CRITIQUES & CONTENTIONS

Isis' Consciousness Raised

By Carolyn Merchant*

WHEN GEORGE SARTON first published in 1913 what became the journal of the History of Science Society, he named it *Isis* after the Egyptian mother goddess associated with the annual flooding of the Nile. Isis, according to Sarton in his *History of Science*, "began her foreign conquests in the seventh century, if not before. Herodotus says that . . . the women of Cyrene worshipped her. . . . Temples and inscriptions to Isis and other Egyptian gods can be found in many of the Islands, even in the sacred Delos. . . ." In Greece, Sarton continued, she was celebrated at the mysteries of Eleusis as "Demeter, the glorification of motherly love (cf. Isis)." She "says of herself 'I am everything which existed, which is now and will ever be, no mortal has ever disclosed my robe.'"[1] For Sarton, as for the Greeks, Isis is symbolic of nature, and her robe conceals nature's secrets. Only those initiated through the mysteries (later through science) could glimpse the reality "which is now and will ever be."

What led from the Egyptian worship of the mother goddess, Isis, to Sarton's approach to the history of science as the "acquisition and systematization of positive knowledge," a process that can be symbolized by the disclosure of Isis' secrets? Does such imagery still pervade the writings of scientists and historians of science? Can feminist history of science contribute to a new perspective on our discipline and the symbolism associated with our patron goddess, Isis?

Feminist history of science involves a female perspective on science, nature, and society, the study of female challenges to traditional scientific roles, and a female consciousness concerning the origins of women's lower position and consequent exclusion from historical literature. A feminist approach to science and history can reveal hidden biases in a field that in recent years has considered itself free of the cultural assumptions of the present when treating the science of the past. Beyond this it can offer alternative interpretations of the rise of science, scientific professionalization, and the scientific world view, and it can create new syntheses in our field.

*Department of Conservation and Resource Studies, University of California, Berkeley, California 94720.

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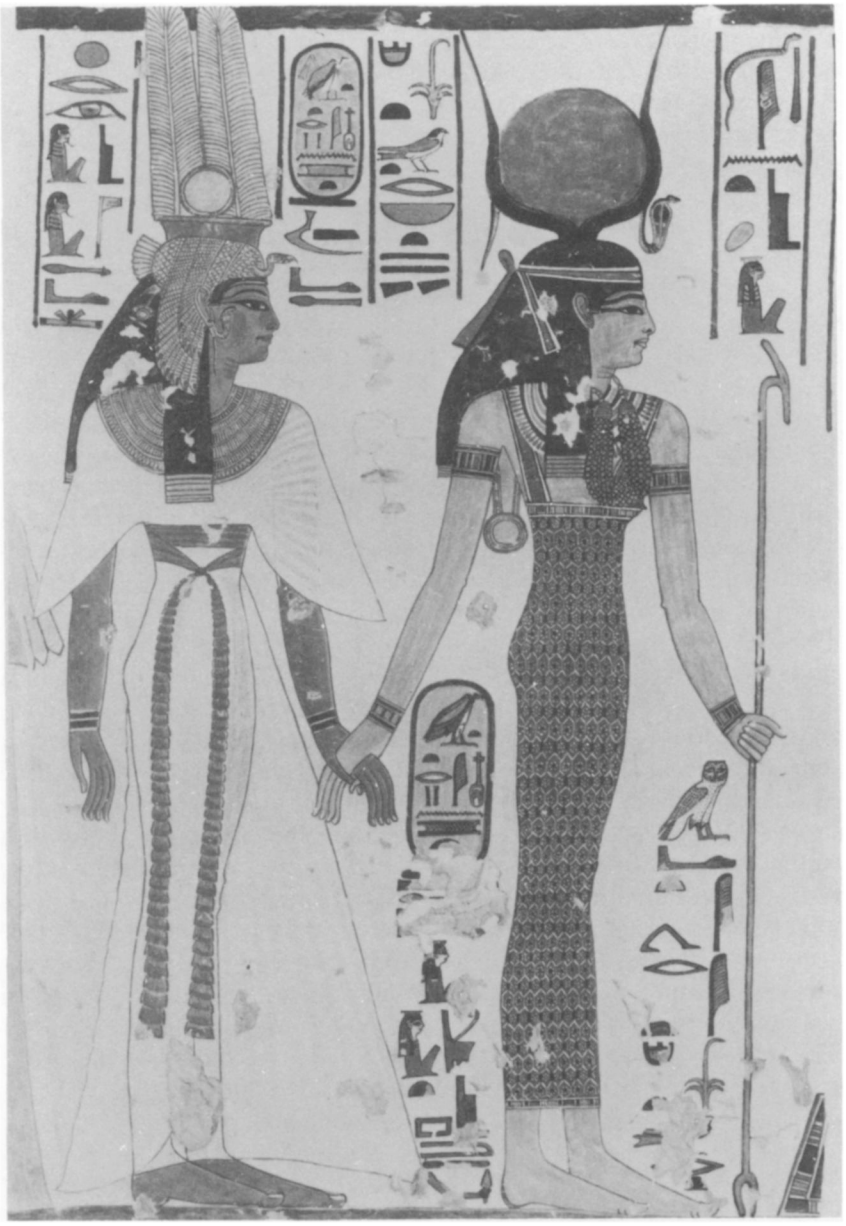
[1]George Sarton, *A History of Science*, 2 vols. (Cambridge: Harvard Univ. Press, 1959), Vol. I, pp. 125, 152; Sarton cites Herodotus 4.186 and quotes Plutarch, *Isis and Osiris* 354c. Sarton's own image of Isis seems to be derived from an Egyptian wall painting showing her leading Queen Nefretere to her tomb. He refers the reader to the painting, with which "the author [Sarton] is very familiar," as reproduced by Nina de Garis Davies in *Ancient Egyptian Paintings, Selected, Copied, and Described*, 3 vols. (Chicago: Univ. Chicago Press, 1936), Vol. II, Plate XCI (see Fig. 1). Davies describes the goddess Isis as "clad in a sheath-like red dress with a network of beads." In contrast to Isis, Queen Nefretere "wears a flowing robe, the transparency of which is well indicated" (Vol. III, p. 177).



