2006

Evaluating Miriam Solomon's social empiricism: The Environmental Endocrine Hypothesis

Robby Joseph Burleigh
Louisiana State University and Agricultural and Mechanical College

EVALUATING MIRIAM SOLOMON'S SOCIAL EMPIRICISM: THE ENVIRONMENTAL ENDOCRINE HYPOTHESIS

A Thesis
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Philosophy and Religious Studies

by
Robby J. Burleigh
B.G.S., Louisiana State University, 2002
December, 2006

TABLE OF CONTENTS

ABSTRACT

Throughout the history of science, philosophers and scientists alike have sought to codify a set of rules that would guarantee those who practice science success. These rules, if followed faithfully, would eliminate the guesswork from science, and instead, mold the practice of science into a rule – governed enterprise. Many philosophers of science have attempted to generate the rules that would govern successful scientific practice; however, with no success.

Miriam Solomon attempts to give scientists heuristic advice by using a naturalistic approach in which she uses various case studies throughout the history of science to illustrate her approach. The core of Solomon's ideas surrounds her use of decision vectors, or those things that lead scientists to accept or reject a particular theory. Decision vectors can come from empirical data, or are based on conceptual biases, and are termed either empirical decision vectors, or non – empirical decision vectors.

I use Solomon's guidelines and apply them to a case study in an attempt to demonstrate that her heuristic advice ought to be developed further if it is to proceed successfully. The Environmental Endocrine Hypothesis was developed by a group of scientists trying to establish a connection between chemical effluents leaching out into the environment and abnormal development in some species of animals.

I have shown that Solomon's suggestions need to be developed further if they are to provide heuristic advice to scientists in the manner in which she strives. Solomon leaves unaddressed problems dealing with conceptual vagueness, such as when it is not clear if a decision vector is empirical or non – empirical. Moreover, though she says that the magnitude of non – empirical decision vectors does not figure in their tally, I have

shown that her project cannot proceed unless she provides a clearer method for determining a strong ranking method for non – empirical decision vectors. To avoid making too hasty a mistake, I have refrained from making suggestions on the direction she should take in order to begin addressing some of the ambiguities present I this particular project.

CHAPTER 1
INTRODUCTION

1.1 Overview of the Thesis

In this thesis I discuss a philosophical problem concerned with scientific theory appraisal. The problem arises when scientists working in groups develop several theories that appear to fit the available data. The question is how those scientists decide which particular theory they choose to endorse. Recent philosophical work has highlighted the potential influence of values in theory appraisal. Furthermore, it has attempted to distinguish between those values that are truth-conducive and those values that bear no relevance to the truth or falsity of a theory (though they may be just as influential in the actual process of theory appraisal).

I evaluate theory appraisal in the light of Miriam Solomon's recent book titled *Social Empiricism* and use the Environmental Endocrine Hypothesis (EEH) as a case study for applying and evaluating Solomon's suggestions regarding theory appraisal. The EEH is a hypothesis that suggests there may be certain chemicals that leach out into our environment and cause the endocrine systems of many animals and humans to function improperly. More precisely, I will focus my analyses on the evidence and the values associated with the EEH and the problems classifying these factors using Solomon's framework. Solomon suggests that we acknowledge that theory appraisal is unavoidably value-laden. Nevertheless, she claims that it is crucial to distinguish those values that are based on empirical data from those that are not. Solomon uses the terms 'empirical decision vectors' and 'non-empirical decision vectors' to refer to these sets of values. The number and distribution of these different kinds of decision vectors is crucial to

appraising competing theories in Solomon's scheme, and it is this particular ordering process that I will be discussing in my paper.

In Section 2 of my thesis, I discuss Solomon's suggestion that science is a social pursuit, and that theory appraisal proceeds within a community of scientists; this is the "social" aspect of social empiricism. I then discuss in further detail Solomon's ideas regarding the "empiricism" part of social empiricism. In section 3, I discuss the EEH more specifically and then plug the EEH into Solomon's framework. Section 4 illustrates the problems I find with Solomon's suggestions. I emphasize the problems encountered when trying to classify decision vectors as empirical or non-empirical. I will also argue that problems arise when trying to weight the influence of each individual decision vector, and that this creates problems for Solomon's program. In conclusion, I will make some suggestions on the future of research in theory appraisal and what some future problems may look like.

1.2 Putting Solomon in Context

Thomas Kuhn (1970, 1977) began a revolution in the philosophy of science by rejecting the logical positivist's view that science proceeds in an algorithmic manner free of any values. Rather, Kuhn proposes that science, and scientific theories, develops by adhering to certain criteria, or epistemic values. Values such as fit with the data and internal coherence are criteria that should be taken into account when appraising differing theories. Kuhn adds simplicity, fruitfulness, and scope to his list of values that a successful theory should possess. Since Kuhn enunciated his set of values that a successful theory should possess, other philosophers have added to the list with values

such as predictive accuracy, external coherence or fit with other accepted theories, and the ability to bring together several theories under one main theory.

Ernan McMullin (1983) also famously describes theory choice as dependent on value judgment. To avoid the objection that value judgment would simply make theory appraisal a matter of taste, McMullin distinguishes between epistemic values and nonepistemic values. Epistemic values are those values which indicate the truth or falsity of a theory. The nonepistemic values are those which are irrelevant to a theory's truth or falsity. For example, most contemporary scientists would regard a person's particular political beliefs or religious ideology as nonepistemic values. Similarly, Larry Laudan (1984) distinguishes "cognitive values" and "methodological rules" from "subjective preferences" and "moral values," while Helen Longino (1990) makes her distinction between "constitutive values" and "contextual values."

There is some debate concerning which values are epistemically significant. Bas van Fraassen (1985), for example, argues that a theory's fit with available data is the only major epistemic consideration for evaluating theories. Van Fraassen regards many of the other values that philosophers such as McMullin consider to be epistemic (e.g., fruitfulness) as pragmatic. He claims that pragmatic values do not directly bear on the truth of a particular theory; rather, they are scientific preferences for particular sorts of theories. Among van Fraassen's pragmatic virtues are consilience, ability to generate novel predictions, mathematical elegance, and simplicity. It should be noted here that van Fraassen does not deny that pragmatic virtues play a role in theory appraisal, he believes that the pragmatic virtues can play a role in the decision making process within the practice of science but they do not yield any epistemic information.

