NATURE AND ITS TRANSFORMATIONS

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Every view of nature connotes a view of the human subject as knower and moral agent, and it is my purpose to explore the implications of this fact. The subjectivity implied by an objective claim cannot, however, be studied by making it the object of some form of direct inquiry like introspection, in which data are collected, analyzed, and finally subsumed under a theory. The subject as subject cannot, of course, be the object of direct scrutiny by the subject. By studying the forms of objectivity assumed to be present in nature, one can, however, infer the forms of subjectivity that are presupposed. Inquiry of this kind must proceed according to phenomenological method, the purpose of which is to uncover the noetic pole (that is, the vector of research and inquiry) constitutive, with the noematic (or objective) pole, of the noetic-noematic (subject-object) intentionality structure within which the form of the question and the form of the answer mutually determine one another.

Sedimented in common usage are two meanings for nature:[1] one opposes it to the artificial, the man-made; the other opposes it to mind or spirit, the domain of meaning, culture, and values. Let me call the first the Aristotelian or romantic sediment, where nature is conceived as impregnated with rational purpose and striving, manifesting the logos of a cosmic organism—a logos that man can co-operate with for his good or violate to his destruction. In this view, man is a part of nature, illuminated spiritually by nature's logos and subject to its moral imperatives. His freedom to modify the course of nature by artificial interventions is limited by objective rules stemming from the supreme imperative of maintaining the harmony of nature as a whole. Christianity came to assimilate this view when it took over the cultural world of Greece and Rome. Nature's logos became the divine ideas, and the natural (or moral) law became the participation by man in God's eternal law. Man was not seen as creative of nature's logoi or of any part of the natural law. These were given to him as a body of articulated and preordained goals furnished with divine sanctions and communicated through the light of natural reason aided by the supernatural grace of God.

The second meaning of nature has its source in the scientific movement of the fifteenth and sixteenth centuries, which, inspired by

[1] For a historical study of the concept of nature, see R. G. Collingwood's classic work *The Idea of Nature* (Oxford: Clarendon, 1945).

Platonic and Archimedean conceptions, set out to mathematize motion and so to geometrize nature.[2] Under the forceful imagination of the pioneers of modern science, such as Galileo, Newton, and Descartes, nature came to be seen as a display of articulated geometrical parts, on the model of a clockwork machine, organized to fulfil purposes that were outside of itself. Separated from the meanings and purposes that accrue to them from spirit, the parts of nature were empty of significance or moral value, mere pieces of inert matter. Consequently, the old distinction so important in the preceding centuries between the natural and the unnatural collapsed, for nature in the new sense was neutral to good or evil. What counted was man's moral purpose and the efficacy of his intervention in nature. That efficacy, according to one widely accepted view, that of Francis Bacon, was given by natural science, which was held to be in essence nothing more than the power to transform nature in order to carry out man's moral purposes.[3] The moral purposes, however, were not in nature but dwelt in the world of spirit apart from nature. This left nature to be no more than raw material to be exploited by the skilful use of scientific knowledge. Spirit, on the other hand, was the domain where the self and the person presided, where motives and values were weighed, intensional objects related, and emotions experienced. Although all of these interacted or seemed to interact with nature, none of the parameters of spirit entered into the scientific account of nature. Nature obeyed blind deterministic laws unresponsive to the influence of good or bad motives, while the conservation laws of physics allowed of no exception that would permit the energy of spirit to flow into or out of the reservoir of nature's total energy pool. Spirit played no explanatory role in natural science, and nature conceived as a scientific object was alien to spirit or mind.

CHRISTIANITY AND THE ECOLOGICAL CRISIS

A twentieth-century view that traces the split between man and nature to the Judeo-Christian tradition, which is then held responsible for the present ecological crisis in the West, is currently being argued by Lynn White, Jr.[4] He claims that, by stressing otherworldliness or

[2] For a summary of the consequences for philosophy and theology of the classical scientific concept of nature, see Ian Barbour's *Issues in Science and Religion* (Englewood Cliffs, N.J.: Prentice-Hall, 1966).

