OLD WORDS FOR NEW WORLDS: MODERN SCIENTIFIC AND TECHNOLOGICAL WORD-FORMATION

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BAUGH WROTE IN 1935 THAT DURING the preceding century the growth of science and related fields had been the chief influence on the vocabulary of English (367). Today he would have to revise the observation only by extending its time-span, for science and technology have continued to produce large numbers of new terms and to contribute many of them to the general vocabulary. For instance, C. Barnhart wrote that almost half of the new words printed in his dictionary supplement for 1982 were scientific and technical terms, some appearing only in specialized journals but many others in widely circulated periodicals and books (1982–85, 1: 53).

Aside from its magnitude, however, the contribution of science and technology to the English vocabulary has not been established. In particular, we do not know whether or how modern scientific terms differ from other words etymologically or semiotically. Until recently, they have been regarded as alien and obscure. Most observers have accepted Jespersen's (1931) assertion that modern science borrows heavily from Latin and Greek roots to create compound words, some of which "would have struck Demosthenes and Cicero as bold, many of them even as indefensible or incomprehensible innovations" (122–23). In 1980, however, Caso (1980, 101) suggested, after studying the etymologies of 3,718 terms from physics and the earth sciences, that "classical sources are being superseded by others ... in at least some fields" of twentieth-century science. More recently, Raad (1989, 128) has echoed and extended Caso's claim:

> While a great deal of scientific vocabulary is still formed in the traditional manner from Latin and Greek roots and affixes, more of the words of modern science manipulate common elements in ways which do not conform to the same linguistic requirements expected in the past by both the scientist and the layman.

In particular, Raad continues, "New meanings are now more freely created by composing them from known words through the use of conjoining, abbreviating, and metaphoric strategies."

Caso and Raad both imply that new scientific and technical terms now differ little, morphologically or semantically, from other new words. They make no comparisons with nonscientific word-formation, however, and

Raad supports his generalizations about scientific terms only with examples. Against both writers' hypotheses can be set the nonscientist's conviction that new scientific and technical terms are somehow foreign, even if they are not derived from other languages: newspaper columnists still lament the "ponderous and metallic" neologisms and the "impenetrable" acronyms produced by technology's "high priesthood" (Satullo 1989), and C. Barnhart (1982–85, 1: 55) describes today's scientific language by citing the phrase used by Bloomfield (1939, 1): "specialized and peculiar."

My aim in this essay is to analyze the words that contemporary scientific and technological fields are generating and exporting to the general English vocabulary. My data are the 906 "scientific and technical terms" and a sample of 120 other terms collected by the editors of the *Barnhart Dictionary Companion* from both specialized and general publications between 1982 and 1985.[1] I have categorized those terms according to their morphological and semantic relationships to preexisting words. I hope to show that the results bear out, paradoxically, both the traditional impression that scientific and technical terms are particularly baffling and the suggestions by Raad and Caso that such terms arise from common roots and derivational processes. Resolving that paradox will suggest significant changes in the way science and technology produce not only words but also knowledge.

Students of language usually analyze new words by determining whether and how they use preexisting morphemes. For instance, in its quarterly listing of new words, the *Barnhart Dictionary Companion* uses six etymological categories: loan word (borrowing, loan translation, or folk etymology); coinage; shortening (back-formation, clipping, initialism, or acronym); composite (suffixation, prefixation, or compound); blend; and shift (grammatical or semantic) (C. Barnhart 1982–85, 4: 123). Similar categories are used in essays on scientific word-formation by Caso, Covington (1981), and Raad, and in the general surveys of word-formation by Algeo (1980), Adams (1973), and Cannon (1987).

Although they usefully describe many processes of word-formation, however, such lists are poor systems for classifying new words. One widely observed shortcoming is that the categories are not mutually exclusive. Because borrowing, shortening, affixation, and compounding affect many words simultaneously, the classifier must often choose one process, on admittedly subjective grounds, as dominant (Caso 1980, 109–10). At the same time, the categories are not sufficient: some words match none of

them well, exhibiting instead hybrid processes that are difficult to name. To take a few of Cannon's (1987) examples, *megaversity* (129) shows affixation of a root newly created by shortening; *hi-rise* (143) is a compound but also looks like a blend because of the way it is respelled; *aeronomy* (57) and *hologram* (160–61) contain only bound morphemes that may be borrowed but are combined in English, so that the terms are neither loanwords nor affixations. Noting the "bewildering number of patterns" evident in such terms, Cannon concludes that they "becloud the traditional parameters of derivation and overturn the view that vocabulary growth today primarily means derivation and compounding" (265; Cannon is discussing shortening here, but he makes similar comments about other word-formation categories).

Another shortcoming in the traditional categories of word-formation is that they are based inconsistently and asymmetrically on two criteria, form and meaning. Thus Barnhart's first five categories are types of morphological change, but the last is "shift" in the function or meaning of an unchanged form. Many taxonomists finesse the inconsistency by defining functional and semantic shift as "zero-derivation," a type of morphological transformation with no physical marker. But that approach begs the question of the role of meaning in word-formation generally. If semantic change can be the sole evidence of a new form, perhaps it is as fundamental as formal change.

Indeed, all new words except the very rare "root creations" can be regarded as transformations of meaning as well as of form. The *Dictionary Companion* classifies *baby farm* and *selfish DNA* as compounds, but they are metaphors as well; *techno-bandit* differs from *technical bandit* not just by shortening and compounding but also by specialization of meaning; even the Latin and Greek loanwords of chemistry and biology acquire new referents when they are borrowed, though many speakers of English will not see the semantic relationship. To acknowledge semantic change only in the absence of formal change is to misrepresent lexical development. Adams concedes as much, near the end of her book: "the topic of word-formation as it is here defined may have to be recognized as after all rather superficially conceived; our real business should be with meanings and how they are expressed and combined" (1973, vii; see also 213–15).

A comprehensive analysis of "meanings and how they are expressed and combined" is beyond my scope, but I have tried to avoid the shortcomings of the traditional categories of word-formation by using two parallel sets of categories, one based on form and the other on meaning.

Criterion One: Novelty of Form

I have abandoned the overlapping and incomplete derivational types described above in favor of a one-dimensional criterion: the degree to which the form appears to be novel. That criterion lacks the descriptive richness of the traditional classes but permits consistent and verifiable assignments to six categories, based on the answers to two questions.

The first question is, How many of the term's apparent root morphemes appear in a moderately complete contemporary dictionary? Possible answers in my scheme are "all," "some," and "none."

