing the theories. The consistency of a theory with other areas of science is a cognitive value because theories consistent with other scientific work are also easier to use, allowing for applications or extensions of both new and old theories, thus again furthering new research. Predictive precision is a cognitive value because making predictions with precision and testing to see if they are accurate helps scientists hone and refine theories more readily.[5] And fruitfulness is an obvious cognitive value because a productive theory provides scientists with many avenues for future investigation. Fruitfulness broadly construed may be considered the embodiment of cognitive values—the presence of any cognitive value should improve the productivity of an area of science. It should allow for more predictions, new avenues of testing, expansion of theoretical implications, and new lines of research. In sum, cognitive values are concerned with the possibilities of scientific work in the immediate future.

If cognitive values are about the fruitfulness of research, epistemic values are about the ultimate goal of research, which is true (or at least reliable) knowledge. As Laudan (2004) points out, many cognitive values have little to do with truth or truth preservation. Laudan argues that virtues such as scope, generality, and explanatory power "are not epistemic virtues," as they have no necessary connection to whether a statement is true (18). Simply because one statement explains more than another does not mean the latter statement is false. It might, however, be less useful to scientists, lacking sufficient cognitive value. In this light, values remaining in the epistemic category are quite limited. Internal consistency should be considered an epistemic value, in that an internally inconsistent theory must have something wrong within it. Because internal inconsistency implies a fundamental contradiction within a theory, and from a clear contradiction any random conclusions (or predictions) can be drawn, lacking internal consistency is a serious epistemic failing. In addition to internal consistency, predictive competence should be considered an epistemic value. If a theory makes predictions that obviously fail to come to pass, we have serious reason to doubt the theory. Predictive competency should be thought of in a minimal way, similar to empirical adequacy[6] or conforming to the world.[7] Predictive competency is thus not the same as predictive precision. A theory can have predictive competency and still not be terribly precise in its predictions, nor terrifically accurate in its success. Competency just implies "close enough" to remain plausible.

These epistemic virtues operate in a negative way, excluding claims or theories that do not embody them, rather than as values, which are aspects of science for which to strive, but which need not be fully present in all cases. For this reason, so-called "epistemic values" are less like values and more like criteria that all theories must succeed in meeting. One must have internally consistent theories; one must have empirically adequate/conforming/predictively competent theories. Without meeting these criteria, one does not have acceptable science.[8] This claim follows from the reason we value science in the first place, that science is an enterprise that produces reliable knowledge. This reliable knowledge is valued for the guidance it can provide for our understanding and our decisions. A predictively incompetent theory is clearly not reliable; an internally inconsistent theory can give no guidance about the world. The goal of science—reliable knowledge about the world—cannot be achieved without meeting these criteria. The other values discussed above, the ethical, the social, and the cognitive, serve different goals and thus perform a different function in science, providing guidance at points of judgment when *doing* science, helping one weigh options. Epistemic criteria determine what the viable options are among scientific theories, acting as baseline requirements that cast serious doubt on the acceptability of a scientific theory when they are not met.

Once we exclude epistemic criteria from our consideration of values in science, it is easier to see how values should play a role in scientific reasoning. Values can be used to make judgments at several places in the scientific process. There are different kinds of choices to be made as the scientist moves through the process, and at different points, different roles for values are normatively acceptable. All the kinds of values described here can have a relevant and legitimate role throughout the process, but it is the *role* of the values in particular decisions that is crucial.

## The Structure of Values in Science: Direct and Indirect Roles

Multiple kinds of values are needed throughout science, contrary to the value-free ideal. Depending on the nature of the judgment required, there are acceptable and unacceptable roles for values in science. Preventing the unacceptable roles preserves the integrity of science (regardless of whether the science is policy relevant or not) while allowing science to take its full measure of responsibility for its prominent place in public decisionmaking (in the cases where the science is policy relevant).

To set the scope of our discussion, let us first presume that we value science. The very decision to pursue scientific inquiry involves a value-laden judgment, namely that such an inquiry is a worthwhile pursuit. The persons deciding to invest their time and resources into science must believe that doing science is a valuable enterprise. What kind of value underlies this decision? It is neither a truth-preserving epistemic criteria nor a cognitive value assisting specific choices. Rather, it is a social value, for it reflects the decision of the society as a whole that science is a valuable and desirable pursuit, that we want to have a more accurate and complete understanding of the way the world is, and that science is a good way to get that understanding. It need not be this way. We could have a society that values stability above all else and cares little for this kind of understanding, with its constant revisions and changes. We could have a society that values stasis above truth and thus eschews the pursuit of changeable knowledge. Happily, from my perspective, we do not. The very decision to pursue science thus depends upon a social value.

Because of the value we place on science, because we care about having a reliable understanding of the world, science must meet certain standards to be acceptable. This sets up the epistemic criteria discussed above. It is because we care about having reliable empirical knowledge that scientific theories must be internally consistent and predictively competent. Our discussion of values in science must take place against the backdrop of this value judgment—the valuing of science itself as the source for reliable empirical knowledge.

