THE term, 'science *by* people', came up in the seventies and is now quite common. It appears mostly in the kind of literature for which the Borremans bibliography is the best guide,* among the multifaceted, decentralized community of authors who unplug themselves from consumption and use modern procedures to live simple, uncluttered and more autonomous lives. I have been asked to clarify my understanding of the term which they use to designate their research activities. It is a new term which, at first, seems slippery and ideological. One finds no antecedents for it in the recent past. I have the impression that those who use it intend a meaning which is the exact inverse of what science has signified ever since Bacon, or even since the thirteenth century.

My survey of the Borremans literature shows that 'science *by* people' is used in opposition to 'science *for* people'. The latter designates something called Research and Development or, since World War II, simply 'R & D'. R & D is usually conducted by large institutions – governments, industry, universities, clinics, the military, foundations. It is also carried out by small teams of enterprising persons who hope to sell their research results to institutions. It is a highly prestigious activity, done for the common good – so its supporters and practitioners claim – expensive and tax-exempt. It provides regular well-paid jobs for academics with advanced degrees. R & D can be social or natural, fundamental or applied, specialized or interdisciplinary. The use of the term 'science *for* people', as applied to R & D does not usually imply reproach; in principle, it does not signify disapproval of an endeavor. It simply means that the

* Valentina Borremans, Guide to Convivial Tools. Library Journal Special Report 13. Published by RR Bowker, 1180 6th Ave, NY 10036, 1979

results of the research have no bearing on the immediate everyday activities of him or her who does it. R & D can be carried out on neutron bombs, muscular distrophy, solar cells or fish ponds – always for the service of *other* people. Obviously, 'science *by* people' is not this.

Initially, the use of the term 'science *by* people' might be interpreted as sour grapes. It designates research that is done with few or no funds, no sponsorship, no access to publication in the prestigious journals, producing results that are without interest to the supermarket. Yet the people who do it seem neither jilted nor on the make. They do careful, methodical and disciplined research, are fully informed of the R & D in related areas, use these results when applicable, and in only one decade have built up an alternative network of publications which provides a forum for the diffusion and criticism of their efforts. They work alone or in tiny teams, primarily for results that directly shape their mode and style of living, are uninterested in patents and rarely produce finished products for sale. They give no impression of being the poor cousins of those working in R & D.

Intuitively, it is easy to recognize the distinction between this research and R & D. In the former, people concentrate on constructing, improving or beautifying the tools and immediate environment which serve them directly, leaving to others the task of imitating or adapting what they do. In practical use, the distinction is clear. But most discussion of this distinction so far has been hazy, emotional, ideological or beside the point. When best formulated the distinction so far has remained a negative one. A good example is that of Borremans herself: "Science by people is . . . research done to increase the use-value of daily activities without increasing the person's dependence on the market or professions."

'Research by people' does convey a search for something which is widely practiced yet difficult to name in twentieth century language. The activity clearly is research, not an assortment of hit or miss tryouts. It is supported by library surveys and critically evaluated by peers around the globe. It represents an effort to unplug its practitioner from the market. It is a search for autonomy, but in a new synthesis, not in a return to the 'good old days' or in an imitation of Amish community

living. Such research is not a hobby, nor a religious enterprise. And since it primarily seeks to improve the actual comfort or beauty of those who do it and critically tests the results, research by people cannot be called utopian in any accepted sense. A set of intensions and activities which fits these criteria is something patently new. No one word can express it. Faute de mieux, let us stick to the term '. . . *by* people'.

As a historian, I am very suspicious of anything which pretends to be totally new. If I cannot find precedents for an idea, I immediately suspect that it is a foolish one. If I cannot find anyone in the past with whom I am acquainted, and in my fancy can discuss with him what surprises me, I feel very lonely, a prisoner of my own present-day and parochial horizon. Therefore, when I was challenged to clarify the meaning of research by people I looked around and finally found Hugh of St. Victor, a twelfth century thinker who has proved to be excellent company. Living before the thirteenth century, but after classical antiquity, he is untainted by what we conventionally call science.

