Microcomputer Software. 2. Scientific and Technical Word Processing on a Personal Computer: Has the Time Come?

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The capabilities of inexpensive microcomputer-based scientific and technical word processors were examined with special emphasis given to what you see is what you get (WYSIWYG) systems. These systems support the display and editing of complex chemical structures and mathematical formulas. Five of the available WYSIWYG systems, Hockney's Egg, Spellbinder Scientific, T^3, Techwriter, and Volkswriter Scientific, were tested and evaluated.

The availability of relatively inexpensive home computers has completely changed how most of us write. It would now be very difficult for most of us to write effectively without a good microcomputer-based word processor. In terms of the IBM Personal Computer (PC), the user's passion for word processors has led to the introduction of about 400 of them[1] in approximately 5 years since the machine's introduction. While all those word processors did not survive, there remain a large number of very excellent ones (and some not so excellent) still competing for this vast market.[2]

In terms of scientific and technical writing, the choices are much more limited. While many of the standard word processors available are quite adequate to write the great American novel, few, if any, would be able to produce an acceptable quiz for a freshman chemistry class. A manuscript in the area of theoretical chemistry or a report of a particularly interesting reaction mechanism in organic chemistry would be totally out of the question. The written language of chemistry is still routinely produced by long-suffering secretaries with a vast array of type balls, infinite patience, and, when all else fails, a steady hand.

There should be a better way. Indeed, there is a better way, but it has taken a long time for microcomputer hardware and software to reach a level of development that makes it possible for each of us to have technical word processing capability when and where we want and need it. In what follows, scientific and technical word processors will be briefly reviewed. The literature on microcomputer software is extremely diverse, frequently appearing in journals and magazines that most people discard. I have made a reasonable attempt to survey this literature but make no claim that the survey is comprehensive. Consequently, I do not claim that the products included here are all such products available. The intent of this review is to present some useful preliminary information for those in the process of considering the purchase and application of such a system.

Most usual microcomputers with some sort of graphics video driver have two modes of operation, namely, text and graphics. In the text mode the screen area is logically divided into a relatively small number of areas, each of which has the capacity to represent a single character. Quite a normal situation is to have a computer that will, in the text mode, display 25 lines of 80 characters. The text mode generally limits your choice of characters to those displaced on the keyboard. These characters (and many others) are commonly provided in read only memory (ROM) by the manufacturer of your computer. This easily available character set, while perfectly adequate for normal prose, is not adequate for anything but the most rudimentary technical writing.

To display nonstandard characters, your computer must do one of two things. The simplest is to have a program that will allow you to display all the hidden symbols and graphics characters that have been lurking in the ROM but are not normally available in the normal text mode (not displayed on the keyboard). If this fails to provide the needed characters, the program must make some provision for either loading in new software character sets and graphics symbols or allowing you to design your own. These additional symbols will be used to replace some or all of the ROM-resident characters. In this mode, symbols must be created "the hard way". Character positions must now be considered an array of individual pixels. The quality of each character produced will depend on how many pixels your particular graphics hardware chooses to allot to each character position and how carefully the dot patterns for each are constructed. Naturally, the more pixels used for each character cell, the more potentially pleasing the appearance of the text font. Knuth is supposed to have remarked[3] that a proper type font should be "sublime in appearance and subliminal in effect". Unfortunately, most computer display systems in either the text or the graphics mode fall a bit short when it comes to sublime type fonts and symbol sets. The main problem in operating in the graphics mode is that each screenful of information requires, even at a modest level of resolution, about 250 000 pixels to be accounted for. In most scientific and technical word processors that use the graphics mode, most of the required images can be created by using suitable combinations of intrinsic text and graphics patterns already ROM resident and sets of character images provided by the program itself to supplement this collection. The final alternative, creating your own special fonts, is both a demanding and a time-consuming task. This alternative is provided by most of the programs described in this review.

The difficulties with and inadequacies of the graphics mode of operation on most common microcomputers call into question the advisability of using it for text processing. A further difficulty comes from the lack of a standard graphics protocol for microcomputers. These difficulties have tended to divide the scientific and technical word processors into the WYSIWYG (say "whizzywig", for What You See Is What You Get) and the ML (for Mark-up Language) implementations. The former requires the computer to operate, at least part of the time, in the graphics mode while the latter allows the computer to operate in the text mode exclusively.