There are two kinds of roles for values *in* science—direct and indirect. To see the difference between the two roles, let us briefly consider the decision context most central to scientists and philosophers, the decision of whether to accept or reject a theory based on the available evidence. Two clear roles for values in reasoning appear here, one legitimate and one not. The values can act as reasons in themselves to accept a claim, providing direct motivation for the adoption of a theory. Or, the values can act to weigh the importance of uncertainty about the claim, helping to decide what should count as *sufficient* evidence for the claim. In the first direct role, the values act much the same way as evidence normally does, providing warrant or reasons to accept a claim. In the second, indirect role, the values do not compete with or supplant evidence, but rather determine the importance of the inductive gaps left by the evidence. More evidence usually makes the values less important in this indirect role, as uncertainty reduces. Where uncertainty remains, the values help the scientist decide whether the uncertainty is acceptable, either by weighing the consequences of an erroneous choice or by estimating the likelihood that an erroneous choice would linger undetected. As I will argue below, a direct role for values at this point in the scientific process is unacceptable, but an indirect role is legitimate.

The difference between a direct role for values in science and an indirect role is central to our understanding of values in reasoning throughout the scientific process. In the *direct* role, values determine our decisions in and of themselves, acting as stand-alone reasons to motivate our choices. They do this by placing value on some intended option or outcome, whether it is to valorize the choice or condemn it. The value provides warrant or reason, in itself, to either accept or reject the option. In this direct role, uncertainty is irrelevant to the importance of the value in the judgment. The issue is not whether the choice will somehow come out wrong in the end, but whether the choice, if it comes out as expected, is what we want. This role for values in science is crucial for some decisions, but we will see that it must be restricted to certain decisions made in science and excluded from others. The integrity of the scientific process cannot tolerate a direct role for values throughout that process.[9]

The *indirect* role, in contrast, can completely saturate science, without threat to the integrity of science. This role arises when there are decisions to be made but the evidence or reasons on which to make the decision are incomplete, as they so often are, and thus there is uncertainty regarding the decision. Then values serve a crucial role of helping us determine whether the available evidence is sufficient for the choice and what the importance of the uncertainty is, weighing the potential consequences of a wrong choice and helping to mitigate against this possibility by requiring more evidence when such consequences are dire. But the values in this role do not determine the choice on their own. If we find new evidence, which reduces the uncertainties, the importance of the relevant value(s) diminishes. In this indirect role, more evidential reasons in support of a choice undercut the potency of the value consideration, as uncertainty is reduced. The value only serves as a reason to accept or reject the current level of uncertainty, or to make the judgment that the evidence is sufficient in support of a choice, not as a reason to accept or reject the options per se.

This distinction between the direct and indirect role for values can be seen in Heil 1983. Heil points out that motives or incentives for accepting empirical claims should not be conflated with reasons that provide "epistemic *support*" for those claims (755). In other words, while values may provide a motivation to believe a claim, values should not be construed as providing epistemic support for a claim. Values are not the same kind of thing as evidence, and thus should not play the role of providing warrant for a claim. Yet we can and do have legitimate motives for shifting the level of what counts as *sufficient* warrant for an empirical claim. Even as Heil warns against the self-deceptive, motive-driven use of values in support of empirical claims, he notes,

> There are many ways in which moral or prudential considerations can play a role in the factual conclusions one is likely to draw or the scientific pronouncements one may feel entitled to issue. We regard it as reasonable to require that a drug possessing an undetermined potential for harm pass rather more stringent tests than, for example, a new variety of hair tonic, before it is unleashed on the public. In such cases, however, we seem not to be tampering with ordinary evidential norms, but simply exercising reasonable caution in issuing judgments of safety. (761)

A footnote in Heil's essay elaborates this point: "One checks the oil and water in one's automobile with special care before setting out on a long journey. This is not because one needs more evidence about one's automobile in such cases than in cases in which one is merely driving across town. It is rather that there is a vast difference in the consequences of one's being wrong" (761n12) The indirect role is on display here, as the consequences of error come to the fore in the indirect role. Thus, the epistemic agent is concerned with whether the evidence is sufficient for supporting a claim that if wrong would prove a deleterious basis for further decisions (like deciding to drive one's car on a long journey or marketing a new drug).

In what particular instances do values legitimately play their distinct roles? First, there are important limits on the direct role for values in science. There are many choices made in science, particularly at the heart of the scientific process, where no direct role for values is acceptable. If we do indeed care about gaining reliable knowledge of the world, it is crucial to keep these limits on values in science. Second, these limits on the role of values in science hold regardless of whether the values we are considering are ethical, social, or cognitive. All of these values can have direct or indirect roles in science, and all must keep to the limits I will describe below. Thus, maintaining a distinction in the *kinds* of values to be used in science is far less important than maintaining a distinction in the *roles* those values play.

## *Direct Roles for Values in Science*

There are several points in the scientific process where a direct role for values is needed. At these points, values can and should direct our choice, telling us which option should be pursued. Values serve an important function in the direct role, particularly for the early stages of a research project, one that should not be overlooked in discussions of the nature of science. In fact, they have been increasingly acknowledged over the past fifty years, as concerns over which projects to pursue and how to ethically utilize human subjects have increased. The proper direct role for values in science has never been a source of worry for philosophers of science, even for those who hold to the value-free ideal.[10]

The first point for a direct role for values is in the decision of which scientific projects to undertake. There are a far larger number of possible scientific studies than can actually be pursued. How we select which ones to pursue is a complex process, a combination of which projects scientists deem feasible and interesting, which projects government and/or private interests think are worth funding, and which projects are ethically acceptable. In these decisions, values play a direct role in shaping scientists' choices, the values serving to weigh the options before the scientist. A scientist may wish to study the migration patterns of whales, for example, because he or she cares about the whales and wants to understand them better in order to improve protections for them. The value (perhaps ethical, perhaps social) the scientist places on the whales is the reason for the scientist's interest, directing the choice. Another scientist may pursue a particular study of a chemical substance because of what that study may reveal about the nature of chemical bonding, a topic pursued purely for the interest in the subject irrespective of any applications. The value scientists place in their intellectual interests is sometimes the primary reason for the choice.