Being interested not in particular derivations but in generalizations about the effect of new terms on speakers of English, I sought to measure novelty against a dictionary representing the reference-vocabulary of a well-educated nonscientist rather than against a comprehensive historical dictionary. I chose the 1980 *Oxford American Dictionary* (*OAD*), an authoritative paperback based on the Oxford University Press *Oxford Paperback Dictionary* and intended to include "words and phrases likely to be met in reading and everyday life, including a number of slang, informal, and technical words and phrases" (v). I regarded a root as "in the dictionary" if it was present as a free morpheme or if it was used as a combining form in at least two words.

Of the new words whose roots are in the *OAD,* some still seem relatively novel to the nonscientist. To allow for distinctions among them, I formulated a second question, a rough measure of frequency of usage: If any of the roots appear in the *OAD,* do any or all of them also occur twenty times or more in the corpus of one million words used for Kučera and Francis (1967)? Again, possible answers are "all," "some," and "none."

Ku era and Francis's corpus includes 500 text-samples, all printed in 1961, "representing the full range of subject matter and prose styles, from the sports page of the newspaper to the scientific journal and from popular romantic fiction to abstruse philosophical discussion" (1967, xix). I chose twenty occurrences as my signal of a word's frequency because twenty is low enough to include a substantial minority of items in Ku era and Francis's corpus (around ten percent) but high enough to exclude most of the terms that happened to occur often in one text (such as *Haney* and *Notte,* each with 19 occurrences).[2] I answered Question 2 in the affirmative if either the word or any of its inflectional or derivational forms appeared in the corpus 20 or more times. For instance, *aging* (in *aging clock* and *aging gene*) occurred only four times but rated a "yes" to Question 2 because *age* occurred more than 20 times.[3]

In answering both novelty-of-form questions, I disregarded homonyms, comparing new forms only with those preexisting ones that a speaker of

English would regard, correctly, as sources. That is, I ignored *aid* in classifying the new term *AIDS,* and I treated the last syllable of *Arabsat* (a shortening of *satellite*) as unrelated to *sit.*

Criterion Two: Referential Distance

Because a new word almost always modifies the meanings of preexisting roots, we might apply to new words such traditional categories of semantic change as specialization, generalization, amelioration, pejoration, metonymy, and metaphor. Like the traditional morphological categories, however, the semantic classes are not mutually exclusive. For instance, metaphoric transfer can coincide with amelioration, as when *hacker* became a complimentary term for a dedicated programmer, or specialization can occur with metonymy, as in the formation of *heliopause* (lit. 'sun-gap') to mean 'the boundary between the sun's magnetosphere and the interstellar wind'.

To avoid the taxonomic dilemmas arising from the qualitative categories for semantic change, I have chosen instead a one-dimensional criterion somewhat like my scale for novelty of form: the distance between a new word's field of meaning and its former one or those of its constituents. My operational test for referential distance is the question, Do the definitions of the term's roots refer to its current field of meaning? By field of meaning, I mean the term's subject-area—in the case of technical terms, its scientific or technological field—or a subject closely associated with it (as disease is with medicine or earthquakes with geology). In answering the question, I have considered the definitions only of recognizable English roots, rather than foreign ones or the sources of acronyms, because I am interested not in etymology but in perceptible meaning. Possible answers are "yes," "nearly" (where the association was with a related scientific field), and "no." A fourth answer, "no associations," is given automatically if, in considering novelty of form, I found no roots in the *OAD.*

The categories derived by means of the two criteria are summarized in table 1. The alphabetic keys shown there are intended to order the classes—from most to least novel (*A* through *F*) and from most to least remote (*a* through *c*). Both sets of categories apply to each word. Because the referential-distance class *x* occurs always and only with the novelty-of-form class *A* (and vice versa), there are sixteen possible combinations.

Applied to the 906 scientific and technological terms and the sample of 120 other terms in the *Barnhart Dictionary Companion* for 1982–85, those categories yielded the lists in the appendix. In the first category are initialisms and acronyms, new borrowings and compounds from newly

TABLE 1
Categories Used for New Terms

Novelty of Form

A. No roots in dictionary
B. Some roots in dictionary but none in high-frequency list
C. Some roots in dictionary and some in high-frequency list
D. All roots in dictionary but none in high-frequency list
E. All roots in dictionary and some in high-frequency list
F. All roots in dictionary and all in high-frequency list

Referential Distance

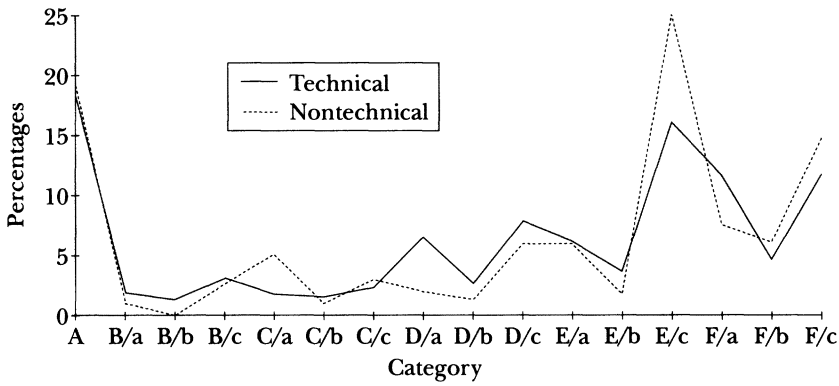
x. No prior definition; class A (novel) forms
a. Roots' definitions make no reference to term's field
b. Roots' definitions refer to related field
c. Roots' definitions refer to term's field

borrowed roots, and a few eponymous terms. The other groups move steadily toward the use of pre-existing forms, with the three *F* categories composed only of forms already in frequent use. Within each morphological category as designated by a capital letter, the three groups *a, b,* and *c* range from least to most association with their new subjects. Thus the words in *B/c* contain some unknown roots and no frequently-used ones, but the roots that do come from existing words provide a good basis for inferring the words' areas of reference. The terms in *E/a,* in contrast, employ no unknown roots and some that are commonly used, but the terms' areas of reference are not included in the roots' definitions.

TABLE 2
Percentage Distribution of Terms in Sixteen Categories

Category	*Technical Terms*	*Nontechnical Terms*
A	18.2%	19.2%
B/a	1.8	0.8
B/b	1.1	0
B/c	2.8	2.5
C/a	1.3	5.0
C/b	1.2	0.8
C/c	2.0	2.5
D/a	6.3	1.7
D/b	2.4	0.8
D/c	7.9	5.8
E/a	6.3	5.8
E/b	3.5	1.7
E/c	16.2	25.0
F/a	12.0	7.5
F/b	4.6	5.8
F/c	12.3	15.0

FIGURE 1
Distribution of Terms



As indicated in table 2 and figure 1, the largest category of scientific and technological terms is class *A*, the completely novel forms.[4] Further analysis (not presented in table 2) shows that of these, about 22 percent are borrowings and 68.5 percent are initialisms and acronyms. The relative size of class *A* might confirm the traditional idea that scientific and technical terms are particularly exotic. The percentage of scientific and technical terms in class *A* is indeed considerably higher than, say, the proportion of borrowed terms and acronyms (7.5 percent and 1.1 percent) in Cannon's corpus of new words in the general vocabulary (1987, 279).