The ML approach, the easiest from the standpoint of the computer implementation and potential exportability of the results, simply passes the graphics problem to the printer and

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$$F(b) - F(a) = \int_a^b f(x)\, dx$$

$$f'(x) = \lim_{\delta \to 0} \frac{f(x + \delta) - f(x)}{\delta}$$

Figure 1. An example of some typical technical text created with a WYSIWYG scientific word processor. This is a representation of the text that would be produced by the instructions given in the text. This figure was produced by Spellbinder Scientific, not by T_EX.

its control programs. In this method, the user describes scientific and mathematical notation in terms of strings of enigmatic characters, which to the casual observer would suggest that a very serious hardware malfunction has occurred. These groups of characters, when interpreted by a special, printer-specific driver program, are transformed into printer commands that will produce the desired result. The advantage of this approach is that the problems of representation depend only on the printer and do not force the computer to operate in the graphics mode. Furthermore, there is no limitation resulting from the inadequacies of the graphics display system. Put another way, you can produce anything your printer is capable of producing without regard to what your graphics can represent. Critics of the WYSIWYG systems are fond of saying that these systems would be more appropriately referred to as WYSIAYG, meaning "What You See Is ALL You Get". The main disadvantage of the ML systems is that the sets of characters required to produce even a fairly simple mathematical formula or a simple chemical structure are quite complex and very difficult to enter correctly because of the lack of visual feedback. In many cases, there is no way to find out what you have created until you send it to the printer. It is not uncommon to find that the fruits of your careful work cause your printer to execute several consecutive top of forms, after which you find your printer permanently locked into its lower case Swahili character set. This problem is at least partially addressed on ML implementations where there is a "preview" feature in the program that allows you to display on your screen an approximate image of what your symbols will create when sent to the printer.