Funding decisions in science also embody the direct role of values. We choose to fund areas of research about which we care to know more. The government may fund a project studying the possibility of increased photovoltaic cell efficiency because the grant administrators consider any increase in efficiency to be important to the country's future energy security and economic development. The social value the administrators place on energy security and economic development directs the kinds of projects they fund. Other values more central to cognitive concerns may drive the funding of other studies, to increase the scope of a particular area of study or to test the predictive precision of a new theory. Thus, ethical, social, and cognitive values help scientists decide where to direct their efforts and are reflected in both funding decisions and the scientists' own choices.

Once one has selected a particular area of research and which question to attempt to answer, one must decide which methodology to pursue, and here concerns over the ethical acceptability of a methodology will directly shape scientific decisions. If the chosen methodological approach involves flatly unethical actions or treatment of others, the approach should be rejected. The ethical values can legitimately direct the selection of methodologies, particularly when human subjects are involved. For example, a scientist may wish to use human subjects in a physiological study that would expose those subjects to substantial risk of injury. The internal review board for the project may decide that the methodology as laid out by the scientist is unethical, and require the scientist to change the approach to the subjects of the study, or perhaps even to scrap the study altogether. Here an ethical value (a concern over the treatment of human subjects) directs the way in which a study will be conducted, and even if it can be conducted.

There can be conflicts among values for these choices about methodology. Consider this admittedly extreme example. It would be very evidentially useful to test pesticides on humans, particularly a large pool of humans in controlled conditions over a long period of time. However, despite the cognitive advantages of such a testing procedure (including the possibility for precise testing of a theory), there are some serious ethical and social concerns that would recommend against this testing procedure. It is very doubtful one could obtain adequate volunteers, and so coercion of subjects would be useful for the study, but ethically abhorrent. Both social and ethical values stand against such a study, for it is doubtful society would approve of such a testing regimen, and very likely a social outrage against the scientists would be expressed when word of the study got out. (An outcry was heard recently against a much less controlling study involving following the exposures to and health of children in families using pesticides in Florida. Imagine if the experimental subjects were exposed against their will.)[11] However, such a test would provide far greater precision to predictions about the health effects of pesticides. So, despite the cognitive value of such a test, the conflicting ethical and social values would overrule that value.

In these examples, the relevant values (social, ethical, and cognitive) act in the direct role, providing reasons for the choices made. If the methodology proposed is unethical, it cannot be pursued by the scientist. If the project proposed is not desired by funders, it will not receive funding support. If a project is not interesting to scientists, they will not pursue it.[12] Conversely, a more ethical methodology, a socially desired research program, a cognitively interesting project, will be selected because of the value placed on those options. The values are used to weigh the options available, determining whether they are acceptable and which is preferable.

Not all direct roles for values in these early stages of science should be acceptable, however. One cannot use values to direct the selection of a problem and a formulation of a methodology that in combination predetermines (or substantially restricts) the outcome of a study. Such an approach undermines the core value of science—to produce reliable knowledge—which requires the possibility that the evidence produced could come out against one's favored theory. For example, suppose a scientist is studying hormonal influences on behavior in children.[13] It is already known that (a) there are hormonal differences in children, and (b) there are behavioral differences in children. A study that simply measures these two differences to find a correlation would be inadequate for several reasons. First, a mere correlation between behavior and hormones tells us little about causation, as we also know that behavior can change hormone levels. Second, we know there are other important factors in behavior besides hormones, such as social expectations. A study that merely examines this one correlative relationship only tells us something interesting against a backdrop of a presumption that hormones determine behavior. If one assumes this going in, deliberately structures the study so as to exclude examination of other possibilities, and then claims the results show that hormones determine behavior, values have played an improper direct role in the selection of research area and methodology. For by valuing the support of the scientist's presumptions in developing the project, the scientist has distorted the very thing we value in science—that it can revise itself in the face of evidence that goes against dearly held theories. By making choices that preclude this, the scientist has (deliberately or inadvertently) undermined a crucial aspect of the scientific endeavor.

Therefore, a direct role for values in the early stages of science must be handled with care. Scientists must be careful that their methodology is such that it can genuinely address the problem on which they have chosen to focus, and that they have not overly determined the outcome of their research. Research by feminist scholars of science has made clear how difficult this can be for individual scientists—that often the underlying presumptions that structure an approach (and may well predetermine the outcome) are opaque to the individual scientist. It is for this reason that calls for diversity in scientific communities are so important, for having colleagues coming from diverse backgrounds can make it easier for someone in the community to spot such problems (Longino 1990, 197–94; Wylie 2003; Lacey 2005).