In my own sample, however, the class of novel items is no smaller—indeed, marginally larger—among the nontechnical words than among the scientific and technological terms. More detailed analysis does reveal in the scientific and technological neologisms some of the characteristics traditionally associated with them: the technical terms of class *A* include more initialisms and acronyms than the nontechnical ones (about 68.5 percent, as opposed to 40 percent), and although there are fewer borrowings (22 percent, in comparison with 40 percent of the nontechnical members of class *A*), most are from Latin and Greek, which contributed none of the borrowed nontechnical terms.[5] To some degree, then, scientific terminology continues to be distinguished by its use of classical borrowing. But the degree is very slight, for new Latin and Greek loanwords constitute altogether about 2.5 percent of my scientific and technical words. Of greater importance in characterizing the scientific and technological words in the *Dictionary Companion* is that they are no more likely than other new words to be completely unrecognizable.

Aside from class *A*, the largest categories of both technical and nontechnical terms are *E/c* and *F/c*, containing together 28.5 percent of the

technical terms and 40 percent of the nontechnical ones. Terms in those categories were formed entirely from roots already in the language; most of their roots (all in class *F* and some in *E*) were in frequent use; and their roots' definitions associate them with their new fields of meaning (referential class *c*). Familiar in form and at least partly self-explanatory, they lie on the border between new words and descriptive phrases. They are well suited to a culture committed equally to innovation and accessible mass communication.

That so many scientific and technological terms fall into those categories supports Raad's assertion that "[many] of the words of modern science manipulate common elements" instead of borrowing or combining Greek and Latin loanwords (1989, 128). And that the same categories are largest among both technical and nontechnical terms confirms the implication by both Raad and Caso that scientific nomenclature is coming to resemble the rest of the vocabulary in morphological and semantic derivation.

On the other hand, scientific and nonscientific words do not "manipulate common elements" entirely in the same ways. Table 2 shows that, in three categories, the distribution in my two samples differs by more than four percent. The largest disparity is that the scientific and technological terms are almost nine percent less likely than others to belong to class *E/c*—terms with no novel roots, some frequently used roots, and close semantic associations with their new fields. Conversely, they are more likely by about the same amount to belong to classes *D/a* and *F/a,* those with all roots in the *OAD,* none or all in the high-frequency list, and no reference to their new fields.

A different tabulation of my data can bring the differences into sharper relief. In the three parts of table 3, I compare the technical and nontechnical terms with respect to my three operational tests: presence of roots in the *OAD,* presence of roots among the words used at least twenty times in Ku era and Francis's corpus, and reference in the roots' definitions to the term's field. Table 3A confirms that technical terms are no more likely than other new words to use unrecognizable roots, and the third row of table 3B shows that they are no less likely to be formed entirely from roots that occur at least twenty times in Ku era and Francis's texts. The first and second rows of table 3B indicate, however, that technical terms are more likely to have only uncommon (but preexisting) roots rather than a mixture of common and uncommon ones. That is, more of them are like *antirishon, ACE inhibitor, afar-ape, adaptionist, bug,* and *aminoglycoside,* containing no morphemes in the high-frequency list, than are like *arcology, Ames test, agricommunity, Apollo object, chroma key,* and *A-bomb cataract,* with some but not all morphemes in the high-frequency list. Neither scientists nor

TABLE 3
Percentage Comparison of Technical and Nontechnical Terms by Three Criteria

A. Novelty of Roots

	Technical Terms	*Nontechnical Terms*
No roots in dictionary	18.2%	19.2%
Some roots in dictionary	10.2	11.7
All roots in dictionary	71.6	69.2

B. Frequency of Roots

	Technical Terms	*Nontechnical Terms*
No roots in high-frequency list	22.3%	11.7%
Some roots in high-frequency list	30.6	40.8
All roots in high-frequency list	28.9	28.3
Not applicable (no roots in dictionary)	18.2	19.2

C. Referential Distance

	Technical Terms	*Nontechnical Terms*
Not associated with subject	27.7%	20.8%
Associated with related subject	12.9	9.2
Associated with subject	41.1	50.8
Not applicable (no roots in dictionary)	18.2	19.2

nonscientists use entirely rare material in their new words, but the former are about ten percent more likely to use some of it.

More difficult to explain is the difference indicated in table 3C: the definitions of technical terms' roots are less likely, by almost ten percent, to allude to the terms' new fields (referential class *c*). By about seven percent, they are more likely to have no associations even with related fields.

That almost 60 percent of technical terms come from roots not associated with their new fields might be taken to mean that they carry no associations at all, being new to English. As I have shown, however, terms with completely unrecognizable roots account for only 18 percent of the technical terms and are about equally prevalent in the technical and nontechnical samples. The terms that make referential classes *a* and *b* substantially larger among technical terms than among nontechnical ones come at least in part from roots in a contemporary popular dictionary, so they necessarily have prior semantic associations—but not with the scientific and technological fields making use of them. Some, such as the geneticist's *dialect* and the computer scientist's *virus,* come from other scientific disciplines; others, such as *Apollo object* (used by astronomers) and *caramel* (a term in nuçlear physics), refer to areas of culture outside science and technology; still others are concepts or objects unassociated with any particular subject-area (*adaptionist, beam dump, critical path*). Old and new meanings are joined by metaphor, metonymy, or specialization, but the

relationships cannot be inferred from the terms themselves or from the definitions of their roots.

Because their components perform unpredictable new functions for which an earlier age might have used fresh lexical material, I will term such words RECYCLED. More precisely, I will use that designation for words whose roots were all in a contemporary popular dictionary but were defined without reference to the words' new subject-areas. To use the scheme of table 1 and the appendix, RECYCLED terms are those in classes *D/a, E/a,* and *F/a.*

Recycled terms constitute about 25 percent of the scientific and technological terms in my sample (see table 4). In contrast, the proportion is only 15 percent for nontechnical terms. Surprisingly, in physics, arguably the most esoteric of modern sciences, and in computer science, the newest field in the sample, the percentage is particularly high—35 percent and 53 percent, respectively. The preference for recycled terms is therefore the most distinctive feature of word-formation in science and technology, particularly in the newer subfields. Apparently Raad did not go far enough: not only do science and technology use existing linguistic resources more heavily than they did in the past, but they do so more extensively than do other domains.