The most notable examples of the ML approach (indeed, the standard against which all programs of this type are judged) are programs derived from the T_EX (pronounced "tech" because the "X" is really a "chi") system created by Donald Knuth of Stanford University.[4] This system was designed to be and is a professional-level typesetting system. The source code for this system is available at nominal cost, and it has recently been ported to microcomputers.[5] To use T_EX to create the formula in Figure 1, the following symbol sequence[5] would be required (a second program will interpret this sequence and transform it to printer instructions):

```
$$F(b) - F(a) = /int_a^b f(x) dx$$

$$f'(x) = /lim_{/delta /rightarrow 0}

{f(x+/delta) - f(x) /over /delta}$$
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The T_EX system, used with a high-resolution laser printer, will produce typeset-quality printing of professional quality. Printer drivers are also available to produce quite acceptable output on high-quality dot matrix printers operated in their graphics mode.

In my opinion, there would be no point in discussing other schemes of scientific word processing if the only issue were

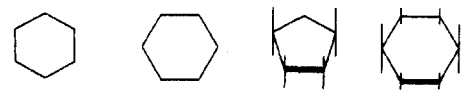

Figure 2. Examples of some chemical building blocks provided with Spellbinder Scientific.

the creation of a final document of the highest possible quality. However, the issues of ease of use, flexibility in the area of chemical structures, and the conceptual advantage of being able to see what you are creating suggest that many people would wish to consider the WYSIWYG type systems as alternatives to T_EX.

A principal advantage of writing with a word processor is that you can let your ideas flow into the computer with little initial concern for organization, sentence structure, spelling, and formatting. Your thought process, however confused, should not be constrained by the details of the writing process, and your collected thoughts should appear explicitly before you for visual and critical examination. If you are working on a scientific document complete with mathematical formulas and chemical structures, the use of the ML-type word processors is really not very helpful during the conceptual stage of your writing unless you stop at frequent intervals and print. The WYSIWYG-type scientific word processors have the advantage of aiding in the creative process of writing by providing immediate visualization. For example, the structure fragments shown in Figure 2 were actually resident on the screen prior to printing.

WYSIWYG systems also tend to intrude less on your work because of their ease of use and immediate feedback in case of errors. A potential difficulty here is that they place great strain on the computer hardware because they must operate in the graphics mode. A general fact about the WYSIWYG systems is that they will be quite slow in their updating of the display, and this can be a source of annoyance.

The final step, regardless of whether you are using a ML- or a WYSIWYG-type system, is to transfer the material to a printer. Here, there is not much to choose between the ML- and the WYSIWYG-type systems. Both systems must frequently treat the printer as a graphics device and address it at the level of its smallest resolution element. Printing will be slow on most microcomputers and strongly dependent on the speed of the computer, the resolution of the printer, and the quality and complexity of the printing you request. In terms of printing, the T_EX system has a potential advantage in that the text file it is printing is usually going to contain very substantial portions of ordinary text that may be sent to the printer as is. Only those sections requiring graphics will cause the printer to be shifted into the graphics mode and force the computer to map the symbolism of the special commands into the dot array of the printer. Printing with the WYSIWYG-type systems can be a more difficult problem because everything is normally in the graphics mode. This can make printing very slow if the software does not efficiently determine which parts of your document are text and which are graphics. In evaluating WYSIWYG scientific word processors, a critical thing to test is the printing speed.

There is one additional approach to scientific word processing—that taken by the "Macintosh world". The fundamental problem with doing the WYSIWYG-style word processing on a traditional computer (i.e., the IBM PC) is that this type of machine, which functions more rapidly and more rationally in the text mode, is forced by the demands of the problem to function in the graphics mode. The architecture of the Macintosh does not face this problem as it operates only in the graphics mode. Indeed, the Macintosh, accompanied by its ever-present mouse, used with commonly available programs like MacWrite, MacPaint, and MacDraw and

