Medical illustration on the Macintosh personal computer

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June 5, 1988
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ACKNOWLEDGMENTS

Thanks to my thesis committee; Robert Wabnitz, Glen Hintz and Robert Keough, whose assistance, patience and direction allowed the investigation and completion of this thesis project.
I. INTRODUCTION

The Macintosh personal computer system offers the artist a new tool completely dissimilar to traditional media. It is a tool that supplements and enhances, but does not replace, many of the other implements found in studios. Its uses range from routine letter-writing to preparation of camera-ready full color artwork. Although a personal computer may not be a tool that every artist would want to address, it certainly offers many possibilities for experimentation and exploration. In order to evaluate the capabilities of the Mac, three types of art were attempted; line art, tone art and color art. The software and hardware necessary for each of these types of art as well as the general procedures for accomplishing the artwork will be discussed.

Certainly, the Macintosh 'interface' should be intriguing to the artist, it is purely visual and does not at all resemble the traditional interface of other personal computers. Instead of lists and arcane key commands, one finds symbols and visual elements that seem logical. On other personal computers, the removal of a file requires the operator to input keyboard commands, that is type in letters or symbols. If the wrong combination is entered, a disk could be erased or reformatted accidentally. Deleting a file on the Mac is as easy as dragging the file into the trash can. In fact the Macintosh interface resembles a desktop. Files are placed in folders and folders are placed in other folders, very similar to the way one handles information without a computer. This visual way of interfacing with a computer ensures that the user will spend less time paging
through manuals than being productive.

Is the Mac useful to the medical illustrator? Is it cost-effective, from the standpoint of initial cost as well as the time lost in learning to operate the computer? Is the art that can be created worthy of print? What equipment is required for different types of artwork? What software is needed and which software will accomplish which task? Are there different ways to draw with the computer? Can I use my sketches in creating computer art? These are all questions that will be addressed.

The Macintosh computer can be configured in many different ways. There are several Macintosh computers; from a basic model with limited power and graphics abilities to a full-fledged model capable of sophisticated imaging, including animation. There are also different add-on devices useful to the medical illustrator.

All of the art created for this project could be completed on a MacPlus, which is an entry-level computer with a small black and white screen. There are drawbacks however, the amount of memory available for loading the software as well as the amount of memory available for creation of files would be limited. It would also be difficult to create color art or tone art with a black and white screen. Nevertheless, it is possible.

An ideal system for medical art would be a Macintosh II equipped with a color monitor and an internal hard-disk. This allows the artist to see the artwork in color or shades of gray. It also allows a larger work space since the screen on a
Mac II is larger than the screen on a Mac Plus or Mac SE. Since the screen or monitor on a Mac II is separate from the CPU (central processing unit), one can opt for a screen that shows two full 8 1/2 x 11 inch pages in actual size, as opposed to the standard 61/2x9 inch standard color monitor.

The internal 'hard disk' allows for the storage of files inside the computer as opposed to storage on many floppy disks. Floppy disks must be inserted into the computer as needed. Since files created by a medical illustrator tend to be larger than those created by the average user, a hard disk should be considered. Because of the limited storage capacity of floppy disks (800k), files created that exceed this limit could not be saved without a hard disk.

In addition to the computer, there are other hardware items that are desirable. The most important of these is a printer. In order to get the high resolution necessary for medical art, access to a Postscript compatible printer is necessary.

Postscript is a page description language developed and licensed by Adobe Systems Inc. It allows software and hardware manufacturers to integrate their products so that the artist need not be concerned with compatibility. Postscript is a 'device-dependent' language that will print at the highest resolution of the printer used. An artist using postscript generating software can create files that can be printed on several different printers at different resolutions. For example, the highest resolution available from an Apple Laserwriter Postscript printer is 300 dots per inch. A file printed on this printer would have an optimum
mum resolution of 300 dpi which would convert to about 50 lines per inch in the default halftone pattern. The same file printed on a Linotronic 100 printer would have an optimum resolution of 1250 dpi converting to an 80 line screen and printed on the Linotronic 300 would have 2450 dpi converting to a 110 line screen.