[3] Cf. Francis Bacon, *Novum organon.*

[4] Lynn White, Jr., "The Historical Roots of Our Ecological Crisis," *Science* 155 (1967) 1203-7, reprinted in White's *Machina ex Deo: Essays in the Dynamism of Western Culture* (M. I. T. Press, 1968). Some of the debate over White's thesis was reported in *Science* subsequent to the publication of his paper.

the grace of the supernatural life here and hereafter, Christianity alienated man from his earthly environment and prevented him from making nature his home. Moreover, the biblical command putting man in charge of all creatures to conquer and subdue them[5] engendered an exploitive attitude towards nature that, together with the other-worldly bias of Christianity, encouraged the sort of irresponsible conduct that had led to the present ecological crisis in the West. White's biblical exegesis, however, is inadequate: it fails to take into account the context of the passages in Genesis showing that the sacred author's concern was not to give permission to do whatever man pleases with nature but to teach monotheism, namely, that there is one God, Yahweh, the Lord of both man and nature, and that man does not need the help or permission of gods other than Yahweh to exercise his cultural arts and crafts. There is nowhere implied an encouragement or permission to exploit natural resources irresponsibly, and in fact such encouragement or permission was never inferred. On the contrary, the Scriptures and especially later Christian teaching in its Hellenistic phase advocate a simplicity of life-style that generated a deep reluctance to exploit nature on a large scale.[6] It was not until the scientific revolution redefined nature as alien to spirit, and spirit as soul, having a being and life alien and transcendent to nature, that we begin to see in the West the development of the kind of amoral conscience about natural resources that White criticizes. This attitude is characteristically that generated by the philosophy of the scientific movement which in the eighteenth century so imposed itself on the intellectual traditions of the West that with some reluctance, particularly in the Catholic Church, it gradually co-opted even the expression of Christianity itself, promoting the spread of dualistic doctrines of body and soul, the natural and the supernatural, this life and the next. These dualisms alienated large sections of the Christian community from the secular scientific world that was, by these doctrines, effectively subtracted from the domain of moral and religious values. Such an effect is less the result of Christianity than of the cultural imperialism of classical science imposing its categories even on man's religious self-understanding. Only in the last decade or so has the Christian community begun to rediscover its authentic secular role and the theological foundations for this in Scripture, tradition, and the life of the Holy Spirit in the Church.

[5] Gn 1:26-29; 2:18-20; Sir 17:2-4.

[6] We find, e.g., the virtues of good husbandry extolled for its religious symbolism, Hos 10:12-13, Is 28:23-29, and the beauty of untouched nature, e.g., of cedars, olive trees, vines, etc., compared with the harmony of the divine attributes, Sir 24:13-30.

CRITIQUE OF CLASSICAL SCIENTIFIC NATURE

This view of nature, widely held by the scientific community, has not gone unchallenged. It became the focus for vigorous, even polemical, criticism, particularly on the Continent after World War II. Its defects were seen as objectivism, scientism, and technicism. Objectivism is the dogmatic assumption that an objectivity which simply ignored the role of human subjectivity in its generation, or else treated it on the model of an uninvolved spectator-subject of natural phenomena, was necessary for scientific knowledge. Its core assumption is that the objects of human objectivizing thought re-present things as they exist independently of human intentionality structures. Consequently, the difference between ontic and ontological levels is dogmatically suppressed,[7] and the world becomes an objective world-picture, already-out-there-now-real, to use Lonergan's term,[8] to which the human spirit adds the cultural superstructure of a *Weltanschauung* or world-perspective. Objectivism is one of the more baneful and pervading influences of Cartesian science. To cite Maurice Merleau-Ponty about this kind of science:

> Science is a second-order expression [of the world]. Science has not and never will have by its nature the same significance *qua* form of being as the world which we perceive, for the simple reason that it is a rationale or explanation of the world.... Scientific points of view according to which my existence is a moment of the world's are always both naive and at the same time dishonest, because they take for granted without explicitly mentioning it, the other point of view, namely that of consciousness, through which from the outset a world forms itself round me and exists for me. To return to things themselves is to return to that world which precedes knowledge, of which knowledge always *speaks* and in relation to which every scientific schematization is an abstract and derivative sign language, as in geography in relation to the countryside in which we have learnt beforehand what a forest, a prairie and a river is.[9]

The view of science criticized in this passage is that of a science concerned only with abstract models or constructs, and not with things seen, felt, observed by, or given to an embodied human subject.[10]

[7] Cf. Martin Heidegger, *Holtzwebe* (Frankfurt: Klostermann, 1950) pp. 82–88; William Richardson, *Heidegger: Through Phenomenology to Thought* (The Hague: Nijhoff, 1963) p. 326; J. J. G. Kockelmans, "L'Objectivité des sciences positives d'après le point de vue de la phénoménologie," *Archives de philos.* 27 (1964) 339–55.

[8] Bernard J. F. Lonergan, *Insight* (London: Longmans, Green, 1957). See also his *Method in Theology* (London: Darton, Longman & Todd, 1971).

[9] Maurice Merleau-Ponty, *The Phenomenology of Perception*, tr. Colin Smith (London: Routledge and Kegan Paul, 1962) pp. viii-ix.

[10] See also Edmund Husserl, *The Crisis of European Sciences and Transcendental Phenomenology*, tr. D. Carr (Evanston: Northwestern Univ. Press, 1970).