Hugh of St. Victor was born around 1096, probably in the Flemish town of Ypres, and grew up in Saxony. To his own century, he was known as Hugh of St. Victor (where he taught), Magister Hugo, Venerabilis Hugo, Hugh the Great. He was also called Hugh the Saxon, because he spent his youth in the Monastery of Hamersleben and later some imputed noble birth to him from the reigning house of Blankenburg. He deserves an important place in the philosophy of technology, since he dealt with the subject in an original way, quite distinct from any other author I know. But up to now his ideas have never been examined for the potential contribution they could make to the current attempt to identify the alternative to R & D. Mindful of this, I find it quite significant that he is not discussed in the major histories of science and technology. At best, one sometimes finds him in a cursory list along with ten other names. Therefore, before I can discuss his ideas, I must first make him come alive.

As a young man, he joined a new kind of religious order the Canons Regular. These were not monks, but communities of men brought into existence by the recent demographic changes

in Europe, principally the rise of the free city. The rule and practice of monks prescribed a life in small rural communities, often quite isolated. They tended to live in self-sufficient enclaves, surrounded by newly cleared land. Their activities were confined almost exclusively to the liturgy and physical labor in the management of their monasteries and fields. The new canons, on the other hand, usually established themselves in the cities, committed to a life of exemplary virtue for the edification of the Christian population.

As a young man, with his uncle, Hugh traveled from Saxony to Paris, where he settled in the Augustinian cloister of St. Victor, then still outside the city walls. Paris teemed with intellectual excitement. Men of immense learning, filled with deep passion for their convictions, acting and speaking out with shameless simplicity, clashed in public controversy. The center of all this spiritual ferment was still the Cathedral school, from which the university would evolve seventy years later. Peter Abelard was prefect. A brilliant cleric with a biting and incisive wit, one of the great teachers of the West, he was idolized by his students. But more than one of Abelard's colleagues, the teachers at the school, were driven into exile by his ridicule. Hugh's own master, William of Champeaux, was among them. Abelard's teaching was decisive in renewing critical procedures and methods in thought. In the midst of an age dominated by faith and obedience, he insisted on the value of methodical doubt. He demonstrated the necessity of doubt by juxtaposing the contrary opinions of respected authorities against each other, and by emphasizing the role of reason when such conflicts between traditions and authors had to be resolved. In ethics, he applied analogous principles, stressing conscience and intention in an age of ritual and legalism. He had powerful enemies. The great mystic, Bernard of Clairvaux, noble and austere, the violent reformer of Benedictine monasticism and preacher of the crusade, was the driving spirit infusing a lifelong witchhunt to silence Abelard. For Bernard, philosophy and the humanities fitted a monk's and scholar's life only to the degree necessary for a better grasp of Holy Writ.

Abelard's enemies achieved a temporary triumph. Because of his notorious affair with Héloïse, the most brilliant of his pupils, he was chased from his chair, gelded and dishonored. Probably

at this moment, Hugh arrived in Paris to teach about the place of science in human life. We find the first documentary evidence for Hugh's presence in this milieu when he was already the recognized Master of St. Victor in a double sense – he was the director of studies, and exercised the powerful intellectual influence which would extend beyond his own lifetime. For two generations, St. Victor owed its odd mixture of down-to-earth mysticism, both tender and humorously critical, to Hugh.

We know very little about his life. Few anecdotes are told about him. He probably traveled to Rome once. But those who read his works have no difficulty in identifying the original and unique character of his ideas. They are all marked by a strong personal style. His repeated advice to his students seems to have been: learn everything; with time, you will find out that none of it was acquired in vain. E. R. Curtius knows of no earlier theologian who would have recommended laughter to Christians. Hugh even encouraged teachers to foster merriment among their students, since serious matters are absorbed more easily and with more pleasure when they are mixed with humor. Such a recommendation flew straight in the face of at least 700 years of Christian exhortation to students to shun not only the flesh but also the laughter which ripples it. Until his last moment, Hugh maintained his high spirits, as Osberg, the Brother who nursed him to the end, records. This monastic doorman relates that throngs of people came to visit his tomb, but ugly rumors also began to circulate in Paris: students, probably from among the Cistercian monks, then very distrustful of technical progress, complained that Hugh's ghost visited them at night. He came to ask for prayers, needed to release him from purgatory where he was doing penance for his exaggerated curiosity about scientific and mechanical matters.