It does not follow, however, that their terminology has become easier to understand. Raad is only partially correct that "the typical trait of modern terminology inheres in its removal of surface distance, both linguistic and chronological" (1989, 131), for he does not go on to say that superficial familiarity of form is often offset by referential distance—a gap between old and new fields of reference, unbridgeable for someone who knows only the old meaning. Recycled terms can in fact be more baffling than either the partially self-explanatory terms in referential classes *b* and *c* or the

TABLE 4
Percentages of Terms in Various Subjects That Are "Recycled" (categories D/a, E/a, and F/a)

Subject	*Recycled Terms*	*Total Terms*	*Percentages*
Consumer technology	9	79	11.4
Computer science	91	172	52.9
Engineering, applied science	38	180	21.1
Medicine	19	168	11.3
Natural science, except physics	19	113	16.8
Physics	29	83	34.9
Social science	18	111	16.2
ALL TECHNICAL TERMS	223	906	24.6
ALL NONTECHNICAL TERMS	18	120	15.0

incomprehensible forms in classes *A, B,* and *C.* The domains and even the new meanings of *mechatronics* (*E/b*), *microbial oil* (*E/c*), and *me too drug* (*F/c*) can be construed, at least with the help of a contemporary dictionary, but those of recycled terms such as *mousse, minifloppy,* and *mailbox* cannot. At the same time, in contrast with *Mauerkrankheit, MBE, megaflop,* or *molecular beam epitaxy,* recycled terms often trigger irrelevant associations that may interfere with correct definitions or contextual clues. Acquainted since childhood with *block* and *board,* students may not attend to the specific and uninferable referents of those terms in computer programming and hardware, and an intimate knowledge of *color* can easily distract the newcomer to quantum physics from understanding *anticolor.* Familiar forms with new associations are aliens in user-friendly clothing.

Conclusions

> Versed in all things and inspired by that Spirit which not only knows all these things but made them, [the Patristic writers] aptly symbolized the natures of one world by those which they knew corresponded to them in the other worlds (Pico della Mirandola 1489, 79).

> For in many ways, the modern theory of computation is the long-awaited science of the relations between parts and wholes; that is, of the ways in which local properties of things and processes interact to create global structures and behaviors. . . . Computer science has such intimate relations with so many other subjects that it is hard to see it as a thing in itself (Minsky 1979, 393, 400).

Although metaphor and allegory were once regarded as faithful representations of reality, scientists have been enjoined since the seventeenth century to avoid allusive, multivalent terminology. In 1667 the British Royal Society decreed that objectivity and empiricism require a "close, naked, natural way of speaking," without "Specious *Tropes* and *Figures*" (cited in Abrams 1953, 285); in 1651 in *Leviathan,* Thomas Hobbes rejected the use of metaphor in "all discourse whose end is 'the rigorous search for truth'" (in Abrams 1953, 286). More recently, Sapir urged that the "rigorous spirit of modern science" should transform English into a language with the formal precision of mathematical symbolism, "an engine of expression which is logically defensible at every point" (1949, 112; discussed in Adams 1973, 209).

As Adams demonstrates, Sapir's ideal has been realized by the nomenclature of organic chemistry, where a precise and unambiguous system of reference governs not only the choice of morphemes but also their punctuation and their sequences within words (1973, 206–10). But the chemical terminology examined by Adams is highly atypical within contemporary

scientific neology in deriving entirely from classical roots, numbers, and cryptic abbreviations—sources outside the existing English lexicon. The evidence that I have presented indicates that, for the most part, scientists and technologists are ignoring the strictures of Hobbes and Sapir and creating a periphrastic, suggestive vocabulary more typical of poetry than of formal notation.

Caso attributes modern scientists' departure from traditional methods of word-formation to their ignorance of the classical languages drawn upon by their predecessors (1980, 101), but even if he is correct we still must explain why those scientists choose, more frequently than either their predecessors or their nonscientific contemporaries, English roots that are associated with other areas of meaning. Economic motivations may play a role: although familiar terminology can be misleading, as I have argued, it at least seems to be the best vehicle for describing scientific and technological achievements to prospective sponsors or consumers. But as table 4 indicates, the most highly commercialized subfield in my sample, consumer technology, uses considerably fewer recycled terms than does the most theoretical field, physics.

A more fundamental and, I think, a more persuasive explanation for the predominance of recycled terms begins with Kittredge's statement (1982, 112) that the structure of a sublanguage "can be said to incorporate certain aspects of a knowledge representation for the subfield." In adopting that position, I mean not that reality determines the language used to describe it, but that the way in which new terms are created may reveal—may even, some have suggested, help to create—the kind of object that is known and the kind of knowledge that is formulated. (On the role of language in shaping scientific concepts, see Gregory 1990.) We could postulate, for instance, that a field where unfamiliar technical concepts are seen as novel and where science appears to operate by discovery will use many unfamiliar neologisms. Similarly, compounds of common roots with unusual ones might be commonest in a discipline where concepts are regarded as reformulations or refinements, and where knowledge is cumulative and progressive. And recycled terms might dominate where new concepts and objects seem to be reapplications or redefinitions of older ones.

It may seem perverse to suggest, as I have just done, that the concepts of some of our newest and most transformative disciplines are not fundamentally new. But nearly the same suggestion is made by a pioneer of one such discipline, Marvin Minsky, in the passage cited at the beginning of this section. In referring to the "intimate relations" of computer science with other subjects, Minsky means that it both grows from and contributes to work in mathematics, logic, psychology, linguistics, neurology, physics, and

electrical engineering. As a recent report on the discipline concludes, "Computing sits at the crossroads among the central processes of applied mathematics, science, and engineering" (Denning et al. 1989, 11). And if computing is particularly multidisciplinary, or even transdisciplinary, older fields of science and technology have also been joining in what Bell calls "a systematic synergism in the discovery and extension of new products and theories" (1983, 502). Bell explains,

> While modern science, like almost all human activities, has moved towards a greater degree of specialization in its pursuit of more detailed knowledge, the more important and crucial outcome of its association with technology is the integration of diverse fields or observations into single conceptual and theoretical frameworks offering much greater explanatory power.

