If we rid the physics of Aristotle and of Scholasticism of the outworn and demoded scientific clothing covering it, and if we bring out in its vigorous and harmonious nakedness the living flesh of this cosmology, we would be struck by its resemblance to our modern physical theory.

At the close of the final article, "The Value of Physical Theory." Duhem summarized his qualified positivism. He said:

> the physicist is compelled to recognize that *it would be unreasonable to work for the progress of physical theory if this theory were not the increasingly better defined and more precise reflection of a metaphysics; the belief in an order transcending physics is the sole justification of physical theory.*

Duhem expressed the previously cited vacillations of the physicist with respect to the foregoing affirmation by a quotation from Pascal, whose philosophic spirit permeates Duhem's book, and who may be permitted to speak in his native tongue:

> Nous avons une impuissance de prouver invincible à tout le Dogmatisme; nous avons une idée de la verité invincible à toute le Pyrrhonisme.

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Recommended Diet for Padded Writing

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FROM a close examination of the writing in many scientific publications (including, if you do not mind, *The Scientific Monthly*), one would never guess that as a nation we are renowned for efficiency. Sentences bulge like overfed matrons with unnecessary words that obscure a writer's ideas and weaken his emphasis, much as the matronly fat obscures the streamlined glory of the past. For both matrons and sentences, a major solution is diet: for writing, a diet of efficient verbs.

The following sentences from *The Scientific Monthly* illustrate the point:

> Whereas [Cannon's] studies have been primarily concerned with the physiological regulations of the internal environment, much of the work of Richter has dealt with the maintenance of the constancy of the internal environment through the operation of behavior regulators.
>
> It is noted by Harrow that pancreatectomy is fatal to the dog, with the death of the animal occurring in one to two weeks and that the length of survival of cats after removal of the pancreas is about five to six days.
>
> Still more unusual is the fact that these surrounding industrial regions give relatively little employment to "Mainliners."

Shorter, clearer, and more forceful versions of these:

> . . . Richter has chiefly studied how behavior regulators maintain the constancy of the internal environment.
>
> Harrow notes that pancreatectomy is fatal to dogs in one to two weeks and fatal to cats in about five to six days.
>
> Still more unusual, these surrounding industrial regions employ relatively few "Mainliners."

Since readers may object, with some justification, to criticism of sentences removed from context, here is a complete—and representative—paragraph, again from *The Scientific Monthly*:

> The decision to stay on a job or leave it, as well as where to work, generally lay with the scientists themselves. Only 18 of the 155 scientists who had remained on their jobs for at least 8 years reported that they had had no other offer or none worth considering during this period. Only 67 of the 574 job exits were due to factors over which the scientists had no control, and 28 of these resulted from the termination of war projects. Furthermore, the scientists were rarely forced to accept a job for lack of another offer; this was the case for only 75 of the 670 job entrances covered by the study. Very likely, the fact that the scientists were able to choose between job offers was at least in part due to their practice of continuing in a position while shopping for a new one: they rarely left a job without having another one lined up.

In this paragraph, as a rewrite shows, more than 10 percent of the words are superfluous:

> The scientists themselves could generally decide where to work, and whether to stay on a job or leave it. Only 18 of the 155 scientists who had remained on their jobs for at least 8 years reported that they had had no other offer or none worth considering during this period. Factors over which the scientists had no control accounted for only 67 of the 574 job exits, and termination of war projects caused 28 of these. Furthermore, the scientists rarely had to accept a job for lack of another offer; among 670 job entrances, the study showed only 75 such cases. Very likely, the scientists could choose between job offers partly, at least, because they normally continued in one position while shopping for another: they rarely left a job without having a new one lined up.

Probably most readers will feel the increased crispness and clarity of the revision, particularly in the first and final sentences. The revision uses 137 words, against the original's 159.

If any contributor to *The Scientific Monthly* feels impelled at this point to mail a poisoned cake, I should like to remind him that I am not carping about a specific magazine or a specific group of writers. The same excesses appear in other publications as well:

> . . . it *has an opportunity to exercise an unobtrusive influence on* the course of science in the United States. . . . [A science review]

> . . . it can influence unobtrusively the course of science. . . .