The second criticism of classical science is its cultural imperialism, that is, the dogmatic belief, called scientism, that the positive sciences are in principle capable of answering all meaningful questions, that philosophy and theology are prescientific stages in the thrust towards positive science, and that these are destined to wither away in a properly scientific culture.[11] It is the function of philosophy, says Boehm, a spokesman for Continental phenomenology, to challenge the imperialism of science, since it is a threat to the very existence of philosophy.[12] Philosophy, following Husserl, is the only rigorous science or *Wissenschaft*, that is, it alone among the branches of knowledge challenges both its own foundations and those of everything that claims to be knowledge.[13]

The third criticism of classical science is technicism, that is, that science is no more than a techne, albeit a very successful one, for manipulating and exploiting nature.[14] The manipulatory character is shown by its use of functional concepts, which are ways of relating mere entities, the extrinsic terms of a set of implicitly defined relations and, like Lockean substances, unknowable in themselves. Scientific research, wrote Heidegger in *Being and Time*, is an "attack on the object,"[15] since processes of measurement impose Procrustean restrictions on the manner of appearing of ontic beings, restrictions that tend to conceal the ontological Being of ontic beings. This will to dominate the earth through science is, for Heidegger, the special way in which the forgetfulness of the ontological difference, that is, of the Being dimension of beings, is crystallized in contemporary society.

That the philosophical positions of objectivism, scientism, and technicism are deeply engrained in our culture, and that they are historically linked with the development of science, cannot be denied. This has been pointed out by numerous philosophers and theologians, historians and

[11] A current expression of the scientific imperialism referred to is B. F. Skinner's *Beyond Freedom and Dignity* (New York: Knopf, 1971). Skinner writes: "What is abolished [by the scientific study of man] is the man defended by the literatures of freedom and dignity" (p. 200).

[12] Rudolf Boehm, "Les sciences exactes et l'idéal husserlian d'un savoir rigoureux," *Archives de philos.* 27 (1964) 425.

[13] Cf. Edmund Husserl, "Philosophy as Rigorous Science," in *Edmund Husserl: Phenomenology and the Crisis of Philosophy*, tr. Q. Lauer (New York: Harper & Row, 1965) pp. 69–147.

[14] See, e.g., Friedrich Nietzsche, *The Will to Power*, tr. Walter Kaufmann and R. J. Hollingdale (New York: Vintage, 1968) p. 328; or, e.g., the contemporary critique of sociologists Theodore Roszak, *The Making of a Counterculture* (New York: Doubleday, 1969) and Floyd W. Matson, *The Broken Image* (New York: Braziller, 1964).

[15] Martin Heidegger, *Being and Time*, tr. J. Macquarrie and Edward Robinson (London, SCM, 1962) p. 122.

sociologists—to mention a few, Edmund Husserl, Alfred North Whitehead, Gabriel Marcel, Paul Tillich, Jacques Ellul, Lewis Mumford, and Theodore Roszak.[16] I do not dispute the historical association of natural science with the widespread entrenchment of an inadequate philosophy of nature in the Western community. What I shall be concerned to show in the following pages is that natural science could coexist in our culture with a view of nature that is not ridden by objectivism, scientism, and technicism, but that enjoys instead the historical, hermeneutical, and dialectical dimensions banished from the view of nature criticized above.

SUBJECTIVITY, OBJECTIVITY, AND LANGUAGE

I propose to develop two related notions in which the missing dimensions are restored to nature: they are the manifest image of nature and the scientific image of nature.[17] The manifest image presents nature as the arena of observable events and processes in which human actions have observable consequences, and which is the perceived pregiven context for practical moral judgments. In order to articulate with greater precision the character of the manifest image, we need to introduce and clarify certain technical concepts.

An object is given (that is, as a noema) when it is a response to a noetic orientation of the subject that grasps this noema immediately (without inference) as the appropriate object of its inquiry. The structure of the inquiry that is presupposed by the act of re-cognition is called an intentionality structure: on the noetic or subjective side is a structured vector of inquiry embodied in appropriate empirical behaviors; on the noematic or objective side is the empirical object manifesting itself immediately—once the warranting procedures are complete—as the appropriate term of the inquiry. The mode of givenness of the object is not or need not be primordial, that is, independent of past history, learning experiences, linguistic conventions, or the use of instrumental aids to observation. Its givenness consists simply in this, that the object is not as a matter of fact inferred: the subject reaches it by observation, without the media-

[16] Edmund Husserl, *art. cit.*; A. N. Whitehead, *Science and the Modern World* (New York: Mentor, 1925); Gabriel Marcel, *The Mystery of Being* (Harvill Press, 1950); Paul Tillich, *Theology of Culture* (London: Oxford Univ. Press, 1959); Jacques Ellul, *Technological Society*, tr. John Wilkinson (New York: Knopf, 1964); Lewis Mumford, *The Myth of the Machine* (New York: Harcourt, Brace, 1967); Theodore Roszak, *op. cit.* For further references see Victor Ferkiss, *Technological Man: The Myth and the Reality* (New York: Braziller, 1969).