Nevertheless, we are all human, and there are no sure-fire ways to guarantee that we are not subtly presuming the very thing we wish to test. The best we can do is to acknowledge that values should not direct our choices in the early stages of science in such a pernicious way. As philosophers of science continue to push into this murky territory, some additional theoretical clarity on the relationship between research project selection and methodology formulation may be forthcoming. For now, let us note that allowing a role for direct values in these early stages of science should not be taken to include a direct role that undermines the value of science itself.

Even with this additional complexity on the table, it remains clear that some direct role in the early stages is acceptable, and that the full range of values (cognitive, ethical, and social) are relevant. Yet this direct role must be limited to the stages early in science, where one is deciding what to do and exactly how to do it. Once the study is under way, any direct role for values must be restricted to unusual circumstances when the scientist suddenly realizes that additional direct value considerations need to be addressed. For example, the scientist may come to understand that the chosen methodological approach, once thought acceptable, actually is ethically unacceptable, and that some modification is needed. This issue arises with medical studies that encounter unexpected adverse effects among test subjects. Such a reconsideration of methodologies, or of the stated purpose of a study, is the only acceptable direct role for values in science during the conduct of the study. Otherwise, values must be restricted to an indirect role.

Why would a direct role for values be consistently problematic in the later stages of science? Consider what would be acceptable reasoning if a direct role for values were allowed in the heart of doing science—during the characterization of data, the interpretation of evidence, and the acceptance of theories. A direct role for values in the characterization of data would allow scientists to reject data if they did not like it, if, for example, the data went against a favorite theory. The value the scientists placed in the theory could override the evidence. A direct role for values in the interpretation of evidence would allow values to have equal or more weight than the evidence itself, and scientists could select an interpretation of the evidence because they preferred it cognitively or socially, even if the evidence did not support such an interpretation. And if values were allowed to play a direct role in the acceptance or rejection of scientific theories, an unpalatable theory could be rejected regardless of the evidence supporting it. For example, it would be legitimate to reject a theory of inheritance that was politically unacceptable solely for *that* reason (as is the standard understanding of the Lysenko affair).[14] Or one could reject the Copernican theory of the solar system solely because it contravenes church doctrine, and ignore the evidence that supports the theory on the grounds that the theory is socially or ethically undesirable.[15] These problems are not just limited to social values in a direct role; they hold for cognitive values as well. We do not want scientists to reject theories solely because they are not simple, not as broad in scope as their competitors, or seem to have less explanatory power.

If we allowed values to play a direct role in these scientific decisions, we would be causing harm to the very value we place in science, the very reason we do science. We do science because we care about obtaining a more reliable, more true understanding of the world. If we allow values to play a direct role in these kinds of decisions in science, decisions about what we should believe about the world, about the nature of evidence and its implications, we undermine science's ability to tell us anything about the world. Instead, science would be merely reflecting our wishes, our blinders, and our desires. If we care about reliable knowledge, then values cannot play a direct role in decisions that arise once a study is under way. The potential for these disturbing possibilities underlies the worry that motivates support for the value-free ideal.

Despite these valid concerns about a direct role for values in science, an indirect role for values in science is still open at the heart of doing science. Such a role does not undermine the purpose of science. The value-free ideal is too strict, excluding needed ethical and social values from a legitimate indirect role, and thus preventing scientists from fulfilling their moral responsibilities to fully consider the consequences of error. The value-free ideal is also too lax, bringing in cognitive values in a way that is often too permissive, allowing them to potentially play a direct role. A better ideal is to restrict values of all kinds to an indirect role at the core of the scientific process.

## *Indirect Roles for Values in Science*

The indirect role for values in science concerns the sufficiency of evidence, the weighing of uncertainty, and the consequences of error, rather than the evaluation of intended consequences or the choices themselves. Values should be restricted to this indirect role whenever the choice before a scientist concerns a decision about which empirical claims to make. If we value having a better understanding of the world, we do not want values *of any kind* determining the empirical claims we make. Our values, whether social, ethical, or cognitive, have no direct bearing on the way the world actually is at any given time.[16] Thus, when deciding upon which empirical claims to make on the basis of the available data or evidence, values should play only an indirect role.

Choices regarding which empirical claims to make arise at several points in a scientific study.

From selecting standards for statistical significance in one's methodology, to choices in the characterization of evidence during a study, to the interpretation of that evidence at the end of the study, to the decision of whether to accept or reject a theory based on the evidence, a scientist decides which empirical claims to make about the world. At each of these decision points, the scientist may need to consider the consequences of error. If there is significant uncertainty and the consequences of error are clear, values are needed to decide whether the available evidence is sufficient to make the empirical claim. But note that values in the indirect role operate at the margins of scientific decisionmaking rather than front and center as with the direct role. Values weigh the importance of uncertainty, but not the claim itself. Evidence has a stronger role in determining the claims we make, with improved evidence reducing the uncertainty and thus the need for values. This should be the case for all kinds of values in science, whether cognitive, ethical, or social, when deciding upon empirical claims.