> The fact that these teachers overlook *is that* the development of new interests is the job of the teacher. . . . [A book on education]

> These teachers overlook the fact that. . . .

> Finally, the Midwest was *in the process of swift change* during the nineteenth century. [A history of politics]

> . . . the Midwest was changing swiftly. . . .

> *There is* considerable work in the literature *which* supplies supporting, circumstantial evidence for the . . . hypothesis. . . . [A botany journal]

> Considerable work in the literature supplies. . . .

Such writing—wherever it appears—hampers the sharp, clear transfer of ideas. And certainly when a writer respects his ideas sufficiently to offer them up to cold print and the tough judgment of his colleagues, he wants to present them as cleanly as he can. This he can do more satisfactorily by forcing every verb to do its full duty. The verb, after all, is the spine of a sentence: when the verb falters, the sentence sags, because a less able word must carry the verb idea.

To use verbs efficiently, obviously a writer must first recognize superfluous verbs. This offers some difficulties, but a little practice helps enormously. Moreover, there are some useful guides.

1) Examine all forms of the verb *to be* (*am, is, are, was, were, be, being, been*). If a sentence contains the verb *to be*—and many sentences do—try converting one of the nouns to a verb. Examples (*1*):

> . . . but the experiment *was a complete failure.*

> failed completely

> . . . but its persistence *is the result of* two major developments.

> stems from

> . . . it *is of concern* also *to* scientists themselves.

> it also concerns scientists

> In all three types of decisions, *the considerations uppermost in the minds of* most of these scientists *were* the interest of the work, the earnings and opportunities it provided, and the working conditions on the job.

> most of these scientists considered primarily the interest of the work (*2*).

Occasionally, in reworking *to be,* the writer will find that converting a noun to a verb does not eliminate *to be* but merely reduces it to a helping verb. In such sentences, certain wordy constructions—often prepositional phrases—needlessly take over some of the verb's functions, as in a sentence quoted earlier: "Finally, the Midwest was in the process of swift change during the nineteenth century." Here, *in the process* suggests continuous action; *was* is the main verb. Use of the progressive (*was changing*) eliminates *in the process,* reduces *was* to an auxiliary, and stresses the notion of change.

The constructions *there is* (*there are, there were,* and so forth) and *it is* frequently employ a useless *to be*:

> For example, in recent years *there* has *been a tendency for* industry to "decentralize." . . .

> industry has tended to "decentralize"

> Although no figures were available for Daylesford, it is listed because *there is no doubt that* it is the least important stop on the route.

> because it is clearly the least important stop

> For some men, *it was* the opportunity to develop and grow with a problem *which* was most important.

> For some men, the opportunity to develop and grow with a problem was most important.

There is and *it is* require various cures. In the first of the foregoing sentences, for instance, a noun (*tendency*) becomes the main verb (*tended*), replacing *been*; in the second, an adverb (*clearly*) eliminates *there is*; in the third, *it was* and *which* are simply removed.

No one, incidentally, should condemn *to be*—or any other verb or construction that is cudgeled here—automatically. *To be,* to quote a good handbook, "is the most necessary single verb in the language" (*3*). But most of us overuse it. Furthermore, a hunt for *to be* synonyms (*exists, consists of*) profits nobody. *Some* word in the existing sentence must carry the

real verb idea, and the writer should search for that word; if the verb does not carry the idea, then a noun probably does (*4*).

2) Examine forms of *to have*. Again, look for a key noun. Examples:

> These developments *had a profound influence on* Philadelphia's Main Line District.
>
> These developments profoundly influenced
>
> Since these attitudes *have a decided influence on* behavior, information concerning them is valuable to employers, personnel workers, and scientists themselves.
>
> these attitudes strongly influence behavior
>
> . . . rats *have an ability to* make selections conducive to their well-being.
>
> rats can make selections

3) Look for verbs such as *give, make, do, occur, cause, effect, bring about*. Since a complete list of such verbs would be extremely long, finding them demands sharper eyes than finding *to be* forms. The verbs named are the chronic offenders, however, and a close inspection of nouns will enable a writer to identify the rest.