coupled with available and inexpensive technical fonts, is a highly competent WYSIWYG scientific word processor. Furthermore, T_EX is now being ported to the Macintosh.[6] That combination, coupled with the very excellent laser printer from Apple, should make formidable entry in the world of scientific word processors. Indeed, such a combination goes far beyond the level of personal scientific word processors addressed in this paper, right to no compromise professional-level typesetting. Clearly, the future is in this general approach, but the future and the present are, as usual, not the same.

Before discussing specific software products, some remarks on copy protection would seem to be in order. While the courts have agreed that it is legal to make as many copies of your own software as you wish, software vendors are concerned (with good reason) that the user's ability to make copies of software will lead to software piracy. To combat such piracy, many software products are copy-protected. These copy-protection schemes vary in detail but in most cases boil down to a single key disk that has been either physically damaged or software damaged in such a way as to make duplication difficult. This places the user in the rather precarious position of depending, in some fashion, on a single disk, which if lost or damaged renders the program and all the files created with it useless. While the trend in the industry seems to be away from copy protection, many programs are still protected, and several of the products mentioned in this paper are copy-protected. If you plan to purchase a copy-protected program, you should first determine that you can, if necessary, circumvent the copy-protection scheme. This is not meant to advocate or condone software piracy. It is simply prudent to be more than a spilled cup of coffee away from losing your work. Schemes for defeating all known copy-protection schemes are widely available both in the public domain and from a variety of vendors at modest cost. For hard disk users, many copy-protected programs provide a system for installing the program on a hard disk so that the key disk is not necessary to execute the program. You are customarily allowed some small number of chances to do this. These installation programs normally place hidden files in the root director of your hard disk. To keep from using up the small number of hard disk installations allowed (some programs allow as few as 1!), you must uninstall the protected software prior to a normal back-up and then install the program again at system regeneration because the protection scheme renders any copy of the program useless. Furthermore, many users, myself included, get annoyed when mysterious things are being done to their root directories. It is unfortunate that vendors and users have been placed in this adversarial relationship.

Two extensive reviews[6,7] on scientific and technical word processors have appeared recently. Of these, the review introduced by Palais[6] is the most comprehensive although it is generally limited to the problems encountered in mathematical text processing. This review covers both ML- and WYSIWYG-style systems. The second review[7] addresses only WYSIWYG-style systems. The ML and WYSIWYG systems will be treated separately below.

The category of ML systems is, in my opinion, limited to one general system, T_EX. This is unquestionably one of the greatest contributions to computer-aided text processing ever made. Two microcomputer implementations of this system have been evaluated recently.[8] For those who are not troubled by the ML approach to scientific text processing, one of the available microcomputer implementations (and there are certain to be many) of this package should be the clear choice. Regarding T_EX, it should be made clear that this system is a formatter, not a word processor. The text file that you create for formatting is just an ordinary ASCII text file that must be created with a word processor capable of creating such a file.

A list of ten WYSIWYG-style and two ML-style scientific word processors is given in Appendix I. As noted above, no claim is made that this list is complete. Of those listed, I have spent several hours each with four of them, Hockney's Egg, Spellbinder Scientific, Techwriter, and T_3, and talked at length with the owner and regular user of one, Volkswriter Scientific. For information about the others, Brit Scientex, Samna Word III, Proofwriter, Wordmark, and Mass-11, the reader is directed to other reviews.[6,7] Of this last group, preliminary information suggested to me that for chemical structure representations on a microcomputer only Wordmark would be of interest to review. Unfortunately, the vendor of Wordmark would only supply a review copy for a $60 fee, an offer good enough to refuse.

The tests performed by the author were carried out on a PC/AT clone (Kaypro 286i) with 640K of main memory, a 20M hard disk, and a color graphics adaptor. Printed material shown in the figures was produced with a Toshiba P351 dot matrix printer. It should be noted that all of the products tested will run on the IBM/PC/XT/AT and compatibles. Printer drivers for the most popular dot matrix printers are supplied in almost all of the products reviewed. A few of these products are available for other popular microcomputers.