A major issue in late twentieth century philosophy of science is whether or not nonepistemic values can or should actually be eliminated from scientific reasoning. The claim that nonepistemic values cannot be eliminated from science revolves around several argumentative strategies. Helen Longino's (1990) argument provides a nice example of one such strategy. Longino claims that the so-called "contextual values" have to play a prominent role in theory appraisal because theories are always left underdetermined by the empirical evidence and therefore must fill in the gap by including nonepistemic, or "contextual values." Longino's perspective has faced strong opposition from those who believe that nonepistemic values should play no role in theory appraisal. One such claim is that even though logic and data alone cannot guarantee which theory to accept, there may be other epistemic factors that may fill the gap (e.g., McMullin 1983, Giere 2003). Another argument is to claim that scientists should not accept theories if the epistemic values alone do not guide them to do so (Giere 2003).

Like Longino, Miriam Solomon (2000) is skeptical of the notion that good science must involve a sharp contrast between "constitutive" and "contextual" values. Rather than using the language of epistemic and nonepistemic values, however, she coins the terms "empirical decision vector" and "non-empirical decision vector" to refer to the various factors that influence theory choice (see Section 2.2 for definitions of these terms). Based on social scientific research, she thinks it is unrealistic to think that scientists can operate without significant influence from non-empirical decision vectors. When scientists face a decision between two competing theories, Solomon proposes that the number of empirical and non-empirical decision vectors in favor of each theory be tallied up. She claims that the scientific community is appropriately ordered if research

effort is distributed proportionally to the number of empirical decision vectors that favor each theory. Moreover, she claims that there should be an equal number of non-empirical decision vectors in favor of each theory. The following section discusses Solomon's work in more detail.

CHAPTER 2
SOLOMON'S SOCIAL EMPIRICISM

2.1 The "Social" Element

Miriam Solomon writes in her recent work titled *Social Empiricism* that there are several major contemporary disputes concerning scientific reasoning. For Solomon, at the core of these disputes lie two major ideas. First, that scientists reason rationally, and second, that science is progressive. Solomon claims that philosophers typically end up on one side of the dispute, defending what she calls "Enlightenment orthodoxy," and sociologists influenced by Thomas Kuhn pushing relativism and constructivism. Solomon adds, "Historians and others in science studies were sometimes guided by philosophers, sometimes by sociologists of scientific knowledge and sometimes, in two-voiced narratives, by both" (Solomon 2001, 1). A crucial theme of Solomon's book is that those philosophers and sociologists actually share a similar framework when it comes to addressing the crucial questions that she raises.

Solomon argues that a very different framework is needed. By utilizing case studies, Solomon incorporates fresh ideas gleaned from "science studies disciplines in addition to philosophy and sociology of scientific knowledge, such as history of science, feminist science criticism, psychology of science and ethnographic studies" (Solomon 2001, 1). This results in a unique vantage point from which to assess scientific rationality and represents a major shift in thought about scientific change. In Solomon's view, the new epistemology of science, called social empiricism, replaces traditional models of scientific rationality and scientific progress, which have the *lone scientist* as their ideal, with a model of rationality and progress that focuses on the scientific community as a

group. Before an analysis of social empiricism, some recounting of the traditional views and "shared assumptions" of scientific rationality and scientific progress needs to be recounted.

Solomon believes that traditional Enlightenment ideas and those held by sociologists of scientific knowledge share the same framework, or point of reference. Chief among those "shared assumptions" as concerns scientific rationality[1] is the notion of individualism. Philosophers have typically regarded rational thinking as an ability that is attributable to the individual human being, and constitutive of their decisions. Solomon concludes that the debate between traditional philosophers of science and sociologists of scientific knowledge turns on how frequently individual scientists reason rationally. Solomon concludes the former "think irrationality is unusual, while the latter think that rational reasoning is unusual" (Solomon 2001, 2). Finally, Solomon concludes both parties to the debate "look at the causes of individual beliefs and draw conclusions about individual rationality" (Solomon 2001, 3).

Objectivity is the next "shared assumption" in Solomon's historical analysis of the traditional ideas in philosophy of science. Most people have traditionally thought that scientific rationality is free of any types of subjective biases or influences. The philosophers of science maintained this assumption by claiming that "cold cognitive processing," or thinking that is motivated only by the desire for "truth," are the proper elements of scientific reasoning. However, sociologists of scientific knowledge contend that all decisions are motivated by social factors or "hot cognitive" factors. The "hot

[1] Solomon thinks it necessary to distinguish scientific rationality from other kinds of rationality such as "acting in one's self-interest, commonsense reasoning, mathematical/logical reasoning", and furthermore, that it "is not important to equivocate on the use of the term when exploring one sense" (Solomon 153).

cognitive" factors would include social factors like peer pressure, ideology, and appeals to funding practices or affinities for emerging technologies.

Solomon contends that there is also an explicit assumption that rationality in scientific reasoning follows an explicit method or set of rules dictating the guidelines for rationality. Rules that underlie probabilistic reasoning or confirmatory practices are examples of the methods that the traditional philosophers of science who, it could be argued, took their cue from the Logical Positivist, would tend to construct. Sociologists of scientific knowledge argue against the methods approach by contending that rational scientific reasoning does not obey an explicit method or adhere to a preconfigured set of rules. Coincident with methods is the assumption that all scientific work considered rational is a product of the same method. Solomon coins this phenomenon the "generality assumption" and argues that the sociologists of scientific knowledge would reject this position for the same reasons they reject any attempt at isolating an explicit set of rules. On the other hand, Solomon says the traditional philosophers of science accept the "generality assumption." Solomon uses the same conceptual structure to trace the historical progression chronicling scientific progress as thought by traditional philosophers of science and the sociologists of scientific knowledge.

Truth was once thought to be the goal of science. That is to say that science progresses by accumulating truths; it is progressive. Solomon says that traditional sociologists of scientific knowledge "who find that there is scientific change without increased truth are skeptical of any claim that there is cumulative progress in science" (Solomon 2001, 5). If science does consist of the accumulation of truths, then it can also be said of it that it is objective. If a truth is to be objective then it must not be tainted by

any ideological or methodological biases. As Solomon says, "such truths are not socially constructed or negotiated, nor are they relative to the theory under consideration" (Solomon 2001, 5). Some philosophers of science who rejected realism continued to favor objectivity as a measurement of scientific rationality as long as it yielded no judgments that were open to the charge of relativism. The sociologists of scientific knowledge were leery of any claims of objectivity.

Consensus was a compelling force in traditional theories of scientific progress. This occurs when the entire scientific community embraces one theory. The traditional philosopher of science cited factors like significant empirical findings as rational causes for accepting a theory. The sociologist of scientific knowledge portrayed the acceptance of a theory as a product of the social and political influences upon the scientists.

Solomon also considers the linguistic aspects of scientific reasoning and claims that they consist of "explicitly stated explanations (which may be set out in traditional deductive form), propositions that claim to correspond to the world, derived predictions that claim to match observation reports" (Solomon 2001, 6). Not surprisingly, the traditional philosopher of science is going to argue for this approach, while the sociologists of scientific knowledge are going to remain skeptical of linguistic analyses, insofar as they neglect other social factors.