[17] These terms are used by Wilfred Sellars in his *Science, Perception and Reality* (London: Routledge and Kegan Paul, 1963) but not quite in the sense here proposed. For a fuller expression of the present author's view, see "Horizon, Objectivity and Reality in the Physical Sciences," *Internat. Philos. Qrtly.* 7 (1967) 375–412.

tion of the kind of argumentation that moves from what is seen to the positing of something unseen. The act of observation connotes that what is observed is real and objective; that is, that other trained observers would observe what is being observed and that the object so observed does not depend for its here-and-now existence on the recognition by an observer of its facticity. When trained, a person can observe electrons, mitochrondria or white dwarf stars with the aid of an appropriate instrument. Training does not preclude observation, nor for that matter does the fact that observational techniques are sometimes based on the inferences of a highly abstract theory, nor the fact that observational techniques need to be warranted by indirect tests before they can be trusted as channels for observational data. All this goes to show that observation can be, and generally is in fact, theory-laden: theory makes observation possible by making experimentation and reliable instrumentation possible. Although theoretical inference and observation are epistemologically opposed, the fact that an object is theoretically inferred in one context of inquiry does not preclude that the same object be observationally given in another context. The only sense of "given" in which the given is a myth is that in which it is supposed that antecedent to personal history, learning, linguistic conventions, and the use of instruments there are primordially given objects of human experience, whether sense data or other more solid objects.

The repertory of possible objects, objective situations, and processes that could be given in response to a noetic intention of a particular kind constitutes the horizon of that intention. A horizon is the open set of objects, or objective discriminations that could be made through the use of a warranted empirical noetic intention.

Empirical noetic intentions are multiple. There are, then, multiple horizons, and together these constitute nature.

Empirical noetic intentions are embodied in the behaviors of the subject. It is not precluded that such behaviors use instrumental extensions of the sensory organs. Such instrumental extensions, when used as channels for observational data, belong to the subject or first-person side of the subject-object cut. Their response is not focally attended to or observed in the same act in which the object is observed: their role is to be read like a written text, which mediates meanings, not as an object, but as a physical modification of the reading subject. The appropriate body through which a particular noetic observational intention acts is variable. A blind man, as Merleau-Ponty points out, is present up to the tip of the cane that taps the sidewalk: he is embodied in his cane.[18]

[18] Merleau-Ponty, *op cit.*, p. 143. The same idea is expressed by Michael Polanyi in *Personal Knowledge* (Chicago; Chicago Univ. Press, 1958).

A driver "feels" the road, and his cognitive intention dwells in the bulk of the moving car he controls; the car is part of the subject, not of the objective horizon in which he moves.

A descriptive language is the historical projection in words at a given time-epoch of the possible objective content of a horizon. Intentions, embodiments, and horizons become the shared possessions of cultural communities through language. In language, moreover, are stored the results of the progressive exploration of a horizon, connoting the functioning throughout this development of an invariant intention. A descriptive language, then, is a historical entity, with a historical development unfolding the potentialities of an invariant empirical noetic intention and an invariant horizon.

Descriptive language, however, is applied properly only to objects as objects. Subjects as subjects, though dwelling in physical bodies and incarnated in physical behaviors, are not objects, at least not of descriptive language, and consequently they do not fall within the purview of objective descriptive intentions. The subject as such is reached experientially only by a kind of reflexion that reveals indirectly the presence and activity of the noetic pole in an inquiry, and language about the subject as such rests for its warrant on arguments of a transcendental sort which attempt to articulate the aprioristic conditions of possibility of an experienced horizon.

The Manifest Image of Nature

To return to the manifest image of nature: the manifest image is characterized by those noetic intentions that give objects as directly related to needs and desires, or the goals of a human life-style, or to discriminations made possible by the sensory organs aided, perhaps, by instruments. Such objects, then, are manifested in their being as essentially relative to a human subject: they are thing-to-subject kind of things, processes, or events. Moreover, objects of any sort will manifest themselves as given only if the human subject possesses the appropriate life-style and consequently is committed to the framework of values presupposed by that life-style. Objects, then, are observed (or given) to the extent that they are appropriated by the subject through his involvement with a set of communally shared values. This double relation—formal and final (or axiological)—to human subjects makes the manifest image, the locus for thing-to-subject-for-subject manifestations of events, processes, or enduring entities.