Sarton's Isis (see note 1): Isis conducting Queen Nefretere to her tomb. Reproduced with permission from Nina de Garis Davies, Ancient Egyptian Paintings, Selected, Copied and Described, *3 vols. (Chicago: University of Chicago Press, 1936), Volume II, Plate XCI.*

Here I discuss three areas in which a feminist perspective can provide a critique of science and its history and suggest new questions for investigation. The first centers on the Western scientific world view, its historical origins, and the way this perception has permeated the history of science; the second on the role played by language, image, and metaphor in science and the writing of its history; the third on the way women, women's roles, and women scientists are portrayed by

historians. This division is consistent with a theory of historical explanation based on the interaction between superstructure (e.g., world view, ideology, conceptual schemes) and substructure (e.g., social roles, behavior, production, reproduction) mediated through symbolic normative structures (e.g., image, metaphor, description, prescription, representation)—the kind of explanation I have tried to develop in my book *The Death of Nature*.[2]

AN IDEOLOGY OF OBJECTIVITY

At the level of superstructure, or ideology, the philosophy of nature that has guided the work of many modern scientists has been logical positivism. Positivism assumes that valid, verifiable, hence positive knowledge of the world derives ultimately from experience obtained through the senses or experiment and interpreted via the conventions and rules of mathematical language and logic. Scientific knowledge is rule-governed, context-free, and empirically verifiable and as such claims to be objective, that is, independent of the influence of particular historical times and places. Yet the positivist approach itself to nature and history relies conceptually on an interlocking structure of dualities that is context-bound and rooted in history: the dualities of subject and object, activity and passivity, male and female, and culture and nature.

The basic dichotomy is that between subject and object, and indeed objectivity, the hallmark of logical positivism, depends upon it. The objectification of nature is rooted in Aristotle's locus of reality in the objects of the natural world and made explicit in Descartes's separation of mind from matter, that is, of thinking subject from external object. The dualism between activity and passivity hypothesizes an active subject—man—who receives, interprets, and reacts to sense data supplied by a passive object—nature. Nature as object, whether conceived as things (in the Aristotelian framework) or as corpuscles (in the Cartesian) is composed of dead passive matter set in motion by efficient or final causes (Aristotle) or the transfer of motion (Descartes). Stemming from the same Aristotelian roots as the ideology of objectivity is the association of passivity with femaleness and activity with maleness. As Aristotle put it, "the female, as female, is passive and the male, as male, is active, and the principle of movement comes from him."[3] The male semen contributes power and motion to the embryo; the female supplies the matter, or passive principle. Finally, culture is identified with the active subject and thus with the male, as a passage from the philosopher Georg Simmel makes clear:

> The requirements of . . . correctness in practical judgments and objectivity in theoretical knowledge . . . belong as it were in their form and their claims to humanity in general, but in their actual historical configuration they are masculine throughout. Supposing that we describe these things, viewed as absolute ideas, by the single word "objective," we find that in the history of our race the equation objective = masculine is a valid one.[4]

[2]Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper & Row, 1980).

[3]Aristotle, *De generatione animalium*, trans. Arthur Platt (Oxford: Clarendon Press, 1910), 1.19, 729b13.

[4]See Georg Simmel (1858-1918), *Philosophische Kulture*, as quoted in Karen Horney, "The Flight from Womanhood," in *Women and Analysis*, ed. Jean Strouse (New York: Grossman, 1974), p. 172. See also Evelyn Fox Keller, "Gender and Science," *Psychoanalysis and Contemporary Thought*, 1978, *1*:409–433, on p. 409.

The Aristotelian identification of the female principle with passivity and the further association of passivity with object and the natural world have furnished the basic philosophical framework of Western culture.

Sociologists of the Frankfurt school have pointed out how the subject-object and attendant dualities of mainstream Western thought entail a philosophy of domination. Because an active controlling subject is separate from and dominant over a passive controlled object, the scientific rationale of objectivity can legitimate control over whatever has been assigned by culture to a lower place in the "natural" order of things.[5] It thus maintains a hierarchical domination of subject over object, male over female, and culture over nature. In particular, this conceptual system can justify the subordination of women when compounded by the separation of productive (public, male), and reproductive (female, private) spheres in modern industrialized society. Historically nature and the female have been identified, and cultural ideology has legitimated the domination of both. This identification appears in the science of such men as Francis Bacon, William Harvey, Thomas Hobbes, Joseph Glanvill, and Robert Boyle, to mention only a few of the "fathers" of modern science, and it permeates the history of science.

How has this ideology of objectivity and its associated sexual bias manifested itself in the work of historians of science? One place to look for these connections is in the writings of those who argue that the history of science ought to portray the progress of objective knowledge. A few quotations from Charles Gillispie's *Edge of Objectivity* will exemplify the implicit bias against women and nature as object.