Solomon says the distinction that traditional philosophers of science draw between "pure science" and "applied science" is also noteworthy. The philosophers of science argue for the existence of a "clear demarcation between "pure" science and "applied" science (technology) (Solomon 2001, 6). They also claim there can be progress in one domain while no progress in the other domain. The sociologists of

scientific knowledge are reluctant to accept this argument and cite the vagueness in the concept of a "clear demarcation" as compelling.

Solomon's crucial point regarding the disputes between philosophers and sociologists is that they shared "individualistic" assumptions about the nature of scientific rationality and that these "shared assumptions about the nature of rationality and progress led to mirror image views of the nature of scientific change" (Solomon 2001, 6). She says that the traditional philosopher of science and the traditional sociologist of scientific knowledge are much closer in their arguments than they realize. In a nice analogy Solomon says "the child (SSK)[2] reacts against the parent (traditional philosophy of science) without changing the framework assumed by the debate" (Solomon 2001, 6).

In *Social Empiricism* Solomon uses contemporary case studies to show how these traditional viewpoints have failed and led to the widespread rejection of them. Indeed, Solomon says that "almost every assumption mentioned above has been jettisoned by at least one philosopher, historian, sociologist, feminist critic or anthropologist, and most by more than one" (Solomon 2001, 6). In particular, Solomon argues for abandoning the notion that scientific rationality is most properly understood to be associated with individual reasoning, as opposed to the product of the interaction of a group. I will look at Solomon's articulation of those factors that might compel one scientist to accept a theory while another scientist explicitly rejects that same theory. Solomon calls such decision making factors "decision vectors" and distinguishes between two specific types of decision vectors, the "empirical decision vector" and the "non-empirical decision vector." She insists that scientific rationality has to do with the distribution of these

[2] The abbreviation SSK here refers to 'sociologists of scientific knowledge'. The footnote is mine.

decision vectors across the entire scientific community (as opposed to their influence on individual scientists).

2.2 The "Empiricist" Element

Solomon argues that empirical success establishes scientific rationality. Under her construction of scientific rationality, truth follows, in some sense, from empirical successes, but her views on truth will not be a central focus of this thesis. Solomon is very concerned to acknowledge that there are non-empirical factors such as competitiveness or bias towards one's own data that may lead a scientist to prefer one theory over another. Moreover, these non-empirical factors may sometimes cause scientists to accept theories that are later regarded as substantially correct. Solomon thinks, "If motives, values, ideologies, and so forth can be conducive to scientific success, they deserve, no less than traditional values of science such as simplicity, fruitfulness, consistency, etc., the status of 'scientifically rational'"(Solomon 2001, 53).

Solomon is suggesting that these non-traditional values should not always be regarded as "biases," because they can encourage scientists to accept the "correct" theories at certain times. Thinking of those non-traditional values as biasing may prejudice scientists, so she suggests using the term "decision vectors" instead. "Decision vectors are so called because they influence the outcome (direction) of a decision," says Solomon (2001, 53). Furthermore, decision vectors do not always have to lead to scientific success, hence Solomon's insistence that they be given an epistemically neutral label; thus, she recommends preserving epistemic judgment until a "neutral description of decision-making" can be attempted (Solomon 2001, 54).

Solomon says the goal is not to eliminate the harmful decision vectors altogether, but to identify and organize them in hopes of achieving scientific success. The basis for the categorization of "decision vectors" as either empirical or non-empirical is fairly straightforward, says Solomon. "Empirical decision vectors are causes of preference for theories with empirical success, either success in general or one success in particular. Non-empirical decision vectors are other reasons for causes of choice" (Solomon 2001, 56). So, a scientist may favor a theory that supports the data collected from an experiment in which he was directly involved, while another theory may be able to account for the same body of data, thus exhibiting an empirical decision vector. Solomon provides examples of both empirical and non-empirical decision vectors; her list is "extensive, though incomplete" (Solomon 2001, 57).

The empirical decision vectors include those influences which, as the name suggests, come from empirical data. Salience of data, availability of data, a bias towards one's own data, and a preference for a theory which produces novel predictions are the empirical decision vectors that Solomon provides. These are also labeled as "cognitive biases" and reflect their "cold cognitive" counterparts, which is cognition that is free of emotional and/or motivational biases. Preference for a theory which produces novel predictions may not appear to be a type of bias, but Solomon assures us that "it is a preference that typically distributes research effort equally over theories with novel empirical success (Solomon, 2001, 57).

The list of non-empirical decision vectors are more concerned with biases that may come more directly from the social milieu in which a particular scientist may be engaged. Ideology, pride, conservativeness, radicalism, elegance, simplicity, and perhaps

the most influential non-empirical decision vector, the representativeness heuristic, competitiveness, peer pressure, deference to authority, and agreement with scripture are the major non-empirical decision vectors that Solomon lists. Non-empirical decision vectors such as pride, ideology, or conservativeness are fairly straightforward in their scope so I will not labor much on explaining them. The representativeness heuristic is perhaps the broadest non-empirical decision vector in scope, covering much experimental work in the domain of cognitive psychology and statistical reasoning. Solomon says that the representative heuristic "leads to preference for a theory that postulates a particular similarity between two domains based only on some other discovered similarity" (Solomon 2001, 58). This is non-empirical because the similarities between the two domains may not be predictive of similar empirical successes across the two domains.

In a clarifying remark Solomon says that "the basis for classifying decision vectors as empirical or non-empirical is itself empirical, *not* conceptual"[3] (Solomon 2001, 59). This is because it is possible that a non-empirical decision vector may become an empirical decision vector in some kinds of cases. For instance, "if simple could be shown to be empirically more successful than complex theories (either as a matter of logic or induction), then simplicity would count as an empirical decision vector" (Solomon 2001, 59). Likewise, it should be obvious that a non-empirical decision vector such as agreement with scripture is not likely to assist in the choice of an empirically more successful theory (Solomon 2001, 59). Emerging decision vectors such as birth order and gender ideology have recently been identified, but their roles in Solomon's theoretical framework have yet to be determined.

[3] The italics are the authors.

Solomon puts the number of decision vectors at around 50-100. They also interact with one another in various ways and "differ in magnitude from one another and from context to context" (Solomon 2001, 62). Furthermore, since Solomon's work focuses on the rationality of scientific decisions within the social context, she is "less interested in predicting the choice on individuals than in seeing how decision vectors are involved in the aggregated decisions of a community" (Solomon 2001, 63). Specifically, she claims that "if empirical decision vectors are distributed *equitably*, i.e., in proportion to the empirical success of the various theories under consideration, and non-empirical decision vectors are distributed *equally*, then, overall, the distribution of decision vectors will be equitable" (Solomon 2001, 77). In other words, Solomon believes that this distribution of decision vectors will cause the distribution of research effort to be ordered in accordance with the amount of empirical evidence that supports each theory. She insists that, even though one cannot realistically remove the influence of non-empirical decision vectors, one can "balance them out" by ensuring that an equal number support each side of a scientific dispute.