The Scientific Image of Nature

If observation is central to the manifest image, measurement is central to the scientific image. A measurement is a contrived act designed for the purpose of gaining publicly verifiable information about the state of a physical system by the use of an instrument. The instrument performs among its functions that of being a public communications medium; that is, the use of the instrument serves to withdraw the data-gathering process from the possible defects and biases of individual human judgments, and it maps the intensity of the measured quantity on the number field in such a way as to provide a record open to public scrutiny. In classical (that is, modern) science, precise, impersonal, and quantified evidence was considered necessary for scientific knowledge. The perfect instrument, it was thought, was one which interacted minimally, if at all, with the object; it played the role exclusively of a public communications medium whose modulation in the presence of the object manifested the objective *state* of the system. The scientific knower in the epistemology of classical science was an unphysical mind or spirit that itself contributed nothing to determining the physical state of a system—for physics had no parameters for the input of mind. The instrument, however, to give a reading, has to be physically coupled with the object. Thus, it cannot stand as a vicarious observer for mind. In the classical account of measurement, the instrument always perturbs the object—perhaps only to an infinitesimal degree—from its original and isolated state. An account of the measurement process that treats it exclusively as a device to obtain public, precise, and quantified information, while ignoring the fact that much information pertains properly only to a system when coupled with a physical observer embodied in an instrument, is inadequate.

A measurement is always an experiment involving the coupling of an instrument and an object through an interaction. An instrument is a kind of standardized controlled environment with which the object interacts. The environment and the coupling interaction must be such that a macroscopic effect is produced which can play the role of signal or communication medium vis-à-vis the trained human person. A scientific instrument, then, is both macroscopic matter (to be modified by physical forces) and medium (to be modulated to give a signal). An instrument "speaks" of an object by recording how this object is related to the standard controlled conditions provided by the experiment. What is given through a measurement process is, then, a thing-to-thing kind of event, or better, a thing-to-instrument kind of event, where the instrument is an artificially contrived thing (a macroscopic piece of the physical environment with which the object can interact in a controlled way) that can play the role of carrier of signals to a trained human inquirer. To the extent that the human inquirer is concerned with decoding these signals, science is a hermeneutic enterprise. But science is not a hermeneutic of natural signs, since the kind of instrumental signals used—pointers, counters, etc.—is more or less arbitrary and subject to the selection of the experimenter. Moreover, the instrumental response has meaning only for man: nature does not know of meanings apart from man. Thus, science is a hermeneutic of man-made signals produced in experimental situations, and these get their meaning from and through the community of scientific inquirers. This becomes clearer when we consider how a student learns science. He does not—with due respect to Galileo, Bacon, and Mill—study arbitrary natural phenomena, whatever is written in the book of nature; he studies how to perform and interpret experiments. Here conventional signs (pointers, etc.) are used in standardized situations to reveal otherwise imperceptible states of the system known (on the basis of theory) to be correlated with these signs. The use of measurement and experimental procedures in the way just described also involves a commitment to a structured activity of inquiry, which presupposes a framework of values. Science, then, is also *for-subject*, where the subject in question is a trained member of the scientific community. In summary, the scientific image of nature yields those horizons sketched out with reference to measurement processes, and the contents of these horizons have the logical structure, thing-to-thing-for-subject, or better, thing-to-instrument-for-subject.

The account of measurement just given places the instrument in a third-person role with the measured object: the instrument is outside the subject as a special class of object, one from which information can be inferred about the measured object. But just as in the typical hermeneutic situation, the deciphering phase of textual hermeneutics gives way to a *reading* of the text, so in scientific experiments, the deciphering (theoretical) phase of measurement gives way to a *reading* of the instrument in which immediate observational access is given to the scientific object.[19] The passage from theoretical (inferential) interpretation to observation in the use of the experimental method involves a displacement of the cut between subject and object. In scientific observation the instrument lies on the subject side of the cut and plays a first-person role: the scientific observer-subject is in this case embodied in the instrument for the purposes of observation. Such a displacement of the subject-object cut is characteristic of the development of a hermeneutic activity: first there is a sign (or text) to be deciphered and then there is a horizon to which the sign (or text) gives immediate access.

[19] See Patrick Heelan, "Towards a Hermeneutic of Natural Science," *Brit. Jour. for Phenomenology*, Sept., 1972, or the brief version in *Main Currents* 28 (1972) 85–93.