> After Galileo science could no longer be human in the deep internal sense of its forerunner in classical antiquity. Bacon makes science what it has become in part and what the public tends to wish it were in its entirety: an innocuous instrument of human betterment which requires of him who would master it not difficult abstract thought but only patience and right method. . . . Scientific thought itself is bound to be far more abstract, elegant, and intellectually aristocratic than Bacon foresaw or would have approved. But scientists are likely to be humane men who wish to do good and like to be told that they do. . . . It is the materialistic commitment of a Bacon, at once tough-minded and humanitarian, rather than the delicacy of a mind of a Pascal, which has shaped the technical tradition.[6]

This passage makes clear that for Gillispie masculine qualities of toughness and mastery are attributes of the scientific mind and technical tradition, that science is an aristocratic elite pursuit, that scientists are clearly male, and that a "feminine" quality such as delicacy will not lead to human progress and betterment. Lest

[5]See, e.g., Vincent di Norcia, "From Critical Theory to Critical Ecology." *Telos*, 1974/75, No. 22, pp. 85–95, on pp. 88–89; Jurgen Habermas, "Technology and Science as Ideology," in Habermas, *Toward a Rational Society* (London: Heineman, 1971), pp. 81–122; William Leiss, *The Domination of Nature* (New York: Braziller, 1972); Theodor W. Adorno *et al.*, *The Positivist Dispute in German Sociology*, trans. Glyn Adey and David Frisby (New York: Harper & Row, 1976). For a feminist extension of the Frankfurt critique of objectivity see Marcia Westkott, "Feminist Criticism of the Social Sciences," *Harvard Educational Review*, Nov. 1979, *49*:422–430. See also Dorothy Smith, "Women's Perspective as a Radical Critique of Sociology," *Sociological Inquiry*, 1974, *44*:7–13; Sandra Harding, "Objectivity in Social Science Revisited: Gaps in the 'Text' of the Dispute," and Nancy Hartsock, "The Natural Science Model in Social Science: Shifting the Boundary Between Nature and Culture," both papers presented to the Philosophy of Science Association, Toronto, Ontario, Canada, 17 Oct. 1980; and Judith Long Laws, "Patriarchy as Paradigm: The Challenge from Feminist Scholarship," paper presented at the American Sociological Association Meeting, New York, Aug. 1976.

[6]Charles C. Gillispie, *The Edge of Objectivity* (Princeton, N.J.: Princeton Univ. Press, 1960), pp. 81–82.

Gillispie's association of male qualities with science seem problematic in the passage just quoted, it is abundantly clear in the following: "Indeed, Diderot was the Spinoza of biology before ever the science had its name—or its Newton. His was no feminine dislike of precision, no soulful sense of God in nature, but a philosophy of necessitarian organism." Gillispie accepts without question the association of nature and the female with object and berates and ridicules Goethe for his failure to dissect, mathematize, and objectify nature as had Newton:

> Nor though he looked through a prism, did Goethe believe in experiment. On the contrary, Newton's errors were the price he paid for his methods, mathematicizing nature into abstractions, torturing her with instruments, with telescopes, prisms, and mirrors, until she expires like a butterfly on a pin. . . . It is impossible to read the *Farbenlehre* without an acute sense of embarrassment at the painful spectacle of the author, a great man, making a fool of himself. . . . The historian is bound to represent this Goethean intrusion as profoundly hostile to science, hostile to physical science, and misleading even if stimulating to biology.

Gillispie evaluates his great men of science according to his standard of tough-mindedness and precision, eschewing Goethean romanticism as weak and permeated by emotion. Descartes, a great man with a "subtle" mind, was led astray by the assumption that "what is simple is nature herself whereas every neat-handed physicist knows that nature is very complex."[7] This historical association of objectivity with masculinity not only reinforces the tendency for scientists to be predominantly male, but also supports the identification of nature as object with femaleness, emotion, soulfulness, and sentience.

THE ROLE OF SYMBOL

The second area in which a feminist perspective offers an opportunity to reveal sexual bias and to reformulate traditional interpretations of the history of science is the realm of symbolic structure. Male and female symbolism and metaphor mediate between a society's ideological superstructure and its daily activities, providing insights into the origins of the linguistic patterns that still permeate modern scientific and historical writing. Images, metaphors, myths, and modes of description can either legitimate dominant conceptual systems or present alternatives to the mainstream view. Such image systems have a normative function, mediating between a society and its conceptual ideology and reinforcing its behavior. The role played by language in structuring the perception of subject-object relations, the interaction theory of metaphor, and the politics of metaphor, topics currently addressed by philosophers of science, should interest feminist historians of science. The most powerful such image is the identification of nature with the female, especially a female harboring secrets.[8]

Female imagery and myths or beliefs featuring female figures reflect a culture's changing values. The symbolism associated with Nature deified that began with

[7]*Ibid.*, pp. 192, 195–197, 93; see also p. 201.

[8]On the philosophy of metaphor see Philip Wheelwright, *Metaphor and Reality* (Bloomington: Indiana Univ. Press, 1962); Max Black, *Models and Metaphor* (Ithaca, N.Y.: Cornell Univ. Press, 1962); Mary Hesse, *Models and Analogies in Science* (Notre Dame, Ind.: Univ. Notre Dame Press, 1966); Richard Olson, ed., *Science as Metaphor* (Belmont, Calif.: Wadsworth, 1971); George Lakoff and Mark Johnson, *Metaphors We Live By* (Chicago: Univ. Chicago Press, 1980); Stanley Brandes, *Metaphors of Masculinity* (Philadelphia: Univ. Pennsylvania Press, 1980); Robin Lakoff, *Language and Woman's Place* (New York: Harper & Row, 1975).