Experience with several of the products suggested some key areas that should be critically examined. How important these specific areas are will depend on the applications of the individual user. The evaluation of these products should include many if not all of the following:

(1) quality and organization of the documentation
(2) ability to import and export text files
(3) speed of display response and printing
(4) ability to define macros and fonts
(5) variety of printers supported
(6) capabilities of the word processing features
(7) ability to edit and move structures and formulas
(8) hardware required for effective use
(9) file size limitations
(10) limitations imposed by copy protection

Hockney's Egg. As you would perhaps suspect from the name of this program and the name of the company that supplies it, this is not your average program. In some ways, this program is more of a cultural experience than a scientific word processor, but beneath it all it is quite an amazing and full-featured program with some unique capabilities that deserve careful consideration. The documentation is reasonably good and very entertaining, although the index is next to worthless. The strong features of this program include the character sets, which are among the very best encountered during this review, facile support of macros, user-designed characters that are fairly convenient to create, and general ease of use of the system. Command protocol is more or less free form, more or less consistent, and usually logical. In several hours of use, I never got so totally lost that I could not recover. The machine requirements in terms of disk space and memory requirements are very modest. This is one of the few systems evaluated that runs without inconvenience on a floppy-based system.

On the negative side, printing speed is quite slow, and the word processing capabilities are barely adequate. The copy-protection scheme is one of the more virulent. When complex structures or formulas are being created, the protocol is a bit unusual, and it is possible to slip up and scatter pieces of your carefully crafted structure randomly across the screen. The good features of this program outnumber the bad, and any serious evaluation of scientific word processors should include it. This is particularly true if the user contemplates working

on a floppy disk-based system. It is important to note that the person that I talked to at Perigrine Falcon was very helpful and cooperative.

Spellbinder Scientific. This is an add-on to a venerable word processor that has been around since near the beginning of the microcomputer scene. Unfortunately, this word processor, while full-featured and powerful, shows its age and has incurred some scathing comments from reviewers.[1] The documentation is voluminous and in two parts. The scientific text processing portion of the program is documented separately from the standard documentation for the word processor. Once it occurs to you that this program is a merging of the standard word processor Spellbinder and the add-on scientific word processor, you realize that you have used both sections of the documentation at the same time and that is a formidable task. Included with the documentation is a delightful little booklet that carefully and skillfully directs you through the trauma of your first mathematical formula. Creating complex mathematical formulas and chemical structures is very convenient when you learn to tolerate the protocol of the system, which is a layered-menu, mode-oriented type of protocol. This layered-menu orientation frequently forces you to cycle around through many menus, submenus, and sub-submenus to find the one that applies. When things go wrong, you can always fight your way to the surface by mashing the escape key repeatedly and then start again. In general, the protocol, while ponderous, is fairly consistent. The ability of this program to edit, copy, and move complex equations and chemical structures is as good as or better than any of the other products evaluated. Some useful chemical structure macros come with the program (see Figure 2 for examples), and you can create and save your own favorite structures, which may then be inserted into any document. Printing speed was very good for a program of this type. In sum, this is a powerful scientific word processor coupled with a full-featured standard word processor. In my opinion, with a modern user interface, this powerful program would be a top choice. This program is copy-protected but in one of the less objectionable ways.

T³. Of all the programs examined, this one has most strongly addressed the problems of creating complex chemical structures. This system provides (as a $30 option) Chemistry-Kbd1 and Biochem-Kbd1, both of which are collections of macros that create common chemical structures. These libraries contain a total of 138 such macros. Particularly impressive is the biochemistry area where simple key sequences can produce many amino acids and the major purines, pyrimidines, and nucleosides. Figure 3 presents a few of the structures in the biochemistry library.