Extension of Observational Horizons through Technology

The ability to observe scientific entities is, in an important way, not restricted to scientists. Scientists design instruments and can give a theoretical account of why they function as they do. But once constructed and standardized, they can be multiplied by mass-production technology and put in the hands of persons untrained in science. For example, a Geiger counter (an instrument which responds to radiation given off by radioactive atoms) can enable an ordinary person to discriminate between radioactive and nonradioactive materials. The distinction does not have for him a properly scientific significance, which he would be incapable anyway of appreciating, but it has a vital significance relative to the dangers to health that lurk in his environment. Nature for the ordinary man becomes more complex when a Geiger counter is readily available: a person's observational faculties are increased, his domain of action is enlarged, his possibilities for making practical moral judgments are expanded.

The mass availability in our generation of technical instruments, like Geiger counters, or technical services, like temporary sterilization, made possible by theoretical scientific knowledge, provides a range of bodily extensions into the environment resulting in new forms of human subjectivity that open up horizons of nature that did not exist a generation ago. However, it should be remarked that whether such instruments and techniques are made available to the general public, which ones are made and which not—remembering that not all possible uses of science become institutionalized in our or any possible society—are decisions that in our society are made very often without formal consultation with the general public or with representatives as such of the scientific community, and without philosophical reflection on their implications, as Boehm has said. Although elective public bodies, e.g., governmental agencies of the State or Federal government, do occasionally contract with the scientific community for the development of technological means to serve a particular purpose, often a military one, the vast majority of such initiatives in our society are taken by business interests for speculative profit, motivated by what they judge to be a potential or fosterable public demand. Official public agencies in our society merely stand watchdog against health hazards, profiteering, and deceit, and when they contract for services, these are often for the purposes of making war. But the initiative to create and make available to the general civilian public a certain repertory of opportunities for human extensions into the environment lies, with doubtful consequences, almost entirely in the hands of entrepreneurial speculators.

When one realizes that man's adoption of any bodily extension, as, for example, of the automobile, telephone, or television, changes the quality of human subjectivity at least transiently, and could affect it permanently if the artifact is sufficiently pervasive in our culture and endures for many generations, we see that the power to take these initiatives is not morally or socially neutral.[20] A permanent change in the quality of human subjectivity is equivalent to a change in human nature—in the pattern of taken-for-granted embodied anticipations and powers with which the normal adult is equipped to act cognitively and morally who has learned to embody the cultural environment of his time. The ability of man to extend himself intentionally into (artificial) parts of his environment brings to light the fact that man qua cognitive and moral agent has not a body of fixed dimensions; in particular, his body does not terminate at the outer surface of his skin. It may extend beyond this or, conceivably, contract to some surface interior to it. Man, we have discovered, has the power to modify his environment by technology so as effectively to alter the range of his habitual embodiments. Such is a power to change man's nature, and is the continuation on the human level of those forces for change manifested in the evolution of biological species. This momentous power, made available by theoretical science, is exercised as a rule not by the scientific community but by other agencies ignorant of the overriding evolutionary significance of their choices and whose sense of public responsibility in this regard is in direct conflict with their more selfish interests.

Mind in the Scheme of Classical Science

If measurement and experiment are at the center of science, and if the scientific object is given to or observed by a subject embodied in the scientific instrument, then it is clear that although mind or spirit is not a parameter of the scientific object, it nevertheless has a place in the scientific scheme of things. Mind resides in the knowing subject, which is embodied in the instrument conjoined to the biological organism of the scientist. Hence, the kind of mind presupposed by science, though not an object of (physical) science, is nevertheless operative in the physical scheme of things, but always on the side of the subject. Mind or spirit, as far as science goes, is not pure disembodied soul, but the embodied subjectivity of the observer and experimenter joined to his instruments.

[20] Don Ihde, "A Phenomenology of the Man-Machine Relation," in *Work, Education and Leisure*, ed. Walter Feinberg and Hank Rosemont (Urbana: Univ. of Illinois Press, forthcoming).

Quantum Mechanics, Complementarity, and Context-Dependence

The conclusions reached in the last section on the basis of general considerations are seen to constitute the essence of that revolution from classical to quantum physics which took place in the first decades of this century. This involved a conversion from the classical model of a subjectless scientific objectivity to the subject-dependent objectivity of quantum mechanics.[21] Quantum mechanics arose as the outcome of Werner Heisenberg's reflection on the role of observables in science. By an "observable" he meant a quantity that, though not imaginable in a classical space-time model, was part of the interpretations of a mathematical model and was measurable in principle. His intuition rejected the objectivist presuppositions of classical physics and, in a profoundly significant epistemological shift, he consciously placed the measuring subject or observer at the heart of quantum mechanics. The classical physics of his time presupposed either no observer or one separated from matter and outside of history. The quantum-mechanical observer, on the other hand, is one of human scale who uses instruments of the same scale to observe quantum-mechanical events and processes. Quantum-mechanical observers, then, are as manifold as the kinds of instruments a scientist can use. The most significant discovery of quantum mechanics, however, is the fact that it is not possible to construct an instrument or a panel of instruments that will give simultaneously the values of all the observable properties of a quantum-mechanical system. The most famous expression of this surprising discovery is Heisenberg's Uncertainty Principle, which relates the measure of inaccuracy (Δx) of a position measurement (x) with the associated measure of inaccuracy (Δp) of a momentum measurement (p) according to the inequality $\Delta x \cdot \Delta p \geqslant h/2\pi$—where h is Planck's constant.