The two kinds of relationship among disciplines that Minsky and Bell describe, INTERCHANGE and SYNTHESIS, both correspond to certain semantic relations between recycled terms and their roots. To the exchange of concepts corresponds the borrowing of terms, often with meanings extended through metaphor or metonymy. Thus *architect* and *icon* become computing terms, *dictionary* is appropriated by genetics, the botanical and archaeological term *bifacial* acquires a new meaning in solar energy, and *digital* moves from mathematics into computer engineering and then into consumer electronics.[6] Conceptual synthesis, likewise, corresponds to word-formation by specialization—that is, the designation of specific referents with terms general enough to be used in many disciplines: *adaptionist, compact object, configurable, expansion slot, first messenger, implementation.*

Moreover, just as interchange and synthesis among modern scientific fields are said to be more profound than in the past, recycled terms are more radically allusive than the usual products of word-formation by metaphor and specialization, because they do not include literal or deictic components. Unmoored to their new areas of reference, they float in what Bell calls an "enlarge[d] . . . 'field of relation'" (1983, 502). If such terms violate the long-standing prohibition on metaphor and ambiguity in scientific language, they do not transgress the larger principle that justified the ban: the injunction to accurate expression. Their allusiveness and referential indefiniteness reflect the wide-ranging, syncretic thought of their creators.

An analysis of recycled terms can do more, however, than reinforce recent conclusions about the "field of relation" that constitutes modern science and technology; it can also refine those conclusions. Minsky's description of interdisciplinary exchange and Bell's of grand synthesis do not account for most of the recycled terms. For instance, although some of the metaphoric and metonymic terms indicate connections among disci-

plines, more of them arise not from other technical fields but from everyday life: *black book, bubble concept, bulletin board, cold leg, crash, dirty snowball, downstream, dustman, eye, football,* and so forth. Similarly, although many of the recycled words with no fixed area of reference are appropriate to express "single conceptual and theoretical frameworks," many others are not at all theoretical—for example, *afterburst, dumb, board, cut-and-run, download, end user, friendliness, gate array,* and *hang off.* Rather than creating complex abstractions, such metaphors and specializations reduce their technical referents to the most mundane common denominator.

In fact, many of them evoke the elementary, apparently universal concepts recently described by Mark Johnson and George Lakoff, students of cognitive semantics. In various separate and joint publications, Johnson and Lakoff contend that we organize knowledge and experience through "basic-level categories" and "kinesthetic image schemas" (Lakoff 1987, 267; Lakoff 1988, 121; Johnson 1987, 2). The former constitute the "'first level' at which children learn object categories and name objects, [a level of classification] which is neither the most general nor most specific" (Lakoff 1987, 14, summarizing Brown 1965, 318–21). As examples, Lakoff cites *dog* and *chair,* simple actions such as running and walking, elementary properties (hard, soft, heavy, light, hot, cold), and basic colors (Lakoff 1987, 271). The basic level is verifiably fundamental to both language and behavior: it is "the level [of classification] with the shortest primary lexemes," "the highest level at which a person uses similar motor actions for interacting with category members," and "the level at which subjects are fastest at identifying category members" (Lakoff 1987, 46). A kinesthetic image schema is similarly fundamental but more holistic and less verbal, functioning "somewhat like the abstract structure of an image" that "connects up a vast range of different experiences that manifest [the] same recurring structure" (Johnson 1987, 2). Johnson illustrates image schemata with a list of 27 items, including COLLECTION, COMPULSION, CONTAINER, COUNTERFORCE, CYCLE, ITERATION, LINK, OBJECT, PART-WHOLE, PATH, and PROCESS (1987, 126).

Many of the English words that Lakoff and Johnson use to illustrate basic-level categories and image schemata have become technical terms within the last several decades—for instance, *run* as a computer term, *walkthrough* as used in systems analysis, innumerable electronics terms incorporating *hard* and *soft,* the newly fashionable programming *object,* and the computing terms *path, cycle, iteration,* and *process.* From the corpus used for this study, such terms as *board, black book, bug, eye, green gold, hot leg, mouse, window,* and *worm* fit the criteria for basic-level concept names; image schemata appear in, for instance, *blocking factor* (comparable to

Johnson's COLLECTION), *command-driven* (close to COMPULSION), *collider* and *crash* (instances of COUNTERFORCE), *componentry* (exemplifying PART-WHOLE), and *delink*. Both types of cognitive model appear especially often in my category *F/a,* whose members' roots are all in the *OAD* and in the high-frequency list but are not associated with the technical field. That category—the most familiar and least technical-sounding of recycled terms—contains only eight percent of my nontechnical terms but 12 percent of the scientific and technical ones and 27 percent of those from computer science.

That the terminology of modern science and technology includes so many of the names of basic-level categories and image schemata suggests that many concepts in those fields incorporate concepts of other domains not by transferring or even abstracting ideas from those domains but by according closely with fundamental structures of human cognition. Therefore, neither their language nor their conceptual models are merely metaphoric or synthetic in the usual sense. As Lakoff and Johnson explain, basic-level categories and image schemata are themselves the basis for analogies, metaphors, generalizations, and other cognitive extensions (Lakoff 1987, 267–68; Johnson 1987, 208–09). Rather than comparing or summarizing specific realms of experience, the morphologically familiar, semantically unfixed terms of contemporary science and technology name the paradigms underlying a great deal of experience.

Recycled scientific and technological terms can easily return to the nontechnical semantic realms from which many of them arose. The jargon of computer science, in particular, has become current in general speech: household equipment is or is not *user-friendly,* managers seek or pretend to seek *input,* weary people as well as malfunctioning machines need *downtime,* human plans and routines must be *debugged.*[7] Partly for that reason, some observers fear that mechanical paradigms are coming to dominate our speech and even our consciousness. After quoting with disapproval a definition of *language* that employs several computer terms, Kenner concludes that "the machine and its languages epitomize what men [*sic*] have come to think of language during humanity's three most recent centuries. Men's [*sic*] technology images what they really believe. . . . During the years between Descartes and Chomsky we have fallen imperceptibly into the habit of regarding one another, much of the time, as machines" (1980, 476).

It seems to me, however, that if mechanical values are indeed infecting knowledge and society, technological terminology is not carrying the plague. Indeed, its influence will probably work the other way. The terms that I

have described travel easily through the general vocabulary not simply because their technological domains are influential but also because they name basic processes and objects of human cognition. "Basic-level categories are defined by the convergence of our gestalt perception, our capacity for bodily movement, and our ability to form rich mental images," writes Lakoff; similarly, image schemata are "relatively simple structures that constantly recur in our everyday bodily experience" (1987, 267). Terms that directly name those categories and forms can be expected not to dehumanize the wider vocabulary but to assimilate nature and machines to a human paradigm.[8]

An upcoming issue of *The Barnhart Dictionary Companion* will undoubtedly include *virtual reality,* defined by Dyson as "the notion of combining three-dimensional simulations of reality with tools that can sense a user's movements—eyes, hands, body," along with "software and a powerful real-time computer . . . [that] compute the changes in the model to coordinate with the user's real movements" (1990, 204).[9] *Virtual reality* epitomizes what I have called recycled terminology, familiar forms with no semantic ties to their new fields. As Dyson concedes, in what would appear out of context to be a breathtaking understatement, "virtual reality is too broad an idea to be defined by a single company, product or approach" (1990, 204). The appropriation of such a term to designate a computer technique might seem to reveal the same reductivism that has already put plastic buttons on mice, transmitted viruses over fiber-optic cables, and begun to formulate the rules of "artificial intelligence."