Hugh's posthumous influence was felt far beyond his own cloister where he had faithful but, on the whole, flat-footed disciples. He influenced the famous Dominicans, Albert the Great and his student, Thomas Aquinas, the Franciscan masters, Alexander of Hales and Bonaventure. His thought and statements years later became popular reading in the *Imitation of Christ*. He is among the few medieval thinkers quoted by Kierkegaard. But his clearest and broadest influence occurred

through the use of his work, *Didascalicon*, which became a textbook.

The middle of the twelfth century constituted one of those rare moments in history when scholars possess a confident sense that the mastery of the works of the past is about to reach a natural end. The thought of Greece, Rome and the Church Fathers seemed assimilated. Thinkers began to feel comfortable about their command of the past's achievements. St. Bernard, Abelard and Hugh of St. Victor represented an entirely new kind of genius that flourished during the short period between 1110 and 1150 – thinkers who, having thoroughly digested their tradition, now felt free to create a new synthesis. The scientific and metaphysical works of Aristotle had not yet reached and upset Paris. They had not yet been translated from the Arabic, and their Arab commentators were still unknown. During this creative lull, some of the West's greatest textbooks were written: Peter the Lombard's *Sentences* (1150), Gratian's *Concordances of the Law* (1140), and the first of them, Hugh's *Didascalicon* (c. 1127). These books remained in use and became obligatory reading for those who sought a liberal education right into the seventeenth century – a part of every cleric's, indeed, every scholar's formation. As school books, with the exception of grammars, they had an extraordinary lifetime. The end of their undisputed acceptance marks the conclusion of the Middle Ages much more decisively than either the Renaissance or the Reformation.

In view of this lengthy and extensive renown, it is highly significant that his fiercely original thoughts on mechanical science went unobserved and unnoted. Hugh defined mechanical science as that part of philosophy which studies remedies for bodily weakness, when such weakness derives from humanly-caused disruptions in the environment – science, then, is a corrective for an ecological disorder. Asked to clarify the notion of a new conception of science which underlies the various 'movements' of science by people, I know of no better approach than a confrontation with Hugh of St. Victor's thought.

It would be beyond the scope of this essay to introduce the reader to Hugh's central concerns about metaphor, analogy,

mystical knowledge and love. Therefore, I must tear out of their context his reflections on science as an aid, remedy or cure and the scientific aspect of the mechanical arts. But, to make his thought understood, I must explain a bit about his perception of the human condition. He accepted the story of man's origins, as related in Genesis. God first created Adam and, out of him, Eve. He made them so that they might live in harmony with the rest of creation. When he appointed them gardeners of Eden, he gave them an exacting task, but one which implied no toil.

Hugh strongly believed that God made each thing according to its own beauty. This insistence on beauty, and on the visual perception of reality, is characteristic of him. He gave three sets of 'eyes' to Adam and Eve – the eyes of the body, providing for ordinary cogitation; the eyes of reason, for meditating on the significance of eternal beauty for the beholder; and eyes fit for the contemplation of the Creator himself. This last set of eyes, made to look into blinding light, is designed to see the invisible, "what he is not, never what he is". The three sets of eyes are part of the basic endowment with which the Creator equipped human beings. For Hugh, the light which fired the three sets of eyes is the divine light, as reflected by nature: the soul and heaven in the mirror which is man.

Accepting the biblical story, he believed that certain restrictions had been imposed on the first couple by the Creator. They were free to use and enjoy the garden. But they were not to break the fruit from just one tree. In Hebrew, it is called the tree of *jadah* – meaning knowledge, penetration, power, possession. The serpent, however, a fallen angel, was envious of their exalted position within the universe. It persuaded Eve to break a branch and a fruit from just that one tree. Adam, Hugh insists, moved not by curiosity but by *affectus dilectionis* (a love of deep affection for Eve), ate what she offered him. As a consequence, the human world was upset. As the mirror of their eyes darkened, they felt ashamed. Simultaneously, nature, which they had offended and from which they had to obtain their sustenance, was accursed. Those who had been created to be the gardeners of Eden now had to be born from a bleeding womb and obtain their wherewithal from a field full of thistles. Created to be leisurely gardeners of Paradise, their own

transgression of the rules of primordial nature compelled them henceforth to eke out their existence in sweat and frustration.