Quantum mechanics thus is concerned with contextual observations or descriptions; that is, every observation of a quantum-mechanical system is dependent on the context of the observation, which is, namely, the measuring instrument used to make an observation. The physicist Niels Bohr used the term "complementarity" for this context-dependent character of quantum-mechanical observations. Given a definite observational or descriptive context, say, that for localizing a quantum-mechanical system with precision, a horizon of possibilities (of localized phenomena) opens up. Given a different but complementary observa-

[21] Cf. P. Heelan, *Quantum Mechanics and Objectivity* (The Hague: Nijhoff 1965), and *The Observable: Observation, Description and Ontology in Quantum Mechanics* (forthcoming); "Complementarity, Context-Dependence and Quantum Logic," *Foundations of Physics* 1 (1970) 95–110.

tional or descriptive context, say, that for determining the precise momentum of a quantum-mechanical system, a new and different horizon of possibilities (of momentum-specified phenomena) opens up. However, although both horizons are objective possibilities, they cannot be simultaneously realized, since, when the two contexts are combined to form one context of observation, each modifies the other in a significant way. One complex context of observation may comprise many constituent contexts provided they be compatible with one another, but in the quantum-mechanical perspective, given any set of compatible contexts, there will always be some other contexts of observation complementary to this set which are incompatible with it. Complementary contexts are generally polar opposites, like precise position or precise momentum. They are not absolutely incompatible (or incommensurable), since they can be combined to give mixed contexts. For example, in a mixed position and momentum context, precise position or precise momentum cannot in principle be observed, but imprecise position (x) and imprecise momentum (p) can be observed and the systematic variabilities (or "uncertainties") Δx and Δp of x and p respectively will obey Heisenberg's Uncertainty Principle. What looks from the classical perspective to be a restrictive principle expressing, namely, our inability to measure simultaneously the precise position and momentum of a system, turns out, with the quantum-mechanical perspective, to be in the first instance a revelation of the context- or observer-dependent character of scientific observations. It also shows that the total scientific horizon is not revealed to any one observer, but that in addition to possible (precise) position states and possible (precise) momentum states there are those imprecise states of position and momentum together revealed in response to mixed contexts of observation. In other words, the synthesis of contexts results in an enrichment of the horizon vis-à-vis the complementary contexts—taken as thesis and antithesis—in their pure dialectical opposition.

Contexts for descriptive discourse are manifold, as has been shown. To every context, moreover, there is a horizon and a historical sequence of descriptive languages representing a tradition, ordered in linear succession towards a more and more adequate revelation of the possibilities of the horizon.

Contexts, though manifold, are not necessarily disparate, unrelated, or unrelatable. Some contexts are simply compatible and, when joined, function as an enlarged context whose horizon is simply the (set theoretic or) Boolean union of the objective possibilities of the separate horizons. That all descriptive contexts are simply compatible was a basic presupposition of classical natural science, and is the only view consonant with a spectator theory of knowing.

Contexts, however, as quantum mechanics has shown, can be incompatible but complementary; that is, though contrarily opposed in their pure states, they can be joined, and in so doing make possible the manifestations of new possibilities not contained in the pure opposites.[22] If, moreover, the passage from the separate and opposed complementary traditions to synthesis is also a historical passage, the relation is more aptly called a dialectical development. The historical synthesis of the Aristotelian and the Platonic traditions in Aquinas, or of Newtonian particle mechanics and Maxwellian electromagnetics in special relativity, are dialectical developments. Similarly, the relation between behavioristic and teleological accounts of human conduct, and between the microphysical and the microbiological accounts of living tissues, are complementary in the sense discussed above and, though they have not yet come together but hopefully will in the future, they are also instances of dialectical relationships.