> Though the Catholic Church has never *given official approbation to* these art forms, they are tolerated. . . .
>
> has never officially approved
>
> A considerable number of scientists also *gave careful consideration to* the prospective working atmosphere in choosing a job.
>
> scientists also considered carefully
>
> . . . this *brought the end of* tolls.
>
> this ended tolls

A writer should not conclude that these verbs are always unnecessary. In "I gave him the book," *gave* or a synonym is the only verb possible. One must analyze the sentence, especially its nouns, to determine whether or not a particular verb carries the verb idea.

4) Finally, to rephrase a piece of advice that seems only slightly younger than the wheel but almost as useful: convert passive voice constructions that name the doer of the action to the active voice. In the passive voice, you may remember—if your grammar teacher harangued you dutifully, the subject is acted upon. A short sample: "their jobs were threatened by war-created circumstances." Using the doer of the action of subject produces a more brisk wording: "war-created circumstances threatened their jobs." Other examples:

> It is rather remarkable that this area has had such a limited development of industry when one considers that *it is surrounded by great industrial regions.*
>
> that great industrial regions surround it
>
> It was during this period that *a cult of the Egyptian Isis was introduced into this area by seagoing natives of Apuglia.*
>
> During this period, seagoing natives of Apuglia introduced into this area a cult of the Egyptian Isis. [This version also removes *it was* and *that.*]
>
> We should mention that *Isis-Horus have/sic/been depicted as black by the Egyptians.*
>
> that the Egyptians have depicted Isis-Horus as black.

A section from a paragraph shows how consistently this construction appears and how it can emasculate ideas (four of the five sentences contain superfluous passives):

> Several weeks after these symptoms had developed the animals were placed on the self-selection diet. It *was found* that a marked appetite for fat and olive oil *was shown* by the rats and they ate little or no carbohydrate, which in this experiment was sucrose. An increased appetite *was manifested* by all 7 animals for yeast. On the self-selection diet the diabetic symptoms of all the rats either disappeared or *were* greatly *reduced*. Upon the return to the McCollum diet, diabetic symptoms *were* again *shown* by 4 of the 7 experimental animals.

Without the italicized passives:

> Several weeks after these symptoms had developed, the animals were placed on the self-selection diet. The rats then showed a marked appetite for fat and olive oil and ate little or no carbohydrate, which in this experiment was sucrose. All 7 animals manifested an increased appetite for yeast. On the self-selection diet, the diabetic symptoms of all the rats disappeared or greatly decreased. Upon return to the McCollum diet, 4 of the 7 experimental animals again showed diabetic symptoms.

Since *manifested* in the third sentence is a general verb, and since the author uses *ate* in the preceding sentence, I cannot resist offering this version also, though the writer might scream "Distortion!": *All 7 animals ate more yeast.*

Writers who tend to overuse prepositional phrases should be especially wary of the passive, because it frequently requires another prepositional phrase. And an overdose of prepositional phrases can easily send a healthy reader to a sick bed. The last half of a sentence quoted earlier supports this statement reasonably well:

> . . . much *of* the work *of* Richter has dealt *with* the maintenance *of* the constancy *of* the internal environment *through* the operation *of* behavior regulators.

A hurrying reader would probably never thoroughly understand this clause; a careful reader would have to reread it. In fact, a linguistically inclined friend of mine considers this clause a monument to the infinite meanings of *of*. Successive *of* phrases, he declares enthusiastically, force a reader into horrifying mental gyrations. He points out that the five *of* phrases in the sentence are an old-fashioned grammarian's paradise; the first is a partitive genitive (*much of work*); the second, a subjective genitive (*Richter works*) or a possessive genitive (*Richter's*

work); the third, an objective genitive (*maintain constancy*); the fourth, a partitive again (he mumbled a little here about a descriptive in reverse); the fifth, a subjective genitive (*regulators operate*) with some possibility of being regarded also as an objective genitive (*operate regulators*). The human mind can stand just so much.