Hugh takes this historical understanding of ecology as the starting point of his general theory of science. Humans, through their own fault, are weakened and must survive in an environment they themselves have damaged. Science, then, is the search for a remedy for this painful condition. Thus the primary emphasis is the attempt to relieve human weakness, not to control, dominate or conquer nature for the purpose of turning it into a pseudo-paradise.

Hugh's metaphors fit the age of faith, not that of the quantum. He inhabits creation, not stellar space. History for him is that of salvation, not that of evolution. Yet, notwithstanding the distance between us, our approaches to ecology can be compared and contrasted. For Hugh ecology is the hypothesis from which the necessity of science derives; for R & D ecology is based on scientific assumptions. To grasp this, we must listen carefully to the language in which he writes.

Hugh was like a moving flame. Brought up in German, he lived in Paris, but his own language was Latin. This Latin was the kind of language which English speakers today experience great difficulty understanding. No one was born to it. Scholars learned its classical variety. But for scholars, scribes, religious and lawyers it then became the main language of everyday intercourse. Therefore, they felt entitled to shape it to their needs, their feelings, their whims. It was not a dead language, nor an élite language into which only some are born. It was the living language of a scholarly community, where all who used Latin acquired it relatively late in life. It is therefore a kind of tongue our age has lost. This fact makes any translation from medieval Latin a risky undertaking. For example, when Hugh speaks about *philosophia*, I strongly suspect that his meaning in contemporary English is much closer to 'science' than to 'philosophy'.

Hugh presents his general theory of philosophy (or, science) in two works: his textbook for a general introduction to advanced studies, the *Didascalicon*, and the *Dialogue of Dindimus on Philosophy*. The *Dialogue* was probably written a couple of years after the textbook. In it, Hugh hides behind the figure of a holy man from the pagan East, Dindimus, King of the Brahmans.

He took his figure out of a novel on Alexander the Great, which reached him in a Latin translation of Pseudo-Callisthenes. As interlocutors for Dindimus, he provides: Indaletus, the legendary apostle who converted southern Spain (at the time of Hugh, this region had been under Muslim domination for more than 400 years), and Sosthenes, the chief of the synagogue mentioned in the Acts of the Apostles (18.17). A subtle method lay in this apparently strange procedure. Hugh wanted to make a point which could not but offend many people. He wanted to give consistency to his ecological foundation of science without recourse to dogmas of faith. So he chose a virtuous pagan, a Brahmin, to make the argument for him. The Brahmin could insist, with more freedom than a Christian, that scientific inquiry was part of the human birthright, and could proceed unaided by Holy Writ. Hugh's choices were severely limited. Had he chosen a pre-Christian Greek, his readers could have argued that, after the coming of Christ, the situation of science had changed. Had he chosen a Muslim, his readers could have interpreted the latter as a hardened infidel arguing against the light of faith. So he chose an ascetic pagan, a man who, in the thought of the time, could be considered an unconscious Christian. To Dindimus he assigned the task of explaining the criterion that gives unity to philosophy/science, and the place of the mechanical arts within it.

When the first couple transgressed the order of nature, the disharmony thereby provoked clouded their eyesight. But it did not totally extinguish the eternal fire of truth, which continues to burn externally in the senses and, internally, in the imagination. This fire continuously kindles curiosity, surprise, admiration – the starting point of science. Science is the attempt to restore, however partially, that human competence which was lost in the original ecological catastrophe which started history on Earth. Science has three principal goals:

> . . . wisdom, virtue and competence to face needs. Wisdom is the understanding of things as they are. Virtue is a habit of the heart, a habit which establishes harmony with reason in the way of nature. *Necessitas* [competence in the face of need] is something without which we cannot live, but without which

aha: we need our needs!

> we would live more happily. These three things are as many remedies against the three evils to which human life is subject: wisdom against ignorance, virtue against vice, and competence against the body's weakness. In order to do away with the three evils, men have sought these remedies, and in order to reach them art and discipline were discovered. For wisdom, the theoretical arts were discovered; for virtue, the practical arts; for needs, the mechanical arts.