First, let us consider the indirect role for values in methodological choices. As noted above, values can play a legitimate direct role in methodological choices, excluding ethically unacceptable methodological approaches. Care must be taken that values do not play a pernicious direct role, where research agenda and methodology serve to decide the outcome of research projects beforehand. In addition to these direct roles, there is also an indirect role for values in methodological choices. For example, the deliberate choice of a level of statistical significance is the choice of how much evidence one needs before deciding that a result is "significant," which usually is the standard to be met before a claim is taken seriously. This choice sets the bar for how much evidence one will demand, thus establishing the burden of proof. It requires that one consider which kinds of errors one is willing to tolerate.

For any given test, the scientist must find an appropriate balance between two types of error: false positives and false negatives. False positives occur when scientists accept an experimental hypothesis as true and it is not. False negatives occur when they reject an experimental hypothesis as false and it is not. Changing the level of statistical significance changes the balance between false positives and false negatives. If a scientist wishes to avoid more false negatives and is willing to accept more false positives, he or she should lower the standard for statistical significance. If, on the other hand, the scientist wishes to avoid false positives more, he or she should raise the standard for statistical significance. For any given experimental test, one cannot lower both types of error; one can only make trade-offs from one to the other. In order to reduce both types of error, one must devise a new, more accurate experimental test (such as increasing the population size examined or developing a new technique for collecting data).[17] While developing a more accurate experimental test is always desirable, it is not always feasible. It may be too difficult or expensive to expand a study population, or there may be no better way to collect data. Within the parameters of available resources and methods, some choice must be made, and that choice should weigh the costs of false positives versus false negatives.

Weighing those costs legitimately involves social, ethical, and cognitive values. For example, consider the setting of statistical significance levels for an epidemiological study examining the effects of an air pollutant on a population. A false positive result would mean that the pollutant is considered a health hazard when in fact it is not. Such a result would lead to unnecessary alarm about the pollutant and the potential for costly regulations that would help no one. In addition, scientists may mistakenly believe that the pollutant is dangerous at that exposure level, thus distorting future research endeavors. A false negative result would mean that the pollutant is considered safe at the measured exposure levels when in fact it is not. Such a result could lead to people being harmed by the pollutant, possibly killed, and scientists would more likely fail to follow up on the research further, having accepted the false negative result. The social and ethical costs are the costs of the alarm and the regulation on the one hand, and the human health damage and resulting effects on society on the other. The cognitive costs include the mistaken beliefs among scientists that shape their future research. How to weigh these costs against one another is a difficult task that I will not attempt here. However, some weighing *must* occur. All these kinds of values are relevant to the choice of statistical significance.[18]

Once the scientist has selected a particular methodological approach, including the level of statistical significance sought, the research project begins in earnest. In the collection and characterization of data, the scientist hopes that all goes as planned, and that no difficult cases arise requiring further judgment. However, this is not always the case. Often, scientists must decide whether an experimental run is a good one, whether to include it in their final analysis of the data or to throw it out. Robert Millikan, when performing his Nobel Prize–winning oil-drop experiment to measure the charge of an electron, had to decide which experimental runs were reliable and which were not. He discarded many runs of the experiment (Holton 1978). Sometimes scientists must also decide how to characterize an event or a sample. For example, if one is looking at a rat liver slide and it appears abnormal, is it in fact cancerous, and is the cancer benign or malignant? Experts in a specialized field can have divergent judgments of the same slides (Douglas 2000, 569–72). In cases where data characterization is uncertain, which errors should be more assiduously avoided?

Depending on the study, different kinds of values are relevant to weighing these errors. If one is looking at a toxicological study assessing the impact of a chemical on test animals, one must decide how to characterize tissue samples. Clear cases of disease should, of course, be characterized as such, as well should clear cases of healthy tissue. To not do so because one prefers not to see such a result is to allow values to play an unacceptable direct role at this stage, thus undermining scientific integrity and basic epistemic standards.

But there are often unclear cases, borderline cases where expert disagreement occurs and there is substantial uncertainty. How to characterize these cases? Eliminating them from the study reduces the sample size and thus the efficacy of the study. Characterizing the borderline cases as diseased to ensure that no diseased samples are missed is to worry about false negatives and the harmful effects of an overly sanguine view of the chemical under study. Characterizing borderline cases as not diseased ensures that no healthy tissue is mischaracterized as diseased, and will ensure a low number of false positives. This approach reflects worries about the harmful effects of having an overly alarmist view of the chemical under study. To split the difference between the two is to attempt to hold the value concerns on both sides as being equivalent.[19] The valuation of the consequences of error is relevant and necessary for making a decision in these uncertain cases. When one has judgment calls to make at this stage, values are needed to characterize data to be used in later analysis, although most scientists would prefer there be no borderline cases requiring a judgment call.

Finally, once the data has been collected and characterized, one needs to interpret the final results. Was the hypothesis supported? What do the results mean? Whether to accept or reject a theory on the basis of the available evidence is the central choice scientists face. Often, the set of evidence leaves some room for interpretation; there are competing theories and views, and thus some uncertainty in the choice. The scientist has a real decision to make. He or she must decide if there is sufficient evidence present to support the theory or hypothesis being examined.

As Rudner and others argued decades ago, the scientist should consider the consequences of error in making this choice. The implications of making a wrong choice depend on the context, on what the empirical claim is, and the implications of the claim in that context. In our society, science is authoritative and we can expect (even desire) officials to act on the basis of scientific claims. So the implications of error include those actions likely to be taken on the basis of the empirical claim. Such actions entail social consequences, many of which are ethically important to us. Therefore, social and ethical values are needed to weigh the consequences of error to help determine the importance of any uncertainty. Note that this role is indirect—it is only in the importance of the uncertainty that the values have any role to play.