Isis' refusal to disclose her robe undergoes significant change in the Middle Ages and after. In the twelfth century the Neoplatonic cathedral school of Chartres depicts her as the goddess *Natura*, the lower form of the Platonic world soul. In Alain de Lille's allegory *Nature's Complaint*, Natura laments her exposure to the view of the vulgar as her garments of modesty are torn by the wrongful assaults of men aggressively penetrating the secrets of heaven. "A damask tunic . . . pictured with embroidered work, concealed the maiden's body. . . . In its principal part man laid aside the idleness of sensuality, and by the direct guidance of reason penetrated the secrets of the heavens." Natura, whose "features are bedewed with a shower of weeping" is questioned about her torn robe:

> "I marvel," then I said, "wherefore certain parts of thy tunic, which should be like the connection of marriage, suffer division in that part of their texture where the fancies of art give the image of man." "Now from what we have touched on previously," she answered, "thou canst deduce what the figured gap and rent mystically show. For since, as we have said before, many men have taken arms against their mother in evil and violence, they thereupon, in fixing between them and her a vast gulf of dissension, lay on me the hands of outrage, and themselves tear apart my garments piece by piece, and, as far as in them lies, force me, stripped of dress, whom they ought to clothe with reverential honor, to come to shame like a harlot. This tunic then is made by this rent, since by the unlawful assaults of man alone the garments of my modesty suffer disgrace and division."[9]

Such symbolism suggests the rape or sexual conquest of both women and nature. Just as nature aggressively investigated is depicted as a woman molested, so femininity is symbolized as an enclosure, often one associated with nature's bounty, that can be breached. Thus medieval artists depict the goddess Venus or the Virgin Mary in enclosed gardens or stone circles symbolic of the female womb and of love, fruitfulness, and pleasure. Chaucer sets comic stories in enclosed gardens in which the lover in gaining access to the garden symbolically penetrates the womb. In *The Merchant's Tale*, based on the biblical "Song of Solomon," Damyan fashions a key to unlock the circular garden and subsequently makes love to a maiden situated in a fruit-bearing tree.[10]

In the seventeenth century the disclosure of Isis is carried beyond her robe into the interior of her body as Francis Bacon advises his new man of science to wrest from nature the secrets harbored in her womb, to search into the bowels of nature for "the truth that lies hid in deep mines and caves" and "to shape her on the

[9]Alain de Lille, *The Complaint of Nature*, trans. Douglas Moffat (New York: Henry Holt, 1908), pp. 15, 33, 41. For original see Alanus de Insulis, *De Planctu Naturae*, in Thomas Wright, ed., *The Anglo-Latin Satirical Poets and Epigrammatists of the Twelfth Century* (London: Longman & Trubner, 1872), Vol. II, pp. 429–522; esp. pp. 441, 467. On the proper role of nature as teacher in unveiling her truths to mankind see p. 457 (Alain, *Complaint*, p. 31). For a commentary see George D. Economou, *The Goddess Natura in Medieval Literature* (Cambridge, Mass.: Harvard Univ. Press, 1972), esp. pp. 72–80; Merchant, *Death of Nature*, pp. 10–20, 31–33.

[10]Yvonne Noble, "What Became of the Image of the Virgin as *Hortus conclusus* in the Augustan Age," paper presented at the 11th Annual Meeting of the American Society of Eighteenth Century Studies, San Francisco, Apr. 1980; Merchant, *Death of Nature*, pp. 8, 10–11. See also the French painting "St. Genevieve with Her Flock" (16th cent.), depicting the virgin with her flock of sheep within a protective stone circle on a hillside of trees and blooming flowers; reproduced in John Michell, *The Earth Spirit* (New York: Avon, 1975). The imagery of the enclosed garden (*hortus conclusus*) as a scene of love stems from the love of the maiden for the shepherd in the Song of Solomon, 4:12. The biblical images appear in Geoffrey Chaucer, "The Merchant's Tale," see *Works*, ed. F. N. Robinson (Boston: Houghton Mifflin, 1957), lines 2044–2046; 2143–2146. For more on the garden symbolism see Stanley Stewart, *The Enclosed Garden: The Tradition and Image in Seventeenth Century Poetry* (Madison: Univ. Wisconsin Press, 1966).

anvil." "Nature must be taken by the forelock, being bald behind," he asserted. "Nor ought a man to make scruple of entering and penetrating into these holes and corners, when the inquisition of truth is his whole object." For Bacon's apologist Joseph Glanvill, who said that nature must be "mastered" and "managed" by "searching out the depths . . . and intrigues of remoter nature," nothing was more helpful than the microscope, for "the secrets of nature are not in the greater masses, but in those little threads and springs which are too subtle for the grossness of our unhelped senses." In the *Vanity of Dogmatizing*, Glanvill pointed out that "Nature's coarser wares" are "exposed to the transient view of every common eye; her choicer riches are locked up only for the sight of them that will buy at the expense of sweat and oil." In achieving such insights, however, true understanding is often misled by the emotions, for "the woman in us, still prosecutes a deceit, like that begun in the Garden: and our understandings are wedded to an Eve, as fatal as the mother of our miseries."[11]

By the nineteenth century nature is removing her own veil and voluntarily exposing her secrets. A sculpture by Louis Ernest Barrias, *La Nature se devoilant devant la science* ("Nature revealing herself to science"), is appropriately located in the entry to the School of Medicine at the Sorbonne in Paris. A naked woman (based on the nymph or nature goddess in a sixteenth-century engraving) picnics on the grass with two fully clothed gentlemen in Edouard Manet's *Le Dejeuner sur l'herbe* (1863). *Mother Earth Laid Bare* by Alexander Hogue (1936) portrays the female shape taken on by eroded earthen mounds in drought-ridden Oklahoma in the 1930s.[12]