On the other hand, designers of virtual reality claim that it is based on "the internal experience of reality," which "is much more a product of your central nervous system than of the actual external world" (Jaron Lanier, quoted in Elmer-Dewitt 1990, 75). They claim, that is, to be continuing a process defined by Lakoff and Johnson as fundamental to human cognition: the projection of bodily experience into the nonhuman world. In so doing, they will probably expand our understanding of bodies and experience, much as their colleagues have already stretched our definitions of *color, friendliness, cold leg,* and *warm boot.* Through the transformation of some of our oldest and most familiar words, modern science and technology challenge us to grasp the ways in which our familiar forms and categories are being extended into microscopic, galactic, or symbolic worlds. At the same time, they make of English not Sapir's logically rigorous "engine of expression," but a more powerful tool for the ongoing reinvention of reality.

APPENDIX
New Words, Listed by Category

A. acarbose, ACE, acyclovir, AD, Ada, AIDS, amblypygid, ARC, ASHRAE, Astria, AVC, AVM, Bacon, baladeur, Bdella, Bdellovibrio, BMD, CAD-CAM, calmodulin, CAM, camcorder, cAMP, CAR, CCRS, CD, ceftazidime, chai, cisplatin, CIWS, clo, coqui, CP/M, CRF, cyclosporin, D & D, dbx, DCB, desaparecido, diesol, DOS, DRG, drin, DSPS, DSR, EBDC, ECS, ECV, EEPROM, El Nino, ENG (mng. 1), ENG (mng. 2), ENIAC, ENSO, Eosat, ESPRIT, ET, EV, Exocet, Exosat, falk, filzocratie, flavon, FOD, FONAR, frit, FRUMP, GFCI, gigaflop, gigalips, gossypol, GTT, GUTS, hara-gei, Haz-Mat, HEL, HGPRT, HPA-23, HPNS HPRT, HREM, HTLV, Hui, IBPGR, IF, IFSTAD, IgF 1, imint, ISS (mng. 1), ISS (mng. 2), Jarvik-7, JVX, Kanak, karaoke, komiteh, L-5-HTP, LAN, LATA, LAV, libreta, LIPS, Mauerkrankheit, MBE, MHC, MIDI, MIMD, MMS, N-CAM, NBC, NDE, nefos, nekulturny, NGU, NIA, NIOSH, NSU, OSCAR, OTA, OTEC, P.M.S., PABX, pardaxin, PASCAL, PC, PDGF, permethrin, PET, PGI_2, PID, PIN, PLU, pre-AIDS, preon, PRO, PROM, pu, qinghaosu, qipao, R.C.R.A., R.P.A.R., RACE, ramapith, RD&D, RERP, RFP, rivarin, SAIDS, Saiqa, Sasol, satnav, SDI (mng. 1), SDI (mng. 2), sialon, Sindbis, sivapith, SLS, SMATV, SNC, sokaiya, somon, SPAS, SPF, SPS, STD, TAT, TCDF, TCE, tce, TDRS, télématique, Telidon, TENS, teratorn, TeV, TGV, Thatcherism, TIRC, trichothecene, Trud, UFFI, VHD, viff, VIP, wetenschapswinkel, Wohnbereich, Woonerf, WORM, Yumpie, ZOMO

B/a. antirishon, Arabsat, Brasilsat, cryptosporidiosis, Cy-mag, epikeratophakia, Fernando-mania, fragile X, inhibin, megaflop, megalips, Non-Von, PGO spikes, Phanerochaete chrysosporium, radial keratotomy, suction lipectomy, Z°

B/b. ACE inhibitor, aggregometer, Bambi syndrome, Ehlers-Danlos syndrome, keratophakia, Munich syndrome, Shwachman's syndrome, simian AIDS, Tevatron, transfectant

B/c. afar-ape, agri-gene, agridish, aichmophobia, auriculin, bagelino, calcitriol, chelation therapy, Cuisinart, dockominium, eleutherococcus, fluorophytosterol, fractal geometry, gastroplasty, infant apnea syndrome, interleukin II, K-Z syndrome, Karmarkar algorithm, leukotriene, myotherapy, osteonectin, parvovirus, phytoestrogen, preplumbing, procuronium bromide, Scheiner's halo, thiophanate-methyl, videotex

C/a. arcology, Bernoulli Box, boutique de science, Canadarm, chirkle away, Contadora Group, Draize test, Falklands factor, Gainesville Eight, granulopoietin, Hubble time, IM board, RSA system, sunchoke, Totegate, Unix, urgicenter, VO2 max

C/b. Ames test, Carbofuran, carboplatin, Dvorak keyboard, gel electrophoresis, molecular beam epitaxy, Pac-Man defense, synroc, telecom, telematics, transputer, von Neumann machine

C/c. agricommunity, angiotensin-converting enzyme, Atari democrat, Baby Doe, C_3 laser, CD player, chondromucoprotein, extracorporeal shock wave lithotripsy, Feingold diet, Higgs particle, human T-cell leukemia, hypoplatic left heart syndrome, Kawasaki disease, no-nukes, Permobile, pill generation, Quelccaya ice cap, Semliki Forest virus, syncell, synfuel, tetrachlorodibenzofuran

D/a. adaptionist, caramel, chromon, collider, colorless, compatibility, configurable, cruise, cryogenized, cryptand, cysted, decorate, delink, Denver shunt,

dialect, digraph, dotmatrix, dumb, hacker, hook echo, icon, illegitimate, implementation, incompatible, infinite scrolling, Legionella, malillumination, menu, mouse, mousse, Nemesis, neocyanine, noninvasive, optical (mng. 1), optical (mng. 2), paddle, passive, Pave Spike, Pave Tack, perfory, post-detox, reanneal, reverse fractionate, rope-a-dope, scavenge, scram, shunt, shuttle glow, simulable, sponge, Stealth, stringy floppy, superlattice, superzap, tablet, taggant, ultrasonographer, virus, worm