In this text, Hugh starts from *ignorantia*, the feebleness of the mind's eye, deprived of God's clear reflection. As a corrective, the mind needs theoretical science, a vision of things as they are. Such science leads to wisdom. Then Hugh deals with *vitium*, moral flabbiness, which requires the aid of *habitus animi*, stable habits of the soul – in the language of Erich Fromm we might translate as character. These one acquires in the ethical or social science, *practica*, which leads to virtue. Finally, we live out of harmony with nature. Because of our aggression, a kind of revenge imposes necessities on us. To live, we must face and overcome these necessities. This can be accomplished through recourse to what Hugh first calls mechanical science. *Theorica*, *practica* and *mechanica* are the three cures for personal weakness.

Dindimus argues that the element common to all science is the fact that it serves as a crutch for human weakness. As far as we know, Hugh was the first to reduce the invention of arts and science to certain defects in human nature. But we do not know whether this reduction is an invention of his own. It is certain, however, that the definition of science as a remedy for the weakness of the persons who engage in it, and who must engage in it in order to survive in an environment originally impaired by human action, is characteristic of Hugh alone. The idea is picked up by Richard of St. Victor (in his *Liber Exceptionum* – c. 1159), and last mentioned eighty years after Hugh's death. It is a view of science which is diametrically opposed to what began to take shape in the thirteenth century – when Aristotle was rediscovered – and to what is still dominant in the West. To see this opposition between Hugh's science and ours more clearly, perhaps we should stick to Hugh's term and, with Dindimus, speak about it as *philosophia* – as "the caring pursuit of truth,

> motivated not by that love which cherishes the well-known, but driven by the desire to pursue further what has been tasted and has been found pleasing", as Dindimus says. Now, this is definitely not what R & D is. Nor is it compatible with the Baconian attempt to subjugate nature. And, more importantly, it is not some pure, disinterested research which aims at finding and publishing the truth. This "caring pursuit of truth motivated . . . by what has been tasted and found pleasing", has no proper name today, unless 'science *by* people' be it. Those who thus label their own activities pursue something analogous to what Hugh meant by science, philosophy, the love of wisdom, when he defined it as the critical pursuit of remedies to self-induced weakness which will remain forever man's destiny in a world which has been marred by him.

For our reflection on 'science *by* people', Master Hugh has a second important contribution to make. He was original, not only with his ideas on science as a remedy, but also when he placed the *scientiae mechanicae* in philosophy. These constituted methodical reflections on specific remedies for bodily weakness – *lanificium* (weaving), *armatura* (metal work), *navigatio* (trade and transportation), *agricultura* (agriculture), *venatio* (perhaps primary sector activities would be a meaningful transposition), *medicina* and *theatrica* (entertainment). In each of these arts, Dindimus maintains, wisdom is hidden. Therefore, reflection on the art should be treated as a part of philosophy.

> All living beings were born with the armor which befits them. Only man comes unarmed and naked into this world. What was given to others by birth, he must invent. Imitating nature and outfitting himself through reason, he shines forth more brightly than if he had been born with the equipment to cope with his environment.

Hugh manifests a deep cheerfulness, an intellectual optimism about human nature, which can only be appreciated when seen against the background of his medieval Christian faith. His theological writings show how fully he was imbued with the

sense of human sinfulness and the need for redemption. He is equally convinced that human disobedience and aggression against nature were now forever reflected in nature's rebellion, nature's refusal to serve human desires and human needs. Yet he neither preaches resignation, nor does he incite us to submit nature to human domination. Rather, he sees in the man-caused disharmony between humans and their environment the critical challenge to humanity – the challenge to create artifacts which imitate nature, and which serve people as crutches on which they can rise above the condition in which they would have been had they lived on in Paradise. The study of the *wisdom* which is implicit in the construction of such crutches Hugh calls the mechanical sciences. And these he includes in philosophy.

A similar stance is taken by several contemporary proponents of science by people. They have no qualms about using the results of science *for* people, but claim that such use is for a purpose which is *sui generis*. To many, this claim sounds sentimental or fuzzy. And those who make it have no tradition of thought about science on which they can fall back. Perhaps reflection on Hugh of St. Victor can help them be more precise in their claims.