These structures were simply "played back" from a disk file with a few commands. This program boasts an impressive list of institutions that have adopted it. This is a professional, state-of-the-art program. The word processor would be adequate as a stand-alone word processor; many very good text fonts are supplied, the protocol, based on pull-down menus, is logical and direct, the documentation is rather good, the printing performance is very good, and the help facilities are really helpful. The facilities for editing in and around complex formulas are superb. A unique feature of this program is that it can be configured much like an operating system, allowing the "system manager" to create password-protected user partitions. This program is not copy-protected.

Naturally, there are a few problems. Page formatting, while flexible, could charitably be described as awkward. This is a big and complex program. It is difficult to imagine how it could be used effectively on a machine without a hard disk although the vendor seems to say that it could. Furthermore, while the instructions for installation are fairly clear, installation would likely prove much too complicated for the office

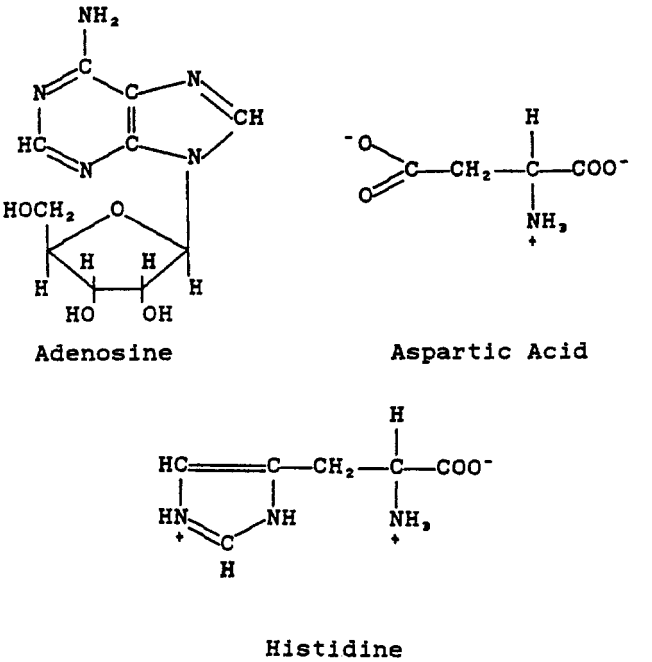

Figure 3. Examples of library structures supplied with T³.

secretary. In sum, if the hardware is available (PC/AT class machine with hard disk), consideration of this program should be very near if not at the top of any list of possibilities when looking for a WYSIWYG-type scientific word processor.

Techwriter. This program features a very capable word processor. A nice feature not common with scientific word processors is that a spelling checker is available, although the vendor did not supply it with the evaluation copy. With Techwriter you can create, edit, save, and print complex chemical structures with an acceptable effort. The documentation is adequate although one of the manuals supplied has no index. The program has quite a useful on-line help facility, and it will automatically number equations and figures. Another nice feature that recognizes the generally slow printing of these systems is a separate program to print completed files, which means that you can print and edit at the same time. Screen response, printing, and file retrieval are very slow. Although the program can be used on a floppy disk system, a hard disk based 80286 machine should be considered mandatory if you wish to get more than extremely sluggish performance. Figure 4 shows both the screen image and the printer image of the structure of quinine produced by Techwriter. In reference to Figure 4, it should be noted that WYSIWYG-type systems are not exactly as advertised.

The screen and the printer images will differ because of the differing aspects of the two devices. This is not a problem specific to Techwriter but one shared by all WYSIWYG systems.

Techwriter, like all programs of this type, remaps the keyboard. Unfortunately, this program remaps the keyboard in a way that I found annoying. For example, the program makes use of an escape key, which is mapped to the insert key on the keyboard while the escape key on the keyboard is mapped to another purpose. The logic of that is not easy to understand. To help the user, an enormous and somewhat intimidating template is provided. Another small annoyance relating to the logic of the user interface is that, as supplied, the user executes the program by typing WPS, which is not exactly an obvious mnemonic derived from the program's name. Techwriter does not handle formulas and equations as single blocks. This can make editing complex formulas and equations a very tricky business. Techwriter supplies a quite reasonable array of printer drivers including downloadable

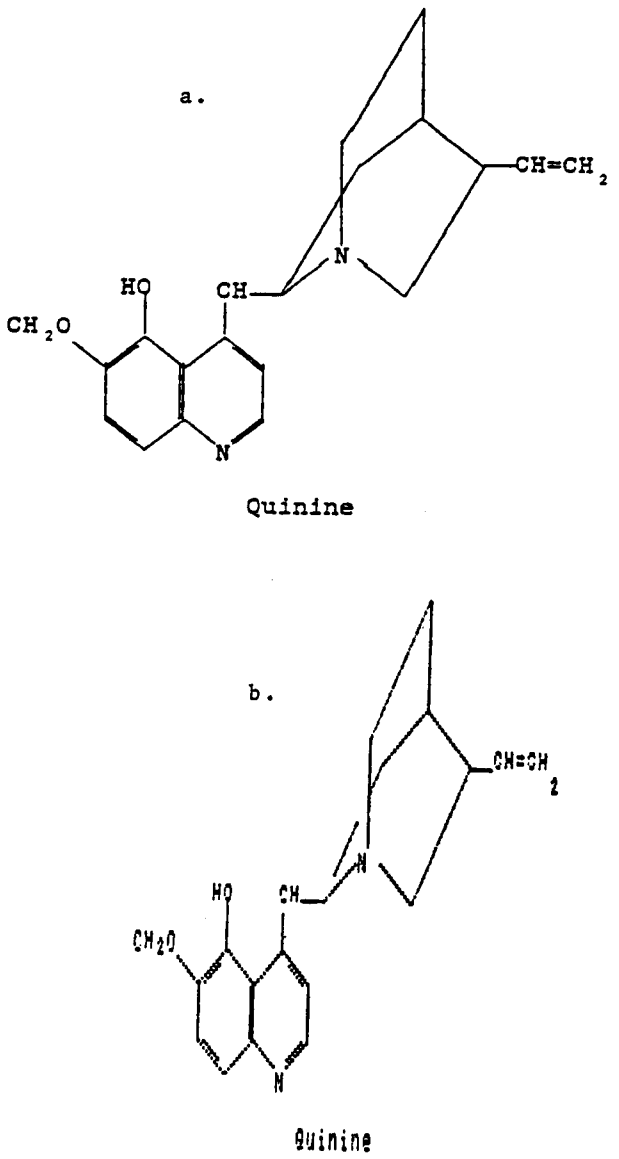

Figure 4. Chemical structure of quinine produced by Techwriter: (a) structure printed; (b) screen image of structure (print screen).

fonts for printers with such capability. In the case of the Toshiba P351 used in this paper, the download process took more than 40 s. In summary, this is a very powerful full-featured program that could satisfy the demands of most technical writing with a user interface that, in my opinion, could easily be made more logical. This program is copy-protected by one of the most inconvenient schemes.