In the twentieth century we find scientists fervently hoping that the veil of nature can be lifted from matter itself (traditionally feminine) so that all may view the hidden secrets of the atom. One may hope "to be able to lift a corner of the veil that conceals creation. . . . Each of us hopes that . . . a sensational application of radium will completely tear away the veil and that truth will appear before everyone's eyes," announced the inaugural editorial from *Le Radium* in 1904. "The notion of impenetrable mysteries has been dismissed," wrote Sir William Crookes in 1903. "A mystery is a thing to be solved—and 'man alone can master the impossible.'" Hans Reichenbach in 1933 charged nuclear physicists with the task of the "unveiling of the secrets surrounding the inner structure of matter," and the editors of *Harper's* (1924) applauded the "laying bare" of its structure.[13]

[11]Francis Bacon, "De dignitate et augmentis scientarum," *Works*, ed. James Spedding, Robert Ellis, and Douglas Heath, 14 vols. (London: Longmans Green, 1857–1874), Vol. IV, pp. 343, 287; Bacon, "The Refutation of Philosophies," in Benjamin Farrington, ed. and trans., *The Philosophy of Francis Bacon* (Liverpool: Liverpool Univ. Press, 1964), p. 130; Bacon, "De dignitate et augmentis scientarum," *Works*, Vol. IV, pp. 294, 296; Joseph Glanvill, *Plus Ultra* (1668; Gainesville, Fla.: Scholar's Facsimile Reprints, 1958), pp. 87, 10, 56; Glanvill, *The Vanity of Dogmatizing* (1661; New York: Columbia Univ. Press, 1931), pp. 247, 118.

[12]George Mauner, *Manet: Peintre-philosophe* (University Park, Pa.: Pennsylvania State Univ. Press, 1975), pp. 7–45, esp. pp. 10–12, 32–33, 40–43. Corky Bush, "Cultural Images of Women and Technology," in *Women and Technology: Deciding What's Appropriate* (Missoula, Mont.: Women's Resource Center, 1979), pp.11–17, 34.

[13]Inaugural editorial, *Le Radium*, Jan. 1904, *1*:2, trans. Spencer Weart (I thank Dr. Weart for this and the three following quotations); Sir William Crookes, "Modern Views on Matter," *Scientific American Supplement*, July 1903, *56*:23014; Hans Reichenbach, *Atom and Cosmos: The World of Modern Physics*, trans. and rev. Edward S. Allen (New York: Macmillan, 1933), p. 222; editor's note in *Harper's*, July 1924, *149*:251, as quoted in Daniel Kevles, *The Physicists* (New York: Knopf, 1978), p. 174.

Such language has by no means vanished from current science. Newscasters describing the May 1980 erruption of Mount St. Helens in Washington interviewed a geologist who had become an instant vulcanist:

> Question: What is going to happen next to Mount St. Helens?
> Geologist: We can't tell what she's going to do. Her flanks are shuddering . . . . We don't know her intentions. Scientists haven't been able to probe her deeply enough with their instruments.[14]

While such quotations may be suggestive of sexual assaults on nature, and can be so viewed when placed in the perspective of the historical evolution of the language and metaphor of science, further work is needed. The meaning of scientific metaphor changes over time and is integrally tied to its historical context. Only context can shed light on the meaning of language for a given society at a given historical moment.

Historians of science have appropriated these same culturally derived sexual metaphors in their presumedly objective histories of scientific development. Reproductive metaphor betraying a masculine bias abounds in the writings of both male and female historians and philosophers of science who eulogize the rationality of the scientific world view. A woman historian of science writes:

> Whereas the physicists believed themselves to be approaching the position of Laplace's omniscient intelligence, the philosophers came to abandon the hope that scientific methods can lead to certainty or even penetrate the veil of appearances. . . . Even Laplace could not penetrate into the "secret springs and principles" producing these phenomena. . . . For Hume a science based on appearances can never penetrate into the real essences of things and yield necessary laws of nature.[15]

Like scientists, historians of science accept without hesitation or critical comment the linguistic identification of nature with the female. When translating from languages with a feminine gender, they retain feminine forms rather than translate feminine articles as "it." Thus John Heilbron quotes Fontenelle: "Or so it was for those who held with Fontenelle that 'nature is never so admired as when she is understood.'" Heilbron may be preserving Fontenelle's intent, but philosopher and systems theorist C. West Churchman appropriates Baconian sexual language in his description of the classical laboratory: "Finally we should note the basic assumption of the classical laboratory—namely, that nature is neither capricious nor secretive. If nature were capricious, she would tell one observer one thing and another observer a quite different thing. . . . Also nature is not secretive, in the sense that she will not forever hide certain aspects of her being. . . ."[16]

Judged within the context of these examples, the sexual overtones of the following quotation from George Sarton become increasingly clear:

[14]Geologist Marvin Beeson, Portland State University, paraphrased excerpts from two television interviews, May 1980. I thank John Sinton and Michael Reardon for this information. Ironically the name St. Helens, which lends credence to the identification of the mountain as female, is not named for a (nonexistent) female saint, but for Alleyne Fitzherbert, Baron St. Helens (1753–1839).

[15]Margaret J. Osler, "Certainty, Scepticism, and Scientific Optimism: The Roots of Eighteenth-Century Attitudes toward Scientific Knowledge," in Paula Backscheider, ed., *Probability, Time, and Space in Eighteenth-Century Literature* (New York: AMS Press, 1979), pp. 3–28; on pp. 3, 21.

[16]John Heilbron, *Electricity in the 17th & 18th Centuries* (Berkeley: Univ. California Press, 1979), p. 43; C. West Churchman, *The Systems Approach and Its Enemies* (New York: Basic Books, 1979), p. 57.