Hugh's originality in the treatment of the mechanical arts will be better understood by following the evolution of the term up to the end of the eleventh century. 'Mechanical' is of Greek origin (*mēchanē*). For the Greeks in classical times, the mechanical arts were procedures to outwit nature by miracles, magic, make-believe, by such technical devices as water clocks and parabolic mirrors. The same mechnical power became visible through gods, witches, actors and artisans. Later, when Greek became the trade language of the Mediterranean, *mēchanē* did the surprising things and *fabrica* did the straightforward. Latin never adopted the term, nor did it create an equivalent. The Roman genius did not need to outsmart nature. Roman builders were sure of their power: not even for that which we would call techniques did the Romans coin a catchall term. They could write with precision about agriculture or about the art of war (*de agricultura*, *de arte bellica*) – their own, that of others, or that which they brought to Rome. Their armies assembled techniques as they assembled gods in the Pantheon

But just as they had no need for theology, so they had no need for technology.

In late antiquity, the term *mēchanē* was rarely used. Before the Moors overran Spain, Isidore of Seville helped it, as so many other classical terms, to survive into the Middle Ages. For him mechanics meant any well thought-through process of 'making' for use or for the market. Then, at the time of Charlemagne, *artes mechanicae* acquired a new, ambiguous meaning. For the first time, scholars used the term explicitly to designate human activities through which artful imitations of nature were created. Gerber of Aurilac, the weird genius who became Pope Sylvester II, declared mechanical art to represent formulas describing the intricate movements of all the heavenly spheres. Simultaneously stone masons were said to use mechanical art to link the visible and the invisible world by the arrangements of apostles and dragons and flowers on the capitals of romanesque columns. Around the year 1000 *mechanica* was an élite term to designate a baffling power beyond that proper to priest or knight. This appears clearly from a letter which, around 830 an anonymous young monk wrote to Master E . . . (the name is illegible), his former teacher at the monastery of Compiègne:

> . . . when I was with you, Master Manno told me what mechanics is all about, and what to think of the mechanical arts. Unfortunately, I have completely forgotten all this. Please find out and send me word – what are mechanical forces? And, above all, how does *mechanica* [magic] differ from *mathesis* [astrology]?

For the Greeks, the term had meant the outwitting of nature: for Hellenism something alike to competence, for the dark Middle Ages it meant a complement to astrology. In scholastic use at the time of Hugh, it meant making artful imitations of nature. It is in this sense that Hugh uses the word 'mechanical'. He explores the relations of practical art to wisdom.

Those who used the term in the Middle Ages before Hugh always combined it with art, writing of *artes mechanicae*. Hugh is alone in uniting it with science. He is the first to speak of

scientiae mechanicae. He was concerned, not with wool making, but with the relationship between this art and wisdom. He dealt with spinning and weaving in a perspective not unlike that of Mahatma Gandhi. He wanted to establish the contribution which research about weaving or trading or medicine or acting would make to the scientist's wisdom, to his ability to remedy the weakness of his own being. In the practical arts, Hugh seeks a mirror of truth, as elsewhere he describes creation and the human soul as the other two great mirrors. And by the practice of the art, guided by science, he hopes to polish his mirror.

Analyzing art as a mirror for truth, Hugh establishes an essential difference between the reflection he sees in art and the one he sees in creation and the soul. Nature and the soul reflect the light of truth in a medium created by God albeit clouded by humans. The ecological aggression of the first couple disarrayed, but did not break these God-made mirrors. Mechanical science seeks the reflection of the same light in a medium made by the artist in the imitation of God's nature, a mirror which is partly natural and partly the work of man. Mechanical science is the study not of God's creation but of man's work insofar as this study can contribute to a practical remedy for human weakness.

Unlike the study of nature and man, the study of man's artifacts, Dindimus says, provides man with a pass-key to the workings of nature. To explain this two-faced, bastard quality of art, half human conception and half imitation of nature, Dindimus employs a preposterous etymology. He derives *mēchanē* from the Greek *moichos* (adulterer). For him, techniques mirror the truth, but also distort it: hence the scientific study of them, however truly philosophical, is a 'mechanical' or bastardly science.