D/b. bug, bully pulpit, calculus, debugger, defuel, ethnotherapy, gauge symmetry, graphicist, graphics tablet, hospice, microfabricate, microgravity, microinject, passive solar, seroma, Stockholm syndrome, toxic syndrome, tranquility tank, transgenic, transposon, twilight zone, vapor-quench, vaporization

D/c. aminoglycoside, antiherpes, antiherpesvirus, antinausea, aromatherapy, Bahama shutter, cannibal galaxy, caplet, Claws, commodification, continent, cryptozoological, de-MIRV, deferral, delta hepatitis, detritivore, digital, diquark, echocardiography, ethnopharmacology, feline infectious peritonitis, fossil botany, gene mapping, genealogy, genetic counseling, gravitational lens, grooved capacitance, heliopause, heliophobia, hippo therapy, hyperacutely, hysteria, immortal, immunomodulator, immunostimulant, infectious peritonitis, kibbutz, kindergarten syndrome, kinemassic, laser gyro, laser welding, lignase, ligninase, methadonian, methoprene, methyl isocyanate, microcassette, needle, opioid, optical transistor, osteogen, phototherapy (mng. 1), phototherapy (mng. 2), photovoltaics, pneumocystis, polarity therapy, pop-psychiatry, premenstrual syndrome, prequark, pulsation tectonics, quark soup, quarkonium, rectenna, remineralization, reverse mortgage, seismic gap, septage, silicon chip, sonic holography, sonograph, sting, stun grenade, superchip, Superclaws, superinsulated, wacko, wafer chip, yumptious, zirconolite

E/a. Apollo object, beam dump, bifacial, Big C, brown dwarf, bubble concept, bulletin board, bump and run, chip detector, chromodynamic, compact object, compassionate use, cross-linker, dotted-line, duckboard: work on the duckboard, expansion slot, explosive bond, fatigue index, filter theory, gate array, global search, glow boy, hi-res, hypercolor, joint-venture, kick motor, laugh meter, lo-res, log off, log on, menu-driven, micro-mainframe link, microburst, microchannel plate, microclimate, micromainframe, Midgetman, minifloppy, option board, piggyback, pindown, plasma display, reversed field pinch, ripple effect, run abort, scenario-dependent, spaghetti suit, speech synthesizer, Supermini, tandem mirror, Tele-Mole, telechir, touch tablet, transactivating, trimix, unfriendly suitor, upgrader, upward compabitility, wafer tape, warp speed, wasp suit, weakon, zap-proof, zoo event

E/b. chroma key, delayed sleep phase syndrome, Desertron, dry deposition, electride, exon, fast twitch, geotextile, grand unified theory, helideck, hip shooter, humalin, ignition machine, intron, laminin, laser card, laser tracking, linearity hypothesis, logic array, mechatronics, optical memory card, phonestheme, platelet-derived growth factor, plug-compatibility, satellite dish, self-evacuate, sick-building syndrome, slow twitch, solar collection, stand-off jammer, steering gas, three o'clock syndrome, toponium, transaction card

E/c. A-bomb cataract, A-bomb lassitude, A-bomb sickness, A-bomb syndrome, acquired immune deficiency syndrome, adoptive pregnancy, adrenoreceptor, aerobic walking, aging clock, aging gene, anti-holdup, antilabor drug, Astro-Ice, audioastronomy, audiodisk, ballistic-missile defense, Big Claws, binary tree,

biocalibration, biological psychiatry, biotoxin, biotoxin weapon, bioweapon, blood doping, brain shunt, bugeye bomb, buzz phrase, cable converter, calcium channel blocker, cancer gene, cancerophobe, cannibal star, center-pivot irrigation, cerebral bypass, chip revolution, chronotherapy, Cinderella complex, cleaved coupled-cavity laser, clinical ecologist, cluster headache, coercive persuasion, cognitive science, cognitive therapy, Compact Disc, compact disk player, computer nerd, cosmic background radiation, credit-aholic, crescent of crisis, cross-media pollution, cryobirth, cytoprotection, data graphics, devastator bullet, diagnosis-related group, digital disc, doll eyes reflex, donor card, dumpsite, electro-rheological, electron neutrino, electronic bulletin board, ellipsoid method, encyclopedia music, Eurodump, Europhobia, exponential time, floating home, follicular regulatory protein, formal equivalence translation, fuzz-talk, garbage energy, garbage-to-energy, gene farming, gene machine, generic research, generic technology, geobuilding, gray technocrat, green dam, harmonic tremor, hex digit, histocompatibility complex, histrionic personality disorders, home robot, home video, hotel burrow, immune system, immunocompromise, immunoengineering, ion-implanted, jamproof, jumping gene, Keyhole satellite, laser chemistry, Laser Disk, laser gun, laser weapon, laser-driven, laser-generated, laser-read, lava tube, lemon law, leukoregulin, macro data, magnetic bacteria, major histocompatibility complex, manic-depressive, megahit, micro data, microbial oil, microwave television, mimodrama, mini-TV, mobile genetic element, neoliberal, numbers-oriented, nurse practitioner, octaphonic, opportunistic infection, optical disk, optronic, ovum transfer, payload assist module, peer review organization, pelvic inflammatory disease, petro-economy, Phoenix heart, Planet X, polynomial time, pop-psych, post-punker, prenatal brain shunt, projection T.V., proto-bird, proto-wing, psychoneuroimmunology, radar map, refuse-to-energy, reproductive isolation, ring laser, ring laser gyro, selfish DNA, selfish gene, severe combined immune deficiency, sexual harassment, shuttlecraft, silent holocaust, slam gate, sociopsychiatric, socks: knock one's socks off, space adaption syndrome, space shuttle, space telescope, starch blockers, Stinger missile, super-NOW account, sword and shield concept, techno-bandit, technophobe, telecommute, telephone gridlock, telesoftware, tetrachlorodibenzodioxin, transcutaneous electrical nerve stimulation, translation software, trash-to-energy, twilight justice, UV-A, UV-B, videocast, windsurfing, winged bean, workaphile, zeta particle