A printer is not an absolute necessity, however, it certainly makes things easier. These printers are expensive. A Laserwriter lists for $5000+ with the Linotronic printers upwards of $70,000. There are service bureaus available in larger cities that will print files on these printers at a reasonable cost. Files can also be sent to the printer electronically via the use of a modem which sends the files over telephone lines.

Because even the best monitors have a screen resolution much coarser than that of a printed file, the screen is not always the same as the printed file. This is an unavoidable phenomenon. Often a file will need to be printed more than one time to eliminate small differences between display and output. This can be annoying and unnecessarily expensive, requiring trip after trip to the printer to correct small errors. Including a Laserwriter printer in a personal system should be considered. Even if higher resolution (than available from the Laserwriter) is desired, the Laserwriter will serve as a proofing device and will pay for itself quickly.

Some other hardware items that should be considered are a digitizing tablet and or scanning device. The digitizing tablet allows the artist to draw in a more traditional fashion with a de-
vice much like a pen or pencil, as opposed to drawing with a mouse. Tablets also allow the artist to trace previously drawn sketches. This is particularly useful for surgical renderings.

A scanner is also a digitizer. Scanners come in different packages; from those that look and work like a desktop copier to those that use video cameras in a copystand fashion. The important considerations are the optimum resolution and the number of levels of gray supported. A 300dpi scanner that supports 64 levels of gray costs about $2000. Often the same service bureaus that offer Linotronic and Laserwriter printing will offer scanning at a reasonable cost.

In addition to hardware, software is also needed. Software refers specifically to programs written for the Mac which perform specific tasks. In this case, software will be used to describe commercially available programs which are available from software dealers. There are, additionally, software programs that allow the user to write specific software for their own use. The most useful of these to the medical illustrator would be software which allows the user to input specific postscript data.

There are currently many software programs that perform essentially the same tasks. Many of these were evaluated before preparing the artwork included within. Software programs in each category of art (line, tone, and color) were selected. The discussion that follows may have specific references to the software used in creation of the related artwork. The selection of

Software
software is a personal choice much like the choice of which brand of paintbrush or paint to use. However, unlike the paintbrush or paint, the software programs used for this project cost from $200-500 each. It was impossible to purchase and experiment with each available program in each category. Selected and used for the specific artwork accompanying this project were the software programs Laserpaint, Laserware Inc., San Rafael, CA. and ImageStudio, Letraset USA, Paramus NJ. Laserpaint was used in the creation of line art, color art and layout and enhancement of tone art. Image Studio was used in the creation of tone art only.
II. LINE ART

Line art is a foundation in medical illustration, it is also a foundation in computer illustration. Since one of the primary uses of the computer is the ease of storage and reuse of artwork, the line art created will be of considerable value to the artist at a later time when certain parts of a previously created image will be reused. This is an important consideration in the creation of line art on the computer. It should always be in the back of the artist's mind that the artwork will be reused. This will provide an orderly sense of direction when creating computer art because computer art is a step by step process. The general process is that of creating an image from the bottom up, altering each previous layer as the successive layer is applied.

There are two different types of lines that can be created on the Mac (and computers in general); vector lines and raster lines. These two types of lines can generally be thought of as lines that are drawn with a ruler or french curve (vector) and those that are drawn freehand (raster). Not all illustration programs for the Mac offer both, but some do.

Vector lines are lines which are defined by a mathematical formula, assigned by a starting point and a vector direction and length. This has little bearing on creating the lines however. They are drawn on the computer by specifying a point (clicking the mouse) and holding the mouse button down while dragging out, then releasing the mouse. This sounds much more difficult than it really is. The point is that the lines and curves that are drawn can be manipulated to exactly the
curve desired. This is done while making the line originally or at a later time. This makes vector lines ultimately reconfigurable, an important point to note.

Vector lines can also be fitted to each other so that a line with multiple curves will have each curve as a continuum of the last. This phenomenon is better shown than described (see left). The line weight is reconfigurable as is the direction of the line, as is the pattern of the line. These alternatives are menu items that can be selected while working within a vector line program.

As noted previously, the screen display will not be able to show the actual size of the line specified, especially the smallest lines. This is very important when dealing with different printing devices. For example when printing a line specified as hairline width on the Laserwriter, the line will have a width of 1/300th of an inch (the highest resolution of the Laserwriter). The same file printed on a Linotronic 300 will have a hairline width of 1/2450th of an inch. This occurs because postscript is, again, a device dependent language.