> I read this morning in the paper that a man called John O'Brien died suddenly in Boston while he was watching a wrestling match. . . . His was probably a heart case, and the wrestling excited him overmuch. I have no trouble in understanding that, and my sympathy goes out to him, for I have been deeply moved time after time while I was contemplating my fellow men wrestling not with other men but with nature herself, trying to solve her mysteries, to decode her message.[17]

The final goal of positivist science is to wrest from Isis the secrets she harbors within. The real meaning Sarton attached to Isis as patron of the history of science, then, is to be found within the linguistic tradition of the sexual conquest of nature. Through such examples historians of science can become aware of the ways in which sexual biases have permeated their own work and help to liberate Isis from culturally derived sexual values.

WOMEN AND SCIENCE

The third area in which a feminist perspective can generate new interpretations in the history of science is on the level of substructure: the influence of social roles on scientific theory, the role of women in science, and the sciences historically associated with women. Much history of science has followed George Sarton in associating the progress of science, the rise of human culture, and the fulfillment of human destiny with men:

> We have some degree of interest in every *man and woman* whom we approach near enough. Should we not be even more interested in those *men* who accomplish more fully the destiny of the race? . . . The same instinct which causes sport-lovers to be insatiably curious about their heroes causes the scientific humanist to ask one question after another about the great men to whom he owes his heritage of knowledge and culture. In order to satisfy that sound instinct it will be necessary to prepare detailed and reliable biographies of the men who distinguished themselves in the search for truth.[18]

By contrast, female roles in science and female scientists are now being resurrected from obscurity and reinterpreted, not according to a great woman theory paralleling the great man approach of Sarton, but from the perspective of women as a sociological group challenging cultural norms that militate against their participation in science. Women with feminist perspectives on science, such as Margaret Cavendish, Mary Astell, and Mary Wollstonecraft, are being studied along with women's scientific work in such fields as astronomy, mathematics, chemistry, and geology. How some scientific fields became professionalized along gender lines that functioned to exclude women, while others such as nutrition, home economics, and teaching became feminized, is also being addressed.[19]

[17]George Sarton, *The Study of the History of Science* (New York: Dover, 1936), pp. 41–42.

[18]*Ibid.* Italics added.

[19]Bibliographies on women in science include Audrey B. Davis, *Bibliography on Women: With Special Emphasis on Their Roles in Science and Society* (New York: Science History Publications, 1974); Phyllis Zweig Chinn, *Women in Science and Mathematics Bibliography* (Washington, D.C.: American Association for the Advancement of Science, 1979); Michele Aldrich, "Review Essay: Women in Science," *Signs*, Autumn 1978, *4*(1):126–135; John Ernest, *Mathematics and Sex* (Santa Barbara, Calif.: Mathematics Dept., Univ. California, n.d.). On Margaret Cavendish and Mary Astell see Hilda Smith, "Feminism and the Methodology of Women's History," in Berenice A. Carroll, ed., *Liberating Women's History* (Urbana: Univ. Illinois Press, 1976), pp. 368–384, on pp. 378–380; Merchant, *Death of Nature*, pp. 268–274; Gerald Dennis Meyer, *The Scientific Lady in England* (Berkeley: Univ. California Press, 1980). On Mary Wollstonecraft see Lois Magner, "Women and

One example of a field traditionally associated with women is botany. Women healers, women's knowledge of herbal properties, the cultivation of herb gardens by women, and the study of Elizabethan herbal handbooks written by women offer rich areas for further investigation. The role of sexual stereotyping in plant study is not completely straightforward. In the eighteenth century, as Ann Shteir has shown, the Linnaean sexual system of classification led to the use of language derived from human behavior as categories of plant taxonomy—virgins, concubines, eunuchs, polygamists. This sexualization of the field then prompted men, as Richard Polwhele did in 1798, to condemn female botanizing as a lascivious form of vicarious sex. But botany provided many women with an intellectual pursuit in which they enthusiastically participated.[20]

Indeed so culturally ingrained had been the association of women with plants that botany had some difficulty establishing itself as a profession appropriate for men. In 1887 J. F. A. Adams felt compelled to write an article entitled "Is Botany a Suitable Study for Young Men?" "An idea seems to exist in the minds of some young men," he began, "that botany is not a manly study; that it is merely one of the ornamental branches, suitable for young ladies and effeminate youths but not adapted for able-bodied and vigorous-brained young men who wish to make the best use of their powers." His defense of botany has a familiar ring. Botany offered men thorough mental training and opportunities to "harden their muscles" and "amid the solitudes of nature, to penetrate her wondrous mysteries." Not only have botanists had difficulty demonstrating that botany was conducive to "a vigorous mind and body and a robust character," but historians of botany seem to have