Given the need for moral responsibility in accepting or rejecting empirical claims, it is clear that social and ethical values can and should play an important indirect role in these scientific choices. But what about cognitive values? Should we consider their role to be direct or indirect in these choices? It might seem at first that their role is direct, for do not scientists choose a particular interpretation of data because it has explanatory power? However, simply because a theory has explanatory power is not a good reason on its own to accept that theory. Any "just-so" story has plenty of explanatory power, but we do not think Rudyard Kipling's explanatory tales, for example, are true or empirically reliable. Lots of theories have explanatory power but are still false, unreliable guides for understanding and making choices in the world. The explanatory power of Aristotle's geocentric universe did not make it true, nor did the explanatory power of phlogiston or ether save them from the dustbin of science.

Similarly, simplicity, scope, fruitfulness, and precision are also not reasons on their own to accept a theory. Occam's razor notwithstanding, a simple theory may not be a true or reliable one. A simple theory, though elegant, may just be wishful thinking in a complex world. A theory with broad scope may not be a true one. Diverse phenomena may not fall under the confines of one theory. A fruitful theory, leading to many new avenues of research, may prove itself false over time, even if it spurs on research. Even a theory that makes a precise prediction may not be a true one. Recall Kepler's model of the heavens as structured by platonic solids. It made rather precise predictions (for its time) about the spacing of the planets, but is now thought to be a quirky relic of the seventeenth century. None of these cognitive qualities increase the chance that a theory is reliable, that its acceptance is the right choice.[20] So what is the value of these cognitive values?

Despite the implausibility of a legitimate direct role for cognitive values, the presence of cognitive values aids scientists in thinking with a theory that exemplifies cognitive values. Thus, a theory with such values is easier to work with, to use, and to develop further. But the importance of this ease is not to make the scientists' work less demanding. Rather, it means that a theory reflecting cognitive values will be more likely to have its flaws uncovered sooner rather than later. Cognitive values are an insurance policy against mistakes. They provide a way to hedge one's bets in the long term, placing one's efforts in theories that, if erroneous, their apparent acceptability will not last long. Thus, scientists should care about cognitive values because of the uncertainties in scientific work, not because one really wants simpler, more broadly scoped, more fruitful theories for their own sake. If more evidence arises that reduces uncertainty in the choice, cognitive values become less important. A simpler or more explanatory theory with lots of evidence against it is not very attractive. A more complex theory with lots of evidence for it is attractive. (Hence, the demise of the simpler DNA master molecule theory in favor of a far more complex understanding of cellular interactions.) Cognitive values in themselves are no reason to accept or reject a theory, just as social and ethical values are no reason in themselves to accept or reject a theory. Cognitive values serve an indirect rather than a direct role in these choices, helping to mitigate the uncertainties over the long term.

Let us consider a general example to make this point clearer. Suppose one has a choice between (1) a theory with broader scope and explanatory power for a range of contexts and examples, and (2) a theory with narrower scope and similarly constrained explanatory power. The evidence for the narrower theory is slightly better than the evidence for the broader theory, but only slightly. Suppose we are working in a very theoretical area of science with no practical implications for error. A scientist would be wise to choose the broader scoped theory because with more areas for application one is more likely to find problems with the theory sooner rather than later. Similarly, a theory that makes precise predictions rather than vague ones will more likely expose errors sooner.

In sum, cognitive, ethical, and social values all have legitimate, indirect roles to play in the doing of science, and in the decisions about which empirical claims to make that arise when doing science. When these values play a direct role in the heart of science, problems arise as unacceptable reasoning occurs and the reason for valuing science is undermined. When values conflict in the indirect role, they must be weighed against each other. A brief account of one of the major medical mishaps of the twentieth century will help to illustrate this understanding of values in science.

## *Diethylstilbestrol (DES): Cognitive, Social, and Ethical Values in Practice*

In 1938, a new compound was discovered that acted like estrogen but was much cheaper to produce and easier to administer. Diethylstilbestrol, or DES, was an exciting discovery in a period of intensive research into human hormones and how they influence human health. Researchers at the time believed that many "female problems" were due to a lack of sufficient female hormones, and thus the appearance of DES seemed a boon to those seeking to treat these female problems, which included menopause, mental health issues, venereal diseases, and miscarriages. By 1947, the FDA had approved DES for all of these medical uses.[21]

Yet there were reasons to believe that the use of DES, particularly in pregnant women, was risky. It was known that DES caused birth defects in animal studies, and it was known that it crossed the placental barrier. So why would scientists think using DES to prevent miscarriages would be a good idea? Some researchers had measured a drop in female hormones in the month before a problem arose in pregnancy. The prevalent view held that men and women were essentially biologically different and that hormones dictated much of this difference. If women experienced a drop in essential female hormones, it was little surprise to scientists of the time that the women would be unable to perform the essential female function of bearing children. The biological essentialism of the day, reflected in this theory of how hormones played a role in childbearing, was reinforced by the social norms of the day, that women and men should play very different social roles because of their biological differences. A decline in female hormones in a pregnant woman would understandably undermine the quintessential female function—childbearing. Thus, social norms and values reinforced the apparent explanatory power and simplicity of the overriding theory, that female hormone levels must be maintained at a high level for a successful pregnancy. Under this view, an estrogen imitator like DES would be naught but beneficial for any pregnant woman. By the early 1950s, tens of thousands of pregnant women in the United States were taking DES every year to assist with their pregnancies. The reasons and evidence to be concerned about DES were largely ignored.