To avoid problems in printing, the artist should first prepare a test print for the device they wish to print on. On the test print should be examples of each line width available. Also included in this test print should be examples of each different fill percentage and each font to save having to accomplish this task again later. Once this is done, the artist will be able to refer to the test print in selecting these items. This should preclude problems in the final output.
Raster lines are somewhat different. They are considered bit-mapped images meaning they consist of a pattern which is an array of dots. As opposed to the perfectly smooth look of a vector line, the raster line is more organic with a look similar to a hand rendered sketch. While the line weight and size of the line is reconfigurable, the actual line cannot be changed without erasing and re-drawing the line.

It is also important to note that raster lines must be created in a zoom mode that relates to the final resolution desired. For example, if a raster line of 72 dpi is needed, then the line would be drawn in the 1:1 mode (actual size). If a more precise or thinner line is needed, the artist would have to zoom in to the specific scale that relates to the line width required. At a 2:1 zoom mode, things will appear twice as large as they will be printed. Raster lines created in this 2:1 mode will have twice the resolution of the screen or 2x72dpi=144dpi. Accordingly, when working in 4:1 the line would have a resolution of four times the screen, or 288dpi. These numbers are approximated since the 4:1 zoom is roughly equivalent to the resolution of the Laserwriter printer (300dpi).

The impact of all this on the artist is simple. In order to get the high resolution of the Laserwriter or Linotronic printers, one must work in a zoom mode. This may sound simple, however it can be cumbersome. One of the images created in this project used raster lines in order to achieve a more organic look (see ankle image in appendix). Sketches from surgery were used in
preparation for this art and input using a digitizing tablet. They were actually traced from a sketchbook. Because the original input was in a one to one mode and a higher resolution was desired (to take advantage of the resolution of the Laserwriter), the tracing that was input from the sketchbook had to be retraced in a 4:1 zoom mode once it was on the computer.

The critical point here is that drawing in a zoom mode can be extremely frustrating since the entire drawing cannot be seen. If original sketching is to be done on the computer without a tracing, the same procedure can be used to avoid problems. Complete a sketch in the 1:1 mode, then retrace it in a higher resolution in the zoom mode. If a 19' diagonal monitor had been available, this would most likely not have been a problem because of the increased area of a larger viewing screen.
III. TONE ART

At the present time there are several software programs that allow the artist to render grays. There is only one, however, that will allow the artist to render and manipulate those grays. This software program is called ImageStudio and is marketed by Letraset USA, Paramus N.J. The program was designed to allow the manipulation of scanned photographic images at very high resolution. It accomplishes this task well, and thanks to its "drawing like" interface it also allows the artist to work with familiar tools; charcoal sticks, paintbrushes, a water droplet, not to mention the electronic tools like contrast knobs and gray-scale maps. There is another software program that has been announced which may provide some of the same capabilities, Digital Darkroom marketed by Silicon Beach Software.

The essence of this type of software is that it allows the subtle application and blending of tones. This is accomplished through different types of pixel averaging formulas. The artist need not be concerned with these details because the drawing environment works in an expected and familiar way. Blending with the "finger" softens the image while moving it in a particular direction. The same blending with the "water droplet" softens without moving tone.

Developing an image in ImageStudio is accomplished in the same fashion as line art – from the bottom up. While it is possible to import a line drawing for use as a template, this method requires considerable clean-up. If the drawing is started with the charcoal tool, it will require little or no clean-up. Because the artist can zoom in...
up to 8X, details can be clearly defined. Therefore, the drawing can be "roughed in" at actual size then be refined at one of the eight zoom levels.

Once the drawing itself is finished it can also be enhanced electronically. There are filters that soften, blur, sharpen and more. These can be applied to a selected area or the whole drawing. The brightness and contrast may be adjusted, much as one would adjust a television.

A drawing may also be enhanced through the addition of vector or raster lines by importing it into another program. This step of importing the image into another program is inevitable since most images require text and ImageStudio does not allow text placement. It may be valuable to consider the purchase of software that allows the addition of vector/raster lines as well as text. Since medical illustrators often illustrate mechanical and organic images, the addition of vector lines is critical. Not only do they help define instruments, they also are necessary for lead lines and other graphic devices.