CHAPTER 3
SOLOMON AND THE ENVIRONMENTAL ENDOCRINE HYPOTHESIS (EEH)

3.1 Description of the EEH

Sheldon Krimsky describes the origins of the environmental endocrine hypothesis (EEH) in his book *Hormonal Chaos* (2000). The EEH arose out of emerging challenges to the cancer paradigm in toxicology, which has been dominant throughout the latter portion of the twentieth century. Newly discovered abnormalities found in the animal kingdom and among some humans in the 1980's and 1990's have not seemed fully consistent with the typical cancer paradigm. These effects often involve the development of secondary sexual characteristics, such as smaller-than-average testes, eggshell thinning, and abnormal sperm counts. Researchers hypothesized that something, perhaps an environmental toxin, could be mimicking certain hormones in organic beings, namely estrogen, and producing undesired effects (Krimsky 2000, 2).

The EEH "asserts that a diverse group of industrial and agricultural chemicals in contact with humans and wildlife have the capacity to mimic or obstruct hormone function – not simply disrupting the endocrine system like foreign matter in a watchworks, but fooling it into accepting new instructions that distort the normal development of the organism" (Krimsky 2000, 4). The EEH did not arise as a specific research path pursued by one or many scientists, nor was it the product of any one scientific discipline, like biochemistry or molecular biology. Rather, the EEH evolved from vast amounts of evidence gathered from many scientists engaged in multiple research paths from a variety of disciplines who did not have the EEH in mind as they were pursuing their own research (Krimsky 2000, 5).

British scientist Sir Charles Edward Dodds, professor of biochemistry at the University of London and fellow of the Royal Society, is the person credited with first synthesizing a synthetic estrogen, which he called stilbestrol, in 1938. Shortly thereafter, Dodds discovered that the hormonal function of animals and humans could be activated by stilbestrol administration in the same manner as if it were endogenous estrogen (Krimsky 2000, 6). Picking up where Dodds left off, two scientists in the Department of Zoology at Syracuse University published a paper in 1950 that received little attention at the time, but which in retrospect proved to be of great value in the formulation of the EEH. The research summarized by the paper centered on rats given daily injections of DDT and a control group given injections of chicken fat. It was discovered that the rats given the injections of DDT had smaller testes and prolonged development of secondary sex characteristics as compared to the control group (Krimsky 2000, 11). Evidence leading to the EEH began to slowly accumulate, but John McLachlan, a graduate student searching for dissertation topics would act as the catalyst that would catapult the EEH into the forefront of science.

McLachlan chose for his dissertation topic the transplacental effects of chemicals such as nicotine, caffeine, salicylate, and DDT to pregnant animals. The effects of DDT proved to be the most interesting to McLachlan, as the effects of DDT were the most salient on the uterus and the blastocyst. McLachlan gradually became more aware of wildlife studies concerning the estrogenicity of DDT. During his post-doctorate years, he began to study the long-term effects of DES (diethylstilbestrol) as an analog to DDT. McLachlan eventually organized the first symposium on estrogens and the environment

while acting as the head of the Developmental Endocrinology and Pharmacology section of the National Institute of Environmental Health Sciences (Krimsky 2000, 10).

DES, or diethylstilbestrol, was the estrogen synthesized by Sir Charles Dodds, and provided the most robust data up to this time for the EEH. DES was approved for a wide array of uses, from agricultural to medicinal, so there was no shortage of subjects to look to for evidence of exposure related phenomena. The FDA withdrew its approval for the administration of DES to women after it was discovered that some female offspring of women administered DES while pregnant had developed vaginal cancer in their 20's, an extremely rare occurrence. This development focused attention on other possible estrogenic substances and allowed researchers to use animal models that had previously been used to study effects of DES to study other possible environmental estrogens. Moreover, in 1972 the Food and Drug Administration withdrew all approval for DES in animals and animal feed (Krimsky 2000, 29).

Another pivotal figure in the development of the EEH is Rachel Carson, most noted for her landmark book on the environment, *Silent Spring* (1962) Carson compiled volumes of data from her observations that wildlife exhibited numerous adverse effects that could be explained by exposure to environmental toxins. Carson believed toxins like weedkillers, plasticizers, pesticides, and residues from some medications were finding their way into the environment and inserting themselves into the foodchain. Carson believed these toxins could harm the organs in the animals that were responsible for producing and regulating hormones, mainly estrogen, thus creating a buildup of this hormone and leading to different cancers. This is a thought the prevailing medical community now knows to be true.

Theo Colborn, a non-traditional scientist, is perhaps the person most credited with elucidating the EEH as it is known today (see e.g., Colborn et al. 1996). Colborn would eventually compile and synthesize data from a large and diverse variety of scientific disciplines and organize the data into a coherent package that formed the EEH. Colborn first began to formulate her opinions while serving with a team of scientists convened by the Conservation Foundation and the Institute for Research on Public Policy to study the environmental conditions of the Great Lakes region. From her research Carson was able to isolate several species in the Great Lakes region that displayed signs of reproductive abnormalities, yet found evidence of cancer in significantly fewer species. Colborn was then able to conclude that the animals in that region were not dying from cancer, but from other problems caused by something in the environment. After Colborn's work in the Great Lakes region had been completed, she had been contacted by Canada's minister of health to undertake a study of the human effects of the environmental toxins she found to be harming the wildlife in the Great Lakes region. Colborn's work eventually landed her a position at the W. Alton Jones Foundation as a senior fellow and finally had the freedom to perform her research without the constant worry of finding support for both her research, and her salary (Krimsky 2000, 29).

Colborn's efforts eventually resulted in the formation of the first Wingspread Work Session, a conference that would serve to be the watershed event in the path of the EEH. The most important contribution made by Wingspread was the formation of a consensus statement in which all the scientists in attendance were able to issue a single, coherent account relating their beliefs regarding the EEH. What came out of Wingspread

was the first detailed description of the EEH and laid out in great detail the future paths for further research.

3.2 Placing the EEH within Solomon's Framework

Recent scientific analyses of the environmental endocrine hypothesis (EEH) illustrate many of the themes found in *Social Empiricism*. In particular, the EEH case illustrates a number of empirical and non-empirical decision vectors that are playing a role in researchers' decisions to accept or reject the hypothesis (see Figure 1). This section lists the major decisions vectors operating in this case, but it does not definitively delineate whether particular vectors are empirical or non-empirical. Section 4 argues that it is actually more difficult than it initially appears to make this distinction.