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the Scientific Idiom," *Signs*, Autumn 1978, *4*(1):61–80. Works on women scientists include H. J. Mozans, *Woman in Science* (1913; Cambridge, Mass.: MIT Press, 1977) [see *Isis*, 1977, *68*:111—eds.]; Lynn S. Osen, *Women in Mathematics* (Cambridge, Mass.: MIT Press, 1974); Marie Louis Dubreil-Jacotin, "Women Mathematicians," in *Great Currents of Mathematical Thought*, ed. Le Lionnais (New York: Dover, 1970); Helen Wright, *Sweeper of the Sky: The Life of Maria Mitchell, First Woman Astronomer* (New York: Macmillan, 1949); Eve Merriam, "Maria Mitchell," in *Growing Up Female in America: Ten Lives* (New York: Doubleday, 1971); Herman S. Davies, "Women Astronomers, 400 A.D.–1750," *Popular Astronomy*, May 1898, *6*:128–229; Deborah Warner, "Women Astronomers," *Natural History*, May 1979, *88*(5):12–26; P. V. Rizzo, "Early Daughters of Urania," *Sky and Telescope*, 1954, *14*:7–10; Lois Barber Arnold, "American Women in Geology: A Historical Perspective," *Geology*, 1977, *5*:493–494; Susan Schacher, ed., *Hypatia's Sisters: Biographies of Women Scientists—Past and Present* (Seattle: Feminists Northwest, 1976); George Basalla, "Mary Somerville: A Neglected Popularizer of Science," *New Scientist*, 1963, *17*:531–533; Elizabeth C. Patterson, "Mary Somerville," *British Journal for the History of Science*, 1969, *4*:311–339; Sherida Houlihan and John H. Wotiz, "Women in Chemistry Before 1900," *Journal of Chemical Education*, 1975, *52*:362–364; Joan Hoff Wilson, "Dancing Dogs of the Colonial Period: Women Scientists," *Early American Literature*, 1973, *7*:225–235; Joan N. Burstyn, "Women in American Science," *Actes du XI^e Congress International d'Histoire des Sciences*, 1965 (pub. 1968), *2*:316–319; Deborah Warner, "Science Education for Women in Antebellum America, " *Isis*, 1978, *69*:58–67; Carolyn Merchant Iltis, "Madame du Châtelet's Metaphysics and Mechanics," *Studies in History and Philosophy of Science*, 1977, *8*:29–48; Anne Sayre, *Rosalind Franklin and DNA* (New York: Norton, 1975); Eve Curie, *Madame Curie*, trans. Vincent Sheean (Garden City, N.Y.: Doubleday, 1937); Joan Dash, *A Life of One's Own* (New York: Harper & Row, 1973), ch. on Maria Goeppert-Mayer. On professionalization see Margaret Rossiter, "Women's Work in Science, 1889–1910," *Isis*, 1980, *71*:381–398; Sally G. Kohlstedt, "In from the Periphery: American Women in Science, 1830–1880," *Signs*, Autumn 1978, *4*(1):81–96; Margaret Rossiter, "Women Scientists in the United States Before 1920," *American Scientist*, 1974, *62*:312–323.

[20]Ann Shteir, "With Bliss Botanic: Women and Plant Sexuality," and Susan Groag Bell, "Women Create Gardens in Male Landscapes," papers read at the 11th Annual Meeting of the American Society for Eighteenth Century Studies, San Francisco, Apr. 1980; Richard Pohlwhele, *The Unsexed Females* (1798; New York: Garland, 1974), pp. 8–9. On the early history of botanic drugs see Edith Grey Wheelwright, *The Physick Garden: Medicinal Plants and Their History* (Boston: Houghton Mifflin, 1935); Joseph E. Meyer, *Nature's Remedies* (Hammond: Indiana Botanic Gardens, 1934).

had equal trouble dissociating it from "the markedly feminine connotation that has been botany's doubtful fate."[21]

Equally rewarding would be an investigation of zoology, including the roles women have played in the development of the field and its professionalization along lines that may have helped exclude them, but especially the influence of social assumptions about women on zoological studies and theory. Historically women have been associated with animality, particularly in regard to sexual desire. Renaissance writers associated the supposed sexual lust of women with a greater preponderance of animal passions, the Christian church saw female sexual desire as the downfall of the male, and the Protestant John Knox (1505–1572) equated the "inordinate appetites" of untamed women with those of beasts. More recently Donna Haraway has investigated the influence of social structure on the history of primate investigation. She examines scientific assumptions and values concerning male-female dominance hierarchies, the infusion of economic and sex-biased language into scientific description, and differences in interpretations made by male and female scientists.[22]

The evolving controversial field of sociobiology, which explicitly seeks the roots of social behavior in animal behavior, offers especially egregious examples of culture-laden language. Sociobiologists' use of such terms as adultery, rape, divorce, monogamy, polygamy, infanticide, and prostitution either legitimates human sexual activities as "natural" or condemns them as "unnatural." Violent attacks by male bluebirds on females who have committed "adultery," "rape" by male mallard ducks when a surplus of males exists, "homosexuality" in acanthocephalan worms, "divorce" in kittiwakes, and "lesbianism" among California gulls are more than just catchy words used to popularize the new field. One sociobiologist, David Barash, asks: "Is it mere coincidence that when a woman is raped, her husband or lover often responds either by rejecting her (mountain bluebird style), or by being remarkably 'turned on' (like the mallard duck)?"[23]

The history of scientific theories of sex differences, reproduction, and childbirth offers further examples of the influence of culture on science as it affects women. Historians have examined ancients—Plato, Aristotle, and Galen—and moderns—William Harvey, Charles Darwin and their followers—who wrote on male-female differences in generation, sexuality, and intellectual activity. The biology of Aristotle, which assumed the activity of the male and passivity of the

[21]Quoting J. F. A. Adams, M.D., "Is Botany a Suitable Study for Young Men?" *Science*, 1887, *9*:117–118; David Allen, *The Naturalist in Britain* (London: A. Lane, 1976), p. 28. See also Emmanuel D. Rudolph, "How it Developed that Botany was the Science Thought Most Suitable for Victorian Young Ladies," *Children's Literature*, 1973, *2*:92–97; and (on botany, plant pathology, and professionalization) Rossiter, "Women's Work," pp. 387–388.