Volkswriter Scientific. One would perhaps think that this program is merely an add-on to the reasonably well-reputed general-purpose word processor of the same name. Such is not the case. This program is most seriously flawed by the lack of much of anything in the way of a word processor and would best be considered as a companion for a general-purpose word processor. The general-purpose word processor of the same name would be an obvious choice although any word processor capable of producing plain ASCII text files should work. It must be noted that this is a one-way street; ASCII text can be imported by Volkswriter Scientific, but it can not be exported. This program has one feature that is unique—microspacing. The user can position things on the screen right down to the pixel. This feature alone could make this program the best choice in certain demanding applications. This is a carefully done attractively packaged professional-level program. The documentation is concise but effective, the installation procedure is clear and direct, and the user interface is menu-driven, logical, and consistent. This program is not really copy-protected. It asks the user to insert his or her name during installation and subsequently identifies the owner by name at program invocation. I applaud Lifetree Software for this refreshing and entirely appropriate approach.

The main problem with this program is the lack of word processing capability. The printing speed is very slow, and to compound this problem, one user reports that for some reason files from this program destroy his printer spooling program. Users who may prefer to prepare the final draft of the text portion of a document on their favorite word processor before adding formulas and structures would be well advised to evaluate this program.

So, which one of these is the best? The choice of a word processor is much like a person's choice of friends, restaurants, clothes, or cars, strictly a matter of taste. Furthermore, the choice of a scientific word processor is also a matter of what sort of science you do and what sort of computer you wish to use. Of the products evaluated, T^3, Techwriter, and Spellbinder Scientific are the most complete total systems. Of these three, T^3 is, in my opinion, the best all-around choice if you have the hardware resources to use it. Hockney's Egg would be a good choice for a floppy-based PC. Volkswriter Scientific is a somewhat different case, because it is really designed to be an add-on to another word processor. Each of the programs evaluated have their unique capabilities and weaknesses, but they are all excellent programs. Be advised, however, that they are all considerably more difficult to master than a normal word processor. The best strategy for selecting one of these systems is to read as much as you can about each product and then actually try out those that would seem to have the capabilities that you need and support for the hardware that you use. One could also talk to someone who owns the program you have interest in. This idea is not without its hazards, however. Computer hackers are notoriously chauvinistic[6] about the hardware and software that they own. Generally, if the software supplier will not send you an examination copy, they will supply their product on something like a 30-day money-back plan.

Finally, for most of these programs there is a loosely defined "educational discount" available either directly from the vendor or indirectly from some other source, which will reduce the price in many cases by a factor of 2 or more. For example, one of the programs noted above, Volkswriter Scientific, is available from a well-known software discount firm that deals with the education market for $75. Quite a remarkable discount from the advertised list price of $495!

APPENDIX I: PRODUCTS MENTIONED IN THIS PAPER

(1) Volkswriter Scientific
style: WYSIWYG
supplier: Lifetree Software, Inc.
address: 411 Pacific St. #315, Monterey, CA 93940
price: $495
phone: 408-373-4718

(2) Hockney's Egg
style: WYSIWYG
supplier: Peregrine Falcon Co.
address: 2330 Marinship Way, Suite 307, Sausalito, CA 94965
price: $495
phone: 415-331-8131

(3) Techwriter
style: WYSIWYG
supplier: Computer Mart Inc.
address: 1395 Main St., Waltham, MA 02154
price: $595

phone: 617-899-4540

(4) Spellbinder Scientific
style: WYSIWYG
supplier: Lexisoft, Inc.
address: P.O. Box 1950, Davis, CA 95617
price: $695
phone: 916-758-3630

(5) T^3 Scientific Word Processor
style: WYSIWYG
supplier: TCI Software Research, Inc.
address: 1190-B Foster Rd., Las Cruces, NM 88001
price: $595
phone: 800-874-2383

(6) Brit Scientex
style: WYSIWYG
supplier: Scientific Communications Corp.
address: 2136 Locust St., Philadelphia, PA 19103
price: $795
phone: 215-732-7978

(7) Samna Word III
style: WYSIWYG
supplier: Samna Corp.
address: 2700 N.E. Expressway, #C700, Atlanta, GA 30345
price: $550
phone: 800-241-2065

(8) WordMark
style: WYSIWYG
supplier: MARC Software International, Inc.
address: 260 Sheridan Ave., Palo Alto, CA 94307
price: $495
phone: 415-326-197

(9) MASS-11
style: WYSIWYG
supplier: Microsystems Engineering Corp.
address: 2400 W. Hassell, Suite 400, Hoffman Estates, IL 60195
price: $995
phone: 312-882-0111

(10) Proofwriter
style: WYSIWYG
supplier: Image Processing Systems
address: 6409 Applacian Way, Madison, WI 53705
price: $425
phone: 608-233-5033

(11) PCT_EX
style: ML
supplier: Personal T_EX Inc.
address: 20 Sunnyvale Ave., Suite H, Mill Valley, CA 94941
price: $379
phone: 415-388-8853

(12) $MicroT_EX$
style: ML
supplier: Addison-Wesley Publishing
address: One Jacob Way, Reading, MA 01867
price: $495
phone: 617-944-3700

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