3.2.1 Decision Vectors for the EEH

Beginning with the decision vectors on the "Pro" side of the EEH, the writing of the forward to *Our Stolen Future* by former presidential candidate and vice-president Al Gore was viewed as a powerful political statement by the authors of *Our Stolen Future* since Al Gore is arguably the most environmental-friendly politico since Theodore Roosevelt. Gore's eloquent prose captured the urgency of the EEH cause and revealed the desperation of those involved with the EEH, as well as provided a feeling of alliance with some members of the government. Since Gore's involvement with the book undoubtedly convinced some of the strength of the EEH, independently of the empirical data, this would appear to be a non-empirical decision vector.

Closely related to Gore's involvement with *Our Stolen Future* is the sheer rhetorical power of the book. Its forceful literary tone with the sense of desperation and deep concern for the environmental and human effects of these estrogenic compounds

For EEH:

- Al Gore writing the forward to *Our Stolen Future*
- The rhetorical power contained in the writing of *Our Stolen Future*,
- The Long Island breast cancer case,
- The DES cases,
- Alleged reduction in global sperm counts and quality,
- Varieties of unexplained phenomena that could plausibly be explained by the EEH; one example would be childhood hyperactivity,
- Research studies of animals, both in the lab and in their natural environments

Against EEH:

- Preference for the dominant cancer paradigm in toxicology,
- Theo Colburn's non-traditional path to becoming an academic scientist,
- Conservativeness of peer-reviewed scientific journals and the scientific community at large,
- Absence of a clear causal mechanism linking suspected endocrine disrupters and adverse health effects,
- Concerns about evidence from cell cultures, based on the fact that not everything that occurs *in vitro* occurs *in vivo*,
- Lack of epidemiological evidence,
- The increase in life expectancy in developing nations,
- The dramatic increase in the global population

Figure 1: Some prominent decision vectors in the EEH case

backed by conjectures extrapolated from animal studies gives *Our Stolen Future* an urgent and strident scientific feeling. Again, this appears to be a non-empirical decision vector.

The Long Island breast cancer case is our first example of the ambiguity present in attempting to classify some decision vectors as empirical or non-empirical. Begun by a group of women from Long Island calling themselves One in Nine, an appeal was made to then New York Senator Al D'Amato to assist in getting a federal study of the breast cancer rates of women on Long Island. The appeal was based on information that revealed that breast cancer rates among women on Long Island were higher relative to

other women in the state of New York, and played a key role in gaining support for a federal study looking into possible links between breast cancer and estrogen mimicking chemicals. The group calling themselves One in Nine sought to persuade the Centers for Disease Control to study possible causes of the increase in breast cancer on Long Island but was not successful in their pleas.

After much political wrangling however, the study was finally conducted and no definitive causes were found linking estrogen-mimicking compounds to the elevated rates of breast cancer among Long Island women. However, despite the lack of a causal link, the efforts of the One in Nine group was influential in affecting public policy by resulting in a dramatic increase in federal funding for breast cancer research, going from "90 million [dollars] in 1990 to nearly 500 million five years later in large part because of the political mobilization of breast cancer activists" (Krimsky 2000, 70). Perhaps the largest victory of the breast cancer activists besides the increase in funding was an amendment to the Food Quality Protection Act calling for a specific estrogen screening program. The study looking into the elevated rates of breast cancer among Long Island women proved inconclusive. Section 4 provides further analysis of this decision vector.

The DES case provides some of the strongest evidence supporting the EEH. This case centers on the administration of DES, or diethylstilbestrol, the first synthetic estrogen. DES acts in much the same way as estradiol, the most abundant estrogenic hormone in the human body, in that it instructs the lining of the uterus to thicken at the beginning of the menstrual cycle. DES acted in two specific ways to solidify the base of knowledge in the beginnings of the EEH. First, DES was a synthetic estrogen, so adverse effects of DES administration in humans focused attention on it, as well as on other

estrogen mimicking compounds in the environment. Second, and most relevant to my project, is the use of animal models that were used to understand how DES works and generalizing those effects to other xenoestrogens. The relevance of this will be discussed later as well. DES was first synthesized in 1940, manufactured from coal tar derivatives. From the onset, DES was known to be highly estrogenic.. Despite the known carcinogenicity of DES, it was widely used throughout the world, in a multitude of medical applications. Eventually it was used as a growth stimulant is cattle feedstock and various other agricultural uses. In 1941 the FDA approved it as a treatment for menopausal women and subsequently expanded its uses to include a wide array of pregnancy related conditions. Studies conducted later found that DES was ineffective at treating these conditions or any other conditions for which it was prescribed. However, its uses in the agricultural sector continued.

In 1971, a link between DES and vaginal cancer, specifically clear cell adenocarcinoma, was discovered by researchers at Harvard Medical School and Massachusetts General Hospital. The cancer occurred in women under 20 years of age, a medical rarity among this demographic, and all but one of the mothers of the women with this specific type of vaginal cancer was treated with DES during pregnancy. Effects of DES exposure during pregnancy was also discovered among males born to mothers prescribed DES. These effects include such things as abnormal penis and testicular development, and lower counts of sperm as well as decreased sperm quality. A long and protracted battle over withdrawing DES from the market and banning its agricultural use followed, eventually resulting in the FDA ordering the cessation of DES use resulting in its production being discontinued.

A global decline in overall sperm count and quality was hypothesized to be a result of environmental estrogens, and it represents another prominent influence on the early development of the EEH (see Figure 1). Widespread growth in the fields of artificial insemination and testicular cancer led to an increase in the study of assessing the overall quality of sperm. Data from sperm banks as well as infertility clinics was collected and maintained, although in a relatively unorganized manner an it was not until recently that scientists became interested in the effects of environmental estrogens on sperm health.

A seminal event in the chronology of the sperm hypothesis occurred when a Danish scientist and specialist in pediatric endocrinology, Niels Skakkebaek, discovered abnormal cells in the testes of men diagnosed with testicular cancer. These specific cells had characteristics of fetal cells and based upon these observations did Skakkebaek theorize that the development of testicular cancer had its origin in fetal development. Once an adolescent reaches puberty and the rush of hormones that occurs during this phase of the lifecycle begins, the affected cells proliferate and tumor formation begins. The beginnings of testicular cancer often coincide with the age of an individual at this time. Skakkebaek was especially interested in testicular cancer because Denmark had the highest incidence of testicular cancer in the world at that time. Because the increase in testicular cancer occurred rather abruptly, and more incidences were being beginning to appear in the suburbs, representing a shift in the demographics of the disease, Skakkebaek hypothesized that environmental factors were to blame.