Neither Hugh's idea of science as a remedy, nor his notion of mechanics as part of science, survived him. This is surprising, since both ideas are clearly expressed in the *Didascalicon*, his most popular work used as an introductory textbook well into the Renaissance. Part of the explanation as to why his readers did not take up these ideas is to be found in the accelerated technological developments which coincided with Hugh's 45 years of life. In less than a century, iron consumption in northwestern Europe more than doubled. The iron was needed for

such things as horseshoes, heavy ploughs and scythes – inventions three centuries old and only now widely used. And the Crusades began in this period, requiring large quantities of armor. In his lifetime the number of watermills doubled and the number and variety of new machines powered by these mills grew even faster. Monasteries appeared to be converted into machine parks. The men who built, maintained and repaired all this milling and mining equipment grew larger in number. They were the new kind of artisan and tradesman – wandering tinkerers and expert miners who did not quite fit former models. Now it was their trades that came to be called the mechanical arts. People tended to look down on the practitioners of such novel arts as a new kind of rabble. When, two generations after Hugh's death, both windmills and universities spread throughout Europe, no educated person would have talked about their trades or mechanics as an academic subject. The men designated as practicing mechanics were seen as a new kind of wage laborer – rare in twelfth century France – related to the first modern forms of mass production. The term 'mechanics' had by this time little to do with outwitting nature, and even less with its imitation. Its meaning was now closer to the exploitation of nature, having already evolved in the direction of its domination. Centuries would pass before any serious attempt would be made to incorporate disciplines which required manual skills into the university curriculum. Even medicine, when it entered the aula, had to exclude surgery. When, half a millenium later in the eighteenth century, finally the science of tool-construction found its way into the university curriculum, it was conceptualized as diametrically opposed to Hugh's *scientia mechanica* (science by people). Where the latter pursued wisdom in the imitation of nature, the new subject clearly was an *engineering* science: a science concerned with production for people.

The science of tools as tools has no proper name in English. 'Technology' will not do. This term is now used to speak about the tools themselves: a computer, bio-gas digester, machine park or the tool kit of some culture. In English, technology is also used to designate a subject. The civil, electronic or marine engineer is said to have received a technological formation. This English meaning of the term is now diffused throughout

the globe. But until quite recently, this was not true in German or French. Jacques Ellul could quite legitimately distinguish techniques (which is what technology now means in English) from *la technologie* (the critical analysis of the relationship between people and tools). To be able to speak about this same matter, I propose the term, 'critical technology'.

When I was asked to write about science by people, I turned to the second quarter of the twelfth century because here, to the best of my knowledge, critical technology first made its appearance. And Hugh of St. Victor was not the only one of that period who had something to say about the relationship between tools and people. Honorius of Augsburg and Theophilus the Priest, for example, both made equally important contributions to the discussion. And I plan to write an essay on each, parallel to the present paper. In all cultures since antiquity, people have used tools, reported on their use and compared the effectiveness of one tool with another. And how-to-do-it manuals were common. Indian Brahmins, even more than Greek philosophers, critically analyzed the tools of thought used in logic and grammar. But no one in these instances explicitly and systematically turned the tools of manual labor into an issue of theoretical importance. Then around the year 1120, the tools of physical nature were for the first time recognized as a social or philosophical problem.

Hugh and the others who began to ask critical questions about techniques were themselves still rooted in cultures which took their tools for granted. In each of these cultures, the tool kit was limited. But from one culture to another, it was as diverse as the language. Further, new tools appeared from time to time and changed ways of living. For example, by the thirteenth century, the landscape of central Europe had been transformed due to a combination of tools which rendered the horse enormously more effective: the horseshoe, the bit, the collar and the deep plough. Meanwhile, other tools became obsolete. But even though tools changed, neither their transformation nor their social impact was seen as an issue for study.

Therefore, at the time of Hugh, it was still perfectly fitting to allow Dindimus the Brahmin to speak with a Christian mystic's voice of worldly wisdom. Christians still perceived the relationship between human beings and the environment in such a way,

that conversation with a Taoist, Jew or Hindu could, in fact have started from common premises. No matter how effective or even destructive man's impact on the environment might be, people everywhere viewed agriculture as the maintenance of a former garden – however much threatened by weeds, insects or bad weather – and not as a form of biological mining. The improvement of tools, or the adoption of new ones, primarily raised yields or eased life rather than producing marketable surpluses.