[22]Donna Haraway, "Animal Sociology and a Natural Economy of the Body Politic," *Signs*, Autumn 1978, *4*(1):21–36, 37–60; Haraway, "The Biological Enterprise: Sex, Mind, and Profit from Human Engineering to Sociobiology," *Radical History Review*, 1979, *20*:206–237. On women, the animal passions, and violence see Merchant, *Death of Nature*, pp. 132–140; Natalie Zemon Davis, "Men, Women, and Violence: Some Reflections on Equality," *Smith Alumnae Quarterly*, Apr. 1977; John Knox, *The First Blast of the Trumpet Against the Monstrous Regiment of Women*, in Edward Arber, ed., *The English Scholars Library* (London, 1878), Vol. II, p. 30; Vern Bullough, *The Subordinate Sex* (Baltimore: Penguin, 1974), p. 98.

[23]For examples of sexual metaphor in sociobiology see David Barash, "Sexual Selection in Birdland," *Psychology Today*, March 1978, pp. 82–86, quoting p. 86; Barash, "Sociobiology of Rape in Mallards (*Anas platyrhynchos*): Responses of the Mated Male," *Science*, 1977, *197*:788–789; Barash, "Male Response to Apparent Female Adultery in the Mountain Bluebird (*Sralia currucoides*): An Evolutionary Interpretation," *American Naturalist*, 1976, *110*:1097–1101; Lawrence G. Abele and Sandra Gilchrist, "Homosexual Rape and Sexual Selection in Acanthocephalan Worms," *Science*, 1977, *197*:81–83. For a feminist response see Marian Lowe, "Sociobiology and Sex Differences," *Signs*, Autumn 1978, *4*(1):118–125.

female to be "natural," was reinforced by William Harvey in the seventeenth century; the assumption continued to hold implications for women's roles and social position. After the Darwinian revolution variability, the basis for evolutionary progress, was used to explain women's intellectual inferiority, since more of women's energy was thought to be directed toward pregnancy, lactation, and nurture with less available for learning and reasoning. Historians have focused on the contemporary challenges to these theories made by both women and men and on alternative theories.[24]

The study of women's actual scientific achievements is insufficient unless the social factors that have excluded women from the scientific professions are also considered. Yet not all claims to have examined these factors are reliable. The recent book *Fair Science* by Jonathan Cole, which presents a sociological analysis of women in science, attempts to demonstrate that science is fair and that "the measureable amount of sex-based discrimination against women is small." To feminist critics, however, his analysis is grossly inadequate because of the nature of his assumptions, the biased interpretation of data, the lack of qualitative sources, and the skewing that results from his drawing data from fields with higher female entry—biology, chemistry, psychology, and sociology. Cole's conclusions might well have been altered had he included mathematics, physics, engineering, and computer science, or considered female isolation, women's lower access to the means of scientific production, and the importance of tenure and higher academic status in determining visibility and access to honorifics.[25]

CONCLUSION

Having delineated what seem to me to be three useful approaches to criticizing and recasting the history of science, I would like to conclude with a plea for new historical syntheses in all fields and periods of the history of science. A feminist perspective can help to redefine the broad periods of scientific change. Those in which scientific or technological advance may seem most marked from a male point of view may appear retrograde when women's issues are included. Feminist history of science offers the potential for syntheses with traditional approaches that could lead to major new interpretations in our discipline as a whole.

[24]On the ancient world see Maryanne Cline Horowitz, "Aristotle and Woman," *Journal of the History of Biology*, 1976, *9*:183–213; Caroline Whitbeck, "Theories of Sex Difference," *Philosophical Forum*, 1973/74, *5*:54–80; Anne Dickason, "Anatomy and Destiny: The Role of Biology in Plato's Views of Women," *ibid.*, pp. 45–53. On early modern Europe see Merchant, *Death of Nature*, pp. 149–163; Hilda Smith, "Gynecology and Ideology in Seventeenth-Century England," in Carroll, ed., *Liberating Women's History* (cit. n. 19), pp. 97–114; Jean Donnison, *Midwives and Medical Men* (New York: Schocken, 1977). On the modern period see Stephanie A. Shields, "Functionalism, Darwinism, and the Psychology of Women," *American Psychologist*, 1975, *30*:739–754; Rosalind Rosenberg, "In Search of Women's Nature, 1850–1920," *Feminist Studies*, 1975, *3*(1–2):141–154; Diana Long Hall, "Biology, Sex Hormones, and Sexism in the 1920s," *Phil. Forum*, 1973/74, *5*:81–96; Elizabeth Fee, "The Sexual Politics of Victorian Social Anthropology," in Mary Hartman and Lois Banner, eds., *Clio's Consciousness Raised* (New York: Harper Colophon, 1974), pp. 86–102; Estelle Ramey, "Sex Hormones and Executive Ability," *Annals of the New York Academy of Sciences*, 1973, *208*:237–245; Joan N. Burstyn, "Brain and Intellect: Science Applied to a Social Issue, 1860–1875," *Actes XII^e Cong. Int. Hist. Sci.*, 1968 (pub. 1971), *9*:13–16; J. Burstyn, "Education and Sex: The Medical Case Against Higher Education for Women," *Proceedings of the American Philosophical Society*, 1973, *117*:79–89; Eliza Gamble, *The Sexes in Science and History: An Inquiry into the Dogma of Women's Inferiority to Men* (New York: Knickerbocker, 1916).

[25]Jonathan R. Cole, *Fair Science: Women in the Scientific Community* (New York: Free Press, 1979), quoting p. 86. For critical reviews see Karen Oppenheim Mason, "Sex and Status in Science," *Science*, 1980, *208*:277–278; and Margaret Rossiter, "Fair Enough?" *Isis*, 1981, *72*:99–103.