The generalization from the effects on animals to humans marks another significant decision vector for those scientists accepting the EEH. The evidence from

wildlife studies led Colburn and her fellow scientists to look toward possible effects the same chemicals would have on humans. Colburn and her fellow scientists showed their radical nature, thus displaying another decision vector, by showing their preference for a new, challenging theory independent of compelling empirical success. It may be said that they were also driven by some competitiveness, another decision vector, but I believe it would be wrong to level that charge at this point, simply because there wasn't enough consensus on the EEH for them to compete against the somatic cancer theory yet. More on the necessity for consensus will be said later.

The evidence gathered from the wildlife studies represented a significant body of data for the EEH proponents. This data pointed to very serious abnormalities in the wildlife populations exposed to certain of these chemical effluents. The scientists studying these phenomena were able to state with a significant degree of certainty that the chemicals did have a noticeable effect on the wildlife being studied. However, effects on animals does not definitively portend effects on humans. The data gleaned from the animal studies represents another decision vector, preference for a theory with some data, because while difficult to establish a direct causal link to humans, the EEH scientists did have *some* data.

3.2.2 Decision Vectors against the EEH

One factor that discouraged attention to the EEH was the fact that, before the emergence of the environmental endocrine hypothesis, the prevailing paradigm under which research into adverse effects of industrial chemicals was entirely constructed around cancer causation. The somatic theory of cancer causation, in which certain chemicals can induce changes in a cell's DNA resulting in that cell becoming cancerous,

was the dominant research agenda for the majority of scientists working within the domain of adverse chemical reactions and their effects of humans. As a result of being at the center of the majority of the research, the somatic theory of cancer causation also consumed the largest portions of funding and distribution of research effort, thus leaving little research funding for the newly emergent EEH.

Scientists working within the cancer paradigm were reluctant to devote any attention to the EEH, probably due to a number of decision vectors, both empirical and non-empirical. The apparent empirical decision vectors for the cancer researchers included factors such as salience of data, because the data collected in the cancer theory was *some* data, and furthermore, the cancer theory enjoyed some empirical successes. Also, the cancer theory proponents were more likely to accept that theory simply because there was some data available, while there was little or no data available yet for the EEH.

The scientists pursuing the somatic theory of cancer causation exhibited many non-empirical decision vectors as well. The scientists displayed some preference towards their theory because of the amount of effort already invested into their research. This made them more apt to accept their theory regardless of the amount of data they gathered in support of it. Quite simply, emotional investment in any research project acts as a significant decision vector. Related to this is the issue of pride. The scientists working within the somatic theory of cancer were reluctant to accept a new theory because they needed to maintain self-esteem and public esteem regardless of the empirical success of their own theory. Another apparently non-empirical decision vector the proponents of the somatic theory of cancer displayed is conservativeness. These scientists displayed preference for this theory because they were already committed to it and any reversal of

commitment would possibly mean seeking new funding, establishing new contacts, and devising new experimental pathways. Peer pressure and willingness to comply with noted authorities are also non-empirical decision vectors that contributed to the somatic theory of cancer receiving the majority of funding and research effort.

Another decision vector counting against the EEH was that proponents of the EEH were viewed by their fellow scientists as radical scientists working on the fringes of the scientific community and not working under the standard scientific methodology. The champion of the EEH, Theo Colburn, was not a typical scientist, receiving her scientific training from majoring in pharmacy while in college. Undoubtedly, Colburn's non-traditional path led to the reluctance of the traditional scientific communities willingness to accept her theories. Colburn went on to work with numerous interdisciplinary groups exploring the effects of chemical pollutants on wildlife species and their offspring. The research done by Colburn and her fellow scientists led to the formation of the EEH, based on the effects on wildlife.

Skepticism over any empirical data is an easy position to take. The same empirical decision vectors can be made to apply to any scientific reasoning process. Much of the same could easily be said of the non-empirical decision vectors as well. Many of the same criticisms can be levied at other supposed effects of environmental estrogens. Breast cancer and any links that may be associated with environmental estrogens stirs much debate within the scientific community. Those scientists skeptical of any attempts to establish a causal connection between the chemicals and cancer are usually funded by the chemical manufacturers and are therefore less willing to break from the strong bonds of tradition, a non-empirical decision vector, than to consider a

more radical hypothesis, another non-empirical decision vector. Furthermore, the scientists working within the traditional cancer causing methodologies were strongly influenced by the salience of their data, probably for several reasons, but no reason more strongly than it was data they were responsible for collecting through experimental methods they themselves designed.

CHAPTER 4
EVALUATION OF SOLOMON

This section argues that the EEH illustrates at least two significant problems with Solomon's framework. The first problem, which will be discussed in much greater detail, is that the distinction between empirical and non-empirical decision vectors is ambiguous. The second problem is that she fails to consider how the relative weights of decision vectors should be factored into her account.

4.1 Ambiguity of Empirical/Non-empirical Distinction

Some of the above decision vectors seem to be easily distinguished as empirical or non-empirical; for example, the writing of the forward to Colborn's *Our Stolen Future* clearly appears to be a non-empirical decision vector. Similarly, Colborn's non-traditional path to scientist and then environmentalist appears to be a non-empirical decision vector. Yet, the animal modeling data that proponents of the EEH appeal to is not as easily categorized as empirical or non-empirical. This section argues that, under Solomon's empirical/non-empirical schematic, some decision vectors are difficult to claim one way or the other and this difficulty may interfere with the overall heuristic nature of her project.

Let us review Solomon's distinction between empirical and non-empirical decision vectors. The empirical decision vectors "are causes of preference for theories with empirical success, either success in general or one success in particular. Non-empirical decision vectors are other reasons or causes for choice" (Solomon 2001, 56). Examples of empirical successes include, but are not limited to, a theories being predictive, retrodictive, experimental, and explanatory as well as some technological

successes. Particular theories empirical successes are not limited to the above examples because a particular theory may come to exhibit an as yet unknown empirical decision vector during the course of that theory's history, as Solomon instructs, "the basis for classifying decision vectors as empirical or non-empirical is itself empirical, *not* conceptual" (Solomon 2001, 59).

Note that empirical decision vectors are influential in that they are causes of choice for theories that have some empirical successes, general success or particular successes. Non-empirical decision vectors "are other reasons or causes for choice" (Solomon 2001, 56). These "other reasons" can be "psychological processes within individual scientists dependent on both personality and interpersonal relations" (Solomon 2001, 56). Non-empirical decision vectors are also called by some philosophers of science "motivational" or "hot cognitive" factors. Some non-empirical decision vectors such as "ideology, funding practices, gender relations and national differences in institutional structure" are more salient on a social level (Solomon 2001, 59).