On a less learned plane, I am convinced that, with a few exceptions, a succession of three *of* phrases, or five of any kind, sets up a rocking-chair rhythm so inimical to ordinary prose that it destroys the reader's concentration on meaning. I first became aware of this fact several years ago when I was analyzing some 2000 revisions of various writers; since then I have seen no evidence that alters this view and I have seen a good deal that reinforces it. Several interesting *of* sentences, for instance, appear in Fowler and Fowler's *The King's English*:

> The signs of the times point to the necessity of the modification of the system of administration.
>
> The first private conference relating to the question of the convocation of representatives of the nation took place yesterday. (*5*)

The authors revise the first sentence to

> It is becoming clear that the administrative system must be modified.

And the second to

> The first private conference on national representation took place yesterday. (*5*)

Science writers' fascination for the passive is deplorable but understandable. For describing experiments, the passive (without the doer) sometimes performs even more efficiently than the active (*6*). Too, editorial demand for objectivity may force a writer into abandoning "I," which eventually leads him to "the writer," which eventually generates self-consciousness, which finally sends him slinking to the passive. Thus, editorial policy and the passive's efficiency in specific circumstances may develop in the writer a passive-psychosis, a state in which the patient cannot differentiate between a good passive and a bad one. However faulty this diagnosis, something certainly causes the disease, and to cure it a writer might well consider every passive sick until he proves it healthy.

To end this oracle-like piece realistically, I must admit that the preceding facts, even if heeded, will not guarantee entry into prose heaven. On the other hand, they do identify certain major snares and temptations along the way.

References and Notes

1. All examples, unless a source is given, are from *The Scientific Monthly*. For obvious reasons, I am not citing the titles of articles or the issue, but I will supply this information to anyone who is interested.
2. A minor comment: *the* (before *working*) and *on the job* are unnecessary.
3. Robert J. Geist and Richard Summers, *Current English Composition* (Rinehart, New York, 1951), p. 419.
4. Occasionally an adjective will contain the verb idea: "Clovers and alfalfa *have a greater beneficial effect on* the soil than any of the other legumes." (benefit the soil more) However, the construction seems rare. This example comes from a student paper.
5. H. W. Fowler and F. G. Fowler, *The King's English* (Oxford Univ. Press, London, 3rd ed., 1931), p. 15.
6. This statement does not mean, incidentally, that the passive minus the doer can do no evil; on the contrary, an unscrupulous or careless writer can easily use it to retreat into remoteness with an unsubstantiated "It is generally thought that . . .," a pronouncement that a comatose reader may accept without the quiver of a brain cell. But to my lay eye, science researchers do not take refuge in the passive unscrupulously.

Does Writing Make an Exact Man?

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IN some parts of the world nothing brings the malign effects of the evil eye upon persons and things more quickly than perfection, or surpassing excellence, or even unqualified praise of them. A somewhat similar idea used to flourish among the Navajo women, who averted ill luck by weaving intentional imperfections into their rugs. Authors and editors do not have to take such precautions, for blemishes defy the utmost efforts to keep them out of manuscripts. A line in Lowell's *Fable for Critics* seems to reveal a psychological need for our inevitable lapses:

> One longs for a weed here and there, for variety.

And in *Idylls of the King,* Tennyson apparently decries perfection:

> He is all fault who hath no fault at all.

We look upon the Greek and Latin classics as the acme of perfection and as models for the molding of literary style and taste, but not all the ancients wrote supremely well. Numerous imperfections that one now finds in manuscripts, such as errors of fact, lapses of memory, faulty syntax, triteness, dud figures of speech, obscurity, verbiage, and pomposity, had counterparts in antiquity, so that a modern editor has to do with age-old problems.

Any critical person can cull from his general reading examples of errors of fact and lapses of memory. An informative article in a good magazine begins inauspiciously with the remark that *gastropod* is a word of Latin derivation. And the latest revision of a manual of botany lists numerous names of Greek origin under the heading "Index to Latin Names of Families, Genera and Species." In a recent issue of our most