F/a. afterburst, anticolor, antirejection, architect, associative storage, authenticator, Autoprocess system, B-scan, base-pairing, black book, blocking factor, board, bones: make one's bones, boot up, broad-jet, build-down, cold leg, combinatoric, command-driven, componentry, controller board, coprocessor, crash, critical path, crossover, cut-and-run, demand-driven, dictionary, dirty snowball, distributed intelligence, distributed processing, download, downstream, dustman, edit, electrician, end user, expert system, eye, Fairlight, fast-tracking, fifth dimension, fifth generation, figure of merit, fine-paint, first messenger, flexible sequence, football, friendliness, gateway system, glass, gold-plating, green gold, greenwash, hand assembly, hang off, hardsuit, head-bender, high-definition, high-load, hot leg, hot reactor, hot spot, inclusionist, intelligent, jet, joy stick, letter, liquid-junction, lock and key concept, low-load, mailbox, mainboard, me too, melt-through, mother board, multi, multi-fibre arrangement, multitasking, N, neutralist, phonecard (mng. 2), prebreathing, re-uptake, real-space, reblock (mng. 1), reblock (mng. 2), reboot, regreen, releasing factor, sacrifice, safety cap, science shop, seek time,

selectionist, sequenator, sequential processing, simplex method, single-tasking, sixth generation, soft laydown, spreadsheet, systematic desensitization, telepresence, thermostabilized, time clock, trackball, transphasor, ultralight, ultrastrength, understand, unencountered, uniprocessing, upload, user-definable, user-friendliness, warm boot, window

F/b. answering machine, bio-belt, black hole, carrier fluid, chemoprevention, density-wave theory, electronic, electronic desk, electroweak, fast burn, feedback loop, fiber bundle, first-sale doctrine, ground track, hard disk, hear, herstory, LifeCard, lightboard, loadicator, loads, machine learning, machine-specific, missing mass, network, oceanic basement, on-board memory, organizational tree, pacemaker, planiversal, protein engineer, random access, reduction machine, scientific creationism, seating buck, skycrane, smart card, Snomax, soft machine, space tracker, Spacetrack, sun protection factor, sun space, technostress, theater nuclear force, touch screen, vision, wing, work front

F/c. anti-star wars, associative memory, auto-destruct, backreact, bio-region, biobehavioral, biobehavioral science, bioenergy, bioequivalence, biomarked, bioplastic, bioprocess, bioshelter, biotechnologist, birth, birthing center, blood packing, bloodletting, briefcase computer, Cardphone, cellular telephone, challenge grant, channel multiplier, computational theory, compute power, computerology, connect hours, conspiracy theory, cool reactor, cooling season, data flow, data-dependent, data-driven, death clock, death star, deep-earth gas, deep-gas, delayed-stress syndrome, designer drug, dirty power, discology, disk camera, disk drive, doc-in-a-box, drillship, electronic intelligence, electronic mail, electronic typewriter, emergicenter, emerging technology, energy war, English basement, Euroblood, Euromissile, exercise-walking, eye-movement potentials, eyetracking, festival seating, fiscal engineering, flower revolution, free-flying platform, fun run, functional programming, Gay Liberation, glass shot, glassy metal, great room, hand-foot-and-mouth disease, health club, healthwalk, hero (Soviet adj.), individual-based medicine, info-sphere, infobit, information utility, magnetic refrigeration, me too drug, memory metal, memory plastic, metallic glass, mini-television, multiprogrammable, natural killer cell, notebook computer, offgas, organic metal, passenger cell, pay research, phonecard (mng. 1), phonecasting, pocket computer, powerwalking, prebuild, pretransplantation, prewiring, racewalk, radiopager, reality programming, reduction computer, resource recovery, S-call, seasonal affective disorder, sex-change, skin fit, skin protection factor, Skylab effect, socialism (Soviet use), soft disk, space astronomy, space mine, species-based medicine, split-level investment trust, Star Wars, Star Wars defense, Strategic Defense Initiative, stressologist, substar, substellar, supercomputer, superminicomputer, superstation, survival curve, systems approach, telecomputer, treat-and-release, truth-in-advertising, unprogrammable, yard: the whole nine yards, yellow rain

Notes

1. The designation "scientific and technical" is one of the categories used by D. Barnhart (1987, x). His *Index* actually includes more than 906 scientific and technical terms because the *Dictionary Companion* lists derivational and inflectional variants separately. Because I intend primarily to compare word-formation in different subject-areas, and because I assume that derivational and inflectional

processes do not differ by subject-area, I have included only a single variant for those terms with more than one.

My sample of 120 nontechnical terms consists of every tenth term (beginning with a random selection) not included in the "scientific and technical" category.

2. Admittedly, my choice of 20 occurrences was mostly arbitrary, as would be any particular number. A continuous scale would have provided a more meaningful measure of frequency. However, the data produced by such a scale would have complicated my classifications unmanageably. Moreover, a more meaningful scale did not seem particularly important for my purposes, since I am using the scale primarily to compare various sets of terms; any distortions produced by my arbitrary cutoff point probably apply equally to all of the sets.

3. Each variant does appear as a separate item in Ku era and Francis's corpus; thus their frequencies—in particular, the fact that ten percent of their items occurred 20 times or more—cannot be taken as a base of comparison with frequencies in my own sample.

4. In table 1 and henceforth in the text, I will occasionally use *technical* instead of the cumbersome *scientific and technological,* particularly when contrasting words from science and technology with words from other ("nontechnical") areas.

5. The borrowed nontechnical terms come in roughly equal numbers from Chinese, Japanese, Russian, and Spanish. Of the 36 scientific and technical borrowings, 22 are from Greek or Latin, four from German, three each from Chinese and French, two from Spanish, and one each from Japanese and Russian.

6. The role of metaphor and metonymy in modern technical nomenclature has been noted by Raad (1989, 132) and Covington (1981, 67). My discussion of recycled terms in the following paragraphs is intended both to confirm their observations and to extend them by pointing later to a type of polysemy more common among these terms than metaphor and metonymy.

7. Although *bug* in the sense 'covert error' did not originate in computer science, most people who now use it would probably attribute it to that field.

8. I am here taking a side in a very large ongoing debate about the balance between human and mechanical elements within what Hardison (1990) calls "the metaphorics of computers—especially metaphorics relating computers to human motives/behavior/attributes." Like most metaphors, those that unite human and cybernetic domains will probably end by creating new, hybrid concepts rather than by assimilating one to the other. Perhaps, then, we are making ourselves into cognitive (and even physiological) cyborgs. But it seems to me that we are humanizing our machines at least as powerfully as they are mechanizing us. As Lakoff points out (1987, 51), the former process is firmly grounded in our long-standing definition of the world to fit "human-sized categories." And if science and technology bring us increasingly into contact with realities NOT on the human scale, as Hardison (1989) argues, we can be reassured by Lakoff's comment that "Microscopes [and, I would add, microchips] turn things that previously couldn't be seen into basic-level precepts" (Lakoff 1987, 298).

9. Other writers would exclude "tools that can sense a user's movements" from the definition, because they deny that virtual reality requires actual physical engagement in the simulation. The dispute does not affect my argument, however, because in any case virtual reality engages the categories and images of physical experience.

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