An empirical decision vector is dependent on its empirical success, as Solomon tells us, but what exactly is "empirical success"? "Empirical successes are contingent on the world outside the inquirers; theoretical successes are not" (Solomon 2001, 17). A theoretical success can function properly independent of their being any phenomenal correlate to match up with it while a theories empirical success must display some successful mapping onto the external world. Theoretical successes, such as simplicity, conservativeness, consistency, and breadth of scope, are attributable to factors internal to scientists, the so called "motivational" or "hot cognitive" factors. Empirical successes are attributable to "dependable behavior" of the world. We must note that Solomon

stresses that "there is no 'paradigmatic' or 'typical' kind of empirical success" (Solomon 2001, 22).

Some examples demonstrating the difficulty in assigning "paradigmatic" or "typical" empirical successes to all cases, regardless of their context, are needed to develop this point further. The discovery of insulin is an example of an experimental and technological success. The discovery came as a result of a long and arduous series of experiments progressing from animals and finally experiments on humans. Due to the complexity of the experiments, the procedures had to be redesigned many times over before success finally came once and for all. Predictive as well as explanatory success in explaining seafloor spreading and magnetic symmetry patterns along the seafloor were found in the Vine-Matthews hypothesis, and, like the discovery of insulin, are examples of empirical successes that are primarily predictive of observations and explanations of observations. In nineteenth century evolutionary biology, there were several competing theories that purportedly explained mechanisms of species change through similar empirical successes. Darwin's theory of natural selection explained species change in a way that no other theories could. However, his theory of evolution was not embraced by all. Other theories, such as Lamarckism, saltationism, and orthogenesis, were able to posit some predictions, but none had the kind of robust predictive success as Darwinism. Again, it should be noted that these examples do not include all types of empirical success, but should show the difficulty in attempting to find "paradigmatic" or "typical" examples of empirical successes. Moreover, differing historical periods have enforced a demand for different types of empirical success. For instance, during the seventeenth

century firm interest in experimental successes prevailed, while in the nineteenth century unified explanations of observations were valued more than experiment.

Adhering to her naturalistic approach, Solomon says, "It is my view that general definitions of empirical success say little, and that understanding and characterization of empirical success comes from looking at types of examples, as I have just done. But general definitions can be given, for example: when there is empirical success, scientists, instruments, and the world successfully coordinate their actions as a result of tinkering, conceptual adjustments and serendipity" (Solomon 2001, 27-28). Furthermore, "only the empirical decision vectors are always conducive to some scientific success, and even then, they do not typically maximize attainable empirical success", and most importantly, "for all decision vectors, context, in particular the context of all decision vectors operating in a community, is crucial for an assessment of their normativity" (Solomon 2001, 63).

Solomon seems to presuppose that the dividing line that separates the empirical decision vector from the non-empirical decision vector is easily decided upon, and easily acted upon by scientists. However, I believe that in certain cases the empirical/non – empirical distinction is not easily visible, and often times vague. One can give a conceptual argument for this point. Any theory that is inferred from a data set is going to be based not only on those data but also on other background assumptions (Longino 1990). Thus, *no* decision vector can ever be empirical, if that means depending *solely* on empirical data and not on any additional assumptions. (One might argue that the assumptions themselves could be justified by empirical data, but this would appear to result in an infinite regress.) Solomon must admit that empirical decision vectors

incorporate both an empirical component and some types of assumptions. Therefore, depending on how prominent a role those assumptions play in the argument (and depending on how much empirical evidence exists in favor of the assumptions), decision vectors plausibly fall on a continuum from "more" to "less" empirical. To the extent that a decision vector's counting as empirical or non-empirical is going to be decided on the basis of other background assumptions, making a clean demarcation between them seems difficult.

This conceptual point can be strengthened further by seeing how it plays out in actual scientific cases. In one of Solomon's case studies that involves the ovulation theory of menstruation, scientists reasoned that, since animals ovulate during estrus, human females must also ovulate during menstruation. Couples trying to conceive were instructed to have intercourse during menstruation, based on reasoning from animals to humans. Solomon believes this was an example of a theory that "had little or no empirical success," and "the consensus was brought about through analogical reasoning, and then reinforced by the usual mechanisms of authority and belief perseverance" (Solomon 2001,126). This is a question-begging example. It is not clear that all evidence from animal models actually counts as non-empirical decision vectors. It seems plausible that there might be cases in which animal modeling can be used as an empirical decision vector. It depends on assumptions about the extent to which animal models and human models differ from one another.

If we can determine from Darwin's theory of evolution that we are sufficiently similar to animals, then perhaps the animal experiments could be considered empirical decision vectors. Darwin's theory of evolution eventually prevailed over its rivals

because it demonstrated superior predictive success, an empirical decision vector according to Solomon. However, the reasoning behind the ovulation theory of menstruation was considered by Solomon to be empty of empirical content, even though one might appeal to Darwin's theory of evolution to support the notion that evidence from animals might be relevant to the case of humans.

The EEH case also nicely illustrates these difficulties of deciding whether particular sets of data count as empirical or non-empirical decision vectors for particular theories. Moreover, it provides further evidence that Solomon may have been too quick in labeling evidence from animal models as a non-empirical decision vector. Animal modeling is cited by proponents of the EEH as a reliable justification for believing that certain chemical compounds induce abnormal physiological events in the human body. One might argue that animal modeling operates in the EEH based on the representativeness heuristic, a non-empirical decision vector. The representativeness heuristic occurs when some similarity is posited between two entities based on some other posited similarity. Thus, what has been posited as carcinogenic in laboratory mice or other animals is extrapolated to humans based on broad similarities shared by both subjects, like both being mammals. Nevertheless, it is not entirely clear that this is a non-empirical inference. Consider some of the facts about animal experimentation.

Animal experiments are often used to assess risks to humans from external agents, whether they are environmental or chemical. When the move is made from asserting causality in animals to asserting causality in humans, two major extrapolations are made: from high dose to low dose and from animals to humans. Freedman and Zeisel (1988) claim that "Numerical assessments of human risk, even if based on good animal data,

seem well beyond the scope of the scientifically possible. There are substantial differences in sensitivity between species, strains, sexes, and individuals" (Freedman et al. 1988, 3). One might regard this claim as further evidence for the notion that animal data should be regarded as a non-empirical decision vector. But, this might be too hasty, given that animal studies do seem to provide somewhat helpful information.

Animal experiments are attractive in many respects, particularly because experiments on animals do not pose quite the same ethical challenges to many scientists that human experiments pose. Rats and mice are the animal of choice for laboratory studies covering broad ranges of induced abnormalities because they are relatively cheap and easy to obtain and experimenters have ample experience conducting experiments with them. When the experiment is begun, scientists must establish the maximally tolerated dose (MTD), the dose that is just below the levels where acute toxicity begins to develop. So, once the MTD has been established, the animals are divided into groups based on the group that received the MTD, the group that received fractions of the MTD, and the control group which received no dose at all. Once the experiments are carried out, the results of the dose-response parts of the experiment will be quantified using mathematical models. The relationship brought out in the mathematical models, although not a perfect guide to human effects, is often used as the basis for developing regulations.