In 1953, a careful controlled study was published which showed that DES produced no reduction in the number of miscarriages (Dieckmann et al., 1953). Despite this new evidence, many researchers refused to accept the study's implications and the FDA did not change its stance on DES. It just made sense to many scientists that DES was good for pregnant women. Earlier studies had lent some credence to the theory of DES's benefits for pregnant women, but none were as carefully done as the contravening 1953 study. However, there were theoretical reasons to reject the 1953 study. It was argued that the 1953 study did not have enough of a focus on high-risk pregnancies, even though the drug was being prescribed for many other pregnancies, and it went against the theory that female hormones were essentially good for female functions. In addition, no other drug was available at the time to help reduce miscarriages; bed rest was the main alternative. It was not until the early 1970s, when evidence emerged that DES could cause a rare and dangerous cancer in the female children of DES mothers, that DES was withdrawn for use for pregnant women.

In the face of substantial uncertainty, all three kinds of values played a role in helping scientists decide what to make of the available evidence in 1953. First, cognitive values reinforced belief in the beneficial efficacy of DES. If one believed that estrogen was the hormone that made everything work well for women, then more estrogen, even artificial estrogen like DES, would improve the womanliness of an expectant mother, thus increasing the health of the baby. Having a simple model of sex and hormones led some scientists to believe that DES was necessarily good for women.[22] In addition, the simple model of hormone function also seemed to have great explanatory power, allowing scientists to understand a range of gender differences. Thus, the theory that DES was good for pregnant women and their babies was supported by the cognitive values of simplicity, scope, explanatory power, and consistency with other theories of the day. Second, social values also seemed to support the use of DES. Beliefs about hormones bolstered faith in the social structure of the 1950s, and vice versa. If women's functioning was essentially determined by their hormones, then women were essentially different from men, and rigid gender roles were appropriate. In addition, if human gender roles were hormonally determined, then it seemed obvious that DES aided women in becoming even better women. The social value of stability in fixed gender roles lent credence to the idea that DES was good for women. Third, ethical values weighed in on both sides. If scientists pushed the use of DES and were wrong, women and their children would be harmed (as they in fact were). If scientists failed to push DES and it was beneficial, a valuable tool for pregnant women would be overlooked, and again women who wanted children and their miscarried fetuses would be harmed.

What does this episode tell us about these values in scientific reasoning? First, it illustrates nicely the way in which cognitive and social values can be mutually reinforcing. The social values of the day bolstered the apparent cognitive values of the theory in use, that female hormones are good for what ails women. The explanatory power of DES as good for women increased when one considered the socially prevalent gender roles, as the hormonal essentialism that explained the success of DES also explained the dichotomous gender roles found in society. And the apparent helpfulness of DES for pregnant women (based on anecdotal evidence or studies without controls) bolstered the sense of the essential gender differences pervasive in the social norms. As Rooney (1992) and Longino (1996) argue, the cognitive and the social can blur together.

Second, the case of DES demonstrates the dangers of using any values, cognitive or social, in a direct role for the acceptance or rejection of a hypothesis. The theory, that a lack in what makes a woman a woman (estrogen) was the cause of a problem in the essential function of womanhood (having children), had great explanatory power, scope, and simplicity. It also fit with the social norms of the day. Yet *neither* the cognitive values *nor* the social values are a good reason in themselves to accept the theory. Unfortunately, they seem to have played precisely such a direct role in this case. This is particularly apparent once the 1953 study appeared, and some key scientists preferred to continue to hold to their ideas about DES in the face of strong evidence to the contrary. Even if the cognitive values are divorced from social values, the explanatory power and simplicity of one's theories are still not good reasons to ignore evidence. The cognitive values competed with and trumped evidence in this case, as they should not.

Third, cognitive, ethical, and social values should play only an indirect role in the assessing of evidence and the choice of interpretation. Thus, the values should focus on the uncertainties in the case and help to weigh the sufficiency of evidence, not compete with the evidence. Ethical values should weigh the consequences of error in accepting or rejecting the theory underlying the use of DES to prevent miscarriages. Which is worse, to cause birth defects or to fail to use a method to prevent miscarriages? Given these potential consequences of error, what should the burdens of proof be for accepting or rejecting DES as a preventer of miscarriages? This is a difficult choice, and given such tensions, the scientist committed to pursuing DES as a treatment should (a) restrict the use of DES to high-risk cases only, and, in the meantime, (b) rely on cognitive values to hedge one's bets. The presence of cognitive values indicates which understanding of DES, if wrong, will be uncovered sooner, and should direct research efforts accordingly. Thus, the scientists should have used the noted simplicity and explanatory power to find flaws in the theory quickly; that is, they should have explored the implications of the underlying theory more rigorously, testing it for reliability in multiple contexts rather than relying on the theory *because* it was simple and had explanatory power. If this reasoning had been followed, either the use of DES by pregnant women would have been rejected (given the general weight of evidence by 1953 that DES did not help prevent miscarriages and that DES had the potential to cause substantial harm), or scientists who viewed the potential benefits as a strong enough reason to continue its use would have put more effort into determining the reliability of the underlying theory, and DES would have been pulled from the market long before the 1970s.