In Hugh's generation, on the other hand, the signs of a profound change were appearing. The plough and the mill, for example, signified an increase in yields which went beyond the needs for subsistence, and the new city constituted a market where this surplus could be traded. A period of intense technical innovation and ecological aggression had started. In this setting, Hugh's ideas on mechanical science appeared: his theoretical insistence on the possibility of improving tools for subsistence, and his moral insistence that this ought to be the purpose of science.

By the end of the twelfth century, the climate of Europe had changed, both in the mechanical arts and in intellectual approaches. The differences between the great thinkers of the early twelfth and the early thirteenth centuries are often obscured when both are simply considered together as the 'scholastics'. Between the two groups, Spanish Jews and Benedictine monks translated the Greek philosophers from the Arabic manuscripts in which they had survived for 400 years. Then, an entirely new conception of science became general. Science came to be regarded as the search for what makes things tick rather than, as for Hugh, the caring pursuit of those remedies for the scientist's weakness which had been tasted by him and found pleasing. In the wake of this new approach to science a new attitude toward technical means came into being. The new mills became symbols of man's power over nature, the new clocks symbols of man's power over time. In fact, as C. S. Lewis remarks, the relationship turned out to be the power exercised by some men over others, with nature as the instrument. Critical technology, in Hugh's sense, ran counter to the passions and interests of the age, and was forgotten.

The critical technologist in 1130 and today are both on the

edge of a stage, but in very different ways. Hugh faced traditional naiveté, and we face its Baconian version. In Hugh's world, a region's hoe and hammer were as much taken for granted as its vernacular language and dress. When he observed innovations, he proposed a theory according to which mechanical science improves the remedies for human weakness by developing the art or by understanding the wisdom hidden in it. In today's world, the critical technologist faces a different form of naiveté, rooted in the formulations of Bacon.

Bacon, too, was concerned with theology, and preached more than Hugh. He was interested in the ". . . restitution and reinvestiture of man to the sovereignty and power which he had in his first state of creation in Paradise". For him, ". . . the progress of arts and sciences [is] to achieve mastery over nature"; the scientist comes to you, in ". . . very truth leading to you Nature with all her children to bind you to her service and make her your slave". He "vindicates the right over nature . . . which is man's by divine bequest . . . [and] promises liberation from the inconveniences of man's estate". Bacon believed that ". . . the mechanical inventions of recent years do not merely exert a gentle guidance over nature's course, they have the power to conquer and to subdue her, to shake her to her foundations".

Bacon proposed putting nature on the rack, torturing her by experiment and thus forcing her to reveal her secrets. Now, in the Seventies, Bacon has been made into a whipping boy. And, although his style has gone out of fashion, his general optimism remains intact. This can be well documented from contemporary ecology-oriented R & D. Such an endeavor seeks to replace the domination of nature through torture by an alternative approach: the seduction of nature through blandishment. Substantially, however, the new 'alternative' science very often remains naive. It is generally an enterprise attempting to liberate other people, indeed, all mankind, from the inconveniences of man's estate. It is a project undertaken by scientists for the sake of other people. And increasingly, the new ecologically-oriented R & D no longer pursues the production of goods or services for more people. Rather, the research seeks to determine what people have to be compelled to do for themselves, all the while believing that they do it for their own good.

From a science which attempts to control external nature, the new R & D has shifted toward the search for means which permit the subtle but effective imposition of self-control on people.

Unless science by people is based on critical technology, it is in serious trouble. It is in immediate danger of being absorbed by the R & D concerned with imposing prescribed forms of self-help on people. Just as Hugh's critical technology was forgotten – with his writings then serving as mere foundations for later scholastics – so science by people is in constant danger of being turned into a didactic tool of advanced ecology-oriented R & D. This cannot but happen unless we clearly recognize that science by people remains faithful to its task and purpose *only* when it starts from an image the inverse of man the worker and consumer, for whose sake specialists must do research.