Compatible contexts enter into a Boolean synthesis; complementary contexts enter into a non-Boolean or dialectical synthesis. There are other contexts, however, which are incommensurable or absolutely incompatible: they cannot enter into a synthesis at all and consequently, if used, they must be used separately. Such, for example, are the various ways in which the space around us can be structured geometrically. Ordinarily we perceive objects as given to us in Euclidean space; and this will be so as long as disagreements about distances, areas, angles, etc., are resolved by scientific criteria of measurement. However, as experiments in binocular visual perception show, if we were to estimate distance, angles, etc., purely by binocular visual estimates, we would find ourselves in a non-Euclidean and hyperbolic space. Floors, walls, tables that are flat in everyday perception would become convex near-by and concave at a distance within the new specialized form of perception mediated by pure binocular vision. Such specialized forms of perception can be shared by trained communities for specialized contexts of inquiry, e.g., for the purposes of artistic expression, without interfering with the individual's ability to perceive in a quite normal fashion in other, say, everyday contexts. Vincent van Gogh and other artists at the end of the nineteenth century seem to have been aware of the fact that binocular vision created non-Euclidean forms, and they attempted to paint such forms rather than those accredited by scientific measurement.[23] It is clear that both Euclidean and non-

[22] P. Heelan, "The Logic of Framework Transpositions," *Internat. Philos. Qrtly.* 11 (1971) 314-34.

[23] P. Heelan, "Toward a New Analysis of the Pictorial Space of Vincent van Gogh," *Art Bulletin*, Dec., 1972.

Euclidean accounts are true: nature can be either Euclidean or non-Euclidean, now one or the other, but not both together simultaneously.

Summary: The Manifest Image of Nature

In summary, the manifest image of nature (at any epoch of time) is the totality of empirical horizons reached by human subjects using available embodied intentions and projecting these horizons into the public domain through the use of descriptive languages. Note that all empirical intentions are embodied and that the body as subject used by these intentions may vary from one to another, sometimes extending itself into the environment, sometimes conceivably contracting to a space interior to the biological organism itself. Secondly, each intention is the invariant of a cumulative linear developmental sequence of more and more perfect linguistic projections of the horizon of that intention. Thus, nature is historical.

Thirdly, some embodied intentions conflict with others absolutely. These are incommensurable and do not enter into any synthesis. Their horizons are context-dependent but mutually exclusive alternatives.

Fourthly, some embodied intentions conflict with others not absolutely but as complementary and dialectical alternatives. In the course of a historical development, these enter into a dialectical synthesis that preserves each while enriching their common horizon. Nature, then, is in dialectical development.

Fifthly, the manifest image of nature as the pregiven arena for human action and practical moral judgment includes horizons that are the product of science and technology. These horizons are the product of a hermeneutic enterprise in which one first learns to decode signals from artificially contrived or technologically manufactured instruments, and then one adopts these instruments as bodily extensions within which, at least on occasion, one lives. Nature, consequently, is in part at least the product of a hermeneutic activity.

It follows from what has been said that nature is not an already-out-there-now-real, objective world-picture spread out in time before, as it were, the gaze of a Supreme Knower whom man tries to emulate, but a historically evolving context-dependent articulation of multiple horizons, among which with increasing importance are to be counted those constituted through the embodiment of a human intention in a product of mass technology. Because of this last-mentioned phenomenon, artificially contrived parts of our environment belong at one time and in one context to objective nature and at another time and in another context to the subject confronting nature as the arena in which his actions unfold. An automobile, a telephone, a television set, a subway system are objects for man in nature within one context, and parts of the embodied human subject—his organism in the extended sense—in another context. Man and nature, then, determine one another reciprocally, but the cut between them is not fixed, and the two are evolving both linearly and dialectically in history. Of the two—man as subject and nature as object—only the latter can be given an objective description: man as subject cannot be made the object of description, he can only be reached, as was pointed out above, by indirect and transcendental analysis and reflection.

MAN, NATURE, AND MORALITY

Within the perspective of this notion of man and nature, what can be said with regard to man's moral world, particularly in relation to the power that is accruing to him through the discoveries, say, of genetics, embryology, and pharmacology? In the first place, a distinction has to be made between the activity of pure scientific research and the use that can be made of scientific knowledge to contrive and make readily available through mass technology specialized instruments or techniques that could become convenient extensions of the human subject as such and thereby effect mass transformations of human subjectivity. Such transformations are part of the continuing evolutionary process for man, but it would be foolish to think that human progress and social development can be served by continuing to allow scientific results to be exploited solely or principally in the interests of speculative profit or of warfare between nations. Human nature will continue to evolve, mostly through the mass effect of applied science in transforming human subjectivity, but how can our society best avoid those cultural cul-de-sacs that would deprive it of the torch of progress, or cause the torch to pass to another society, or (God forbid!) would extinguish it forever? This is the most serious cosmological and moral dilemma of our times. It is evident that there can be no solution that does not involve the recognition by the scientific community of the dangers of irresponsible exploitation of scientific information, and the exercise of increased supervision by properly educated, publicly responsible bodies over the forms of applied science that are intended for general use. Much more needs to be said on this point. My purpose in this present paper has been to prepare the context for such discussions.