The scientists who supported DES use did not act in this way. Instead, the explanatory power, simplicity, and fit with social custom were taken as reasons for the correctness of the view. But values should not act as reasons in this manner; they should not be taken to provide warrant. It took decades for a more complex understanding of hormone functioning to emerge. The direct role for cognitive and social values hampered science and led to children being harmed by exposure to DES in the womb.

In sum, cognitive values should serve as heuristics to figure out how quickly and with what ease one might uncover an error. To think about cognitive values as indicators of reliability themselves is to make a serious error. Cognitive values themselves do not improve the likelihood that a choice is accurate or reliable. When present, they do indicate that one may discover a potential error more quickly than otherwise, *if* one pursues further research using the positive aids of the cognitive values to develop further tests of the theory.

Because cognitive values are no indicator of reliability, they should not function in the place of evidence, nor be on a par with evidence, just as social and ethical values should not function in that way. Both cognitive and ethical values function as ways to mitigate against uncertainty just in case one chooses incorrectly. Ethical values appropriately weigh the potential consequences of error, thus shifting burdens of proof to avoid the more egregious consequences. Cognitive values signal where error is more likely to be uncovered quickly by scientists, if error is present. Neither ethical nor cognitive values should play a direct role in deciding upon empirical claims. An indirect role, however, is pervasive and necessary, both to provide guidance when making judgments in the face of uncertainty and to meet the moral responsibilities of scientists.

## Conclusion: Value-Laden versus Politicized Science

Science is a value-laden process. From the decision to do science, to the decision to pursue a particular project, to the choice of methods, to the characterization and interpretation of data, to the final results drawn from the research, values have a role to play throughout the scientific process. We need social, ethical, and cognitive values to help weigh the importance of uncertainty and to evaluate the consequences of error. In addition to this indirect role for values in science, there is also a direct role, crucial to some decisions in science. The direct role must be constrained to those choices in the early stages of science, where one is not yet deciding what to believe from one's research or what empirical claims to make. Once a scientist has embarked on the course of research, the indirect role for values should be the only role for values, whether social, ethical, or cognitive. To admit of a direct role of values in these later stages is to violate the good reasoning practices needed to obtain reliable knowledge about the world.

This distinction between the two roles for values in science allows for a clearer understanding of the concern over the politicization of science. In the cases of politicized science, the norm against a direct role for values in the decisions about empirical claims is violated. When scientists suppress, or are asked to suppress, research findings because the results are unpalatable or unwelcome, values are playing a direct role in the wrong place in science. When scientists alter, or are forced to alter, the interpretations of their results because they are unwelcome by their funders or their overseers, values again are playing an unacceptable, direct role.

In both of these kinds of cases, values are directing what we think, rather than helping us grapple with uncertainties. It is one thing to argue that a view is not sufficiently supported by the available evidence. It is quite another to suggest that the evidence be ignored because one does not like its implications. In the former case, we can argue about the quality of the evidence, how much should be enough, and where the burdens of proof should lie. These are debates we should be having about contentious, technically based issues. In the latter case, we can only stand aghast at the deliberate attempt to wish the world away. Allowing a direct role for values throughout science is a common way to politicize science, and to undermine the reason we value it at all: to provide us with reliable knowledge about the world.

The conceptual structure I have described in this chapter thus allows for a clear distinction between value-laden and politicized science. All science is value laden. But unacceptable, politicized science occurs when values are allowed to direct the empirical claims made by scientists. This understanding of values in science also addresses the concerns that underlie the value-free ideal. Values should never suppress evidence, or cause the outright rejection (or acceptance) of a view regardless of evidence. The classic cases of Galileo and Lysenko fall into unacceptable uses of values in this framework. By distinguishing between direct and indirect roles for values, the fundamental integrity of science is protected.

Science is saturated with values, and not only in the real and imperfect human implementation of scientific ideals. Values are needed in the indirect role to assess the sufficiency of evidence. There may be cases of scientific research where only cognitive values are relevant to these assessments, but these cases are merely simplified instances of the norms I have articulated (only one general kind of value is relevant rather than all kinds) rather than an ideal for which scientists should strive. Such “pure science” is the special case of science without clear ethical or social implications, one that can switch rapidly to the more general case when research scientists suddenly find themselves facing social implications. The new ideal I have articulated here should cover *all* of science. The importance of values in the heart of science decreases with decreasing uncertainty, but as long as science is inductively open, uncertainty is ineliminable, and thus so are values.

So science is saturated with values in the ideal—any ideal which claims for science a value-free zone in principle is an inadequate and incomplete ideal. This conclusion seems to leave us in a quandary. For so long, we have been convinced that the value-free nature (or ideal) of science was what made it valuable. Being value free gave science its objectivity; being value free gave science its superior ability to resolve disputes over contentious empirical issues. But the objectivity of science does not fall with the rejection of the value-free ideal. Value-saturated science can still be objective, as we will see in the next chapter.