So, to return to the EEH case, it appears that several of the important decision vectors cannot be neatly classified either as empirical or non-empirical. First, the evidence for the EEH in animal models plausibly provides some evidence for the EEH in humans, but the foregoing discussion of the complexity of extrapolating from animals to humans shows that this evidence is ambiguous. Second, the preference for the dominant

cancer paradigm, which guided much of the research into environmental pollutants around the time the EEH was being formulated, would plausibly count as a non-empirical decision vector since *preference* for a particular theory alone is not enough to consider it an empirical decision vector. Or is it? After all, the research fueling the cancer paradigm was based on empirical findings (namely, that many of the severe health effects of toxins involved cancer), so could the preference for the dominant cancer paradigm then be considered an empirical decision vector since it was related to empirical data? In sum, the EEH case supports the claim that Solomon's distinction between empirical and non-empirical decision vectors (which is central to her account of proper scientific practice) needs to be developed further if it is to be convincing.

4.2 Failure to Consider Strength of Decision Vectors

One encounters another set of problems when trying to add up the non-empirical decision vectors (assuming that they could be distinguished from the empirical ones). The problem centers on considering the various strengths of individual non-empirical decision vectors. Solomon writes that "if empirical decision vectors are distributed *equitably*, i.e., in proportion to the empirical success of the various theories under consideration, and non-empirical decision vectors are distributed *equally*, then, overall, the distribution of decision vectors will be equitable" (Solomon 2001, 77). And it is the equitable distribution of decision vectors (according to the empirical success of the various theories) that Solomon believes is conducive to distributing research appropriately throughout the scientific community. Once again, there are conceptual reasons for thinking that Solomon's account is too simple. To the extent that some non-empirical decision vectors may be much more influential than others, it is not clear that

keeping the mere *number* of non-empirical decision vectors equal is enough to keep the distribution of scientific research ordered equitably in accordance with empirical success. Solomon is, of course, aware that her account is fairly simple as it stands. Nevertheless, it is not clear whether one can even use her account to evaluate a case like EEH in the simplistic form that she has developed so far.

When considering the non-empirical decision vectors operating in the EEH, some consideration of the strengths of the various non-empirical decision vectors seems crucial. For instance, conservativeness on the part of the established scientific community, which led to reluctance in accepting the EEH, seems to have had a more powerful impact with respect to the EEH than did, say, Al Gore's involvement with writing the forward to *Our Stolen Future*. Solomon's account presupposes, though, that these non-empirical decision vectors operated in an equally influential manner. So, even if we could clearly distinguish a particular set of non-empirical decision vectors in the EEH case, it seems unlikely that we can legitimately say whether current research is distributed appropriately across the endocrine hypothesis and competing hypotheses. Even if there are an equal number of decision vectors in favor of each hypothesis, that does not provide a good reason to think that the research will be distributed appropriately.

CHAPTER 5
CONCLUSION

Science does progress, despite the philosophical wrangling over values and their influence and whether science is best served by the individual scientist, or by communities of scientists. In my thesis, through using an actual case, I have shown that Solomon's ideas towards developing a more normative account of theory appraisal does not proceed undaunted. In spite of the problems with its ambiguities, I believe Solomon's suggestions to be moving in the right direction towards a more workable account of theory appraisal. Recent philosophical work highlighting the pervasiveness of values in theory appraisal has demonstrated that values may play a more prominent role in theory appraisal than was previously thought.

As Solomon and others have shown, values can be incorporated into the appraisal process successfully as long as the appraisal of competing theories does not draw us too far from the data, thus ensuring research into the theories most likely to exhibit empirical success, hence leading us closer to the truth. The application of the EEH to Solomon's framework has illustrated the difficulties faced when trying to isolate the values that are in play and quantify them in a manner that allows us to accurately assess their influence in the overall scheme of theory appraisal. Solomon's social empiricism is attractive in many respects, though, particularly by trying to ensure that legitimately competitive theories continue to receive research funding, even if other theories temporarily display more empirical promise, which leads to a more equitable distribution of research effort.

The distribution of research effort among competing theories is becoming more dominant among some groups of philosophers of science that believe values should be

admitted into the appraisal process. This path is particularly promising as it seeks to locate rationality more within the group of scientists rather than with the individual scientist. Rationality, as displayed by groups of scientists, would take the form of a community of scientists working in an environment through which the critical evaluation of individual ideas would, as Helen Longino thinks, "wash out" the values not relevant to the task of theory appraisal.

BIBLIOGRAPHY

Freedman, D.A., and Zeisel, H. (1988), "From Mouse-to-Man: The Quantitative Assessment of Cancer Risks," *Statistical Science* 3: 3-56.

van Fraassen, Bas (1985), "Empiricism in the Philosophy of Science," in Paul Churchland and Clifford Hooker (eds.) *Images of Science: Essays on Realism and Empiricism, With a Reply From Bas C. van Fraassen*. Chicago: University of Chicago Press.

Giere, Ronald (2003), "A New Program for Philosophy of Science?" *Philosophy of Science* 70: 15-21.

Krimsky, Sheldon (2000), Hormonal Chaos. Maryland: Johns Hopkins Press.

Kuhn, Thomas (1970), The Structure of Scientific Revolutions. Second ed. Chicago: University of Chicago Press.

Kuhn, Thomas (1977), "Objectivity, Value Judgment, and Theory Choice." In Thomas Kuhn, *The Essential Tension*, pp.320-339. Chicago: University of Chicago Press.

Laudan, Larry (1984), Science and Values: The Aims of Science and Their Role in Scientific Debate. Berkely: University of California Press.

Longino, Helen, (1990), Science as Social Knowledge: Values and Objectivity in Scientific Inquiry. Princeton: University of Princeton Press.

Solomon, Miriam, (2001), Social Empiricism. Cambridge: MIT Press.

VITA

Robby Burleigh was born and raised in Baton Rouge, Louisiana. One of three brothers, Robby would eventually become the only member of his family to attend college, and thus, receive his bachelor's degree. The intellectual challenges brought about by life in academia, combined with the wonderful spirit that permeates the Louisiana State University campus led Robby to pursue his master's degree studying philosophy.

The study of philosophy challenged Robby to think critically and examine many of life's eternal questions, as well as some of the more contemporary questions facing any college graduate in today's dynamic world. In consideration of the future, Robby is trying to find his place in the world, where he can utilize his love of philosophy while trying to make a positive impact on those around him.