ImageStudio runs on a Mac Plus or SE, however, you won't see the image in very clear resolution. This is because the Plus and SE have bi-level monitors. A pixel is either black or white. In order to see the image at its best, a monitor that displays grays is required. When using this type of monitor a pixel may be any of 256 shades of gray. Either of the Macintosh II optional monitors, the RGB or Gray-scale, will do the job. Another consideration is the amount of
RAM (random access memory) required. Two megabytes of RAM should be considered a minimum, for optimum performance consider five megas. A Mac II with 2 megas of RAM will not open a full page scanned image in actual size. It reduces the image to postage stamp size before it will open. The same is true of creating full 8.5x11 images from scratch. They might not be able to be saved in their entirety.

ImageStudio, and other image manipulation software, store their images in a file format known as TIFF (tagged image file format) or RIFF (raster image file format). It is important to note whether the software chosen will address these file formats. TIFF is becoming an industry standard, RIFF however seems to be less popular though it saves information in less space.

Both of these file formats require large amounts of RAM, as well as disk storage space. To minimize this problem always eliminate white space around a drawing before saving it. This can be accomplished by selecting an area to be saved as opposed to saving the whole page. It should also be noted that most software which allows TIFF files to be imported requires that they be saved "uncompressed" first.

Once an image is completed (regardless as to whether it was enhanced in another program), it will print at the highest resolution of the device used. The results that can be obtained by printing this image at 2450 dpi on a Linotronic 300 printer are very impressive. Care should be taken to ensure that if vector lines are added, the artist is sure as to the actual size they will appear.
This phenomenon was discussed previously and deserves consideration.
IV. COLOR ART

Color art can be accomplished on any of the Macintosh computers, it can only be seen in color on the monitor if the monitor is an RGB color monitor. A color monitor is an option on the Macintosh II computers and available as an add-on device for the Mac SE computers. This may seem contradictory, however, color can be specified and separated, or slides produced without seeing the image in color. This is accomplished with software that provides color output by referring to a PMS chart (Pantone Matching System, or other matching system). The artist can refer to marker renderings, or other color comps prepared by hand, and specify the colors while looking at a black and white display. Of course this task is much simpler if the artwork appears in color on the screen, however it is not absolutely necessary to see color to actually get color.

There are several types of color output that should be defined. Color output for printed pages, color output for slide production, color output to a color printer, and color output for video animation are all different processes. They require different software and different procedures for getting the output. This research concerns only color output for printed pages. Hard copy output is an active area of research and development for the Mac. Hardware has been developed that will allow the Mac II to display a different color on every pixel on the screen from a palette of 16.5 million colors. This allows 700,000 colors to be displayed at once for near photographic resolution. Magazines are now using the Mac II for layout and design, the images needed in conjunction with the text are scanned, the computers net-
worked, allowing editors and designers to work interactively in the production. This translates into a reduction in photostat and typesetting costs as well as the number of people involved, thus, overall costs drop considerably. In addition, a book entitled *Christmas in America* was completed on the MacII and will be available later this year.

The key to this kind of ability is twofold; the development of the 24 bit video card for accurate display, and the development of software that will automatically separate the screen images into the four color plates required for full color process printing (spot or line color separation is also possible). Once the software separates, rotates and registers the plates, they can be printed (as with normal black and white files) using any of the high-resolution printing devices mentioned previously. This output can also be printed directly onto film plates that are press-ready. Further camera work would not be required.

Since the medical illustrator is often confronted with the preparation of simple color charts, graphs and diagrams; this software can be very useful. With a color monitor, the artist simply creates the artwork in color on the screen. Once the image is completed, the artist simply exercises a menu item that automatically separates the files into their respective plates. At this point the artist can open and manipulate each of the plates individually if required, or print the plates in black and white. This presents the problem of proofing the art in color to make sure the elements are correct and the colors used are
true to the screen.

Of course, color proofing is commercially available through most color printing houses, however, this is expensive (most methods of proofing cost $100 or more for a single proof). Another way of proofing a color image is to use a color copier. On color copiers that use plain paper (such as the Canon color laser copier), each of the four plates may be overprinted on each other in their process color.

The hardest part of this procedure may be convincing the owner/operator of the copier to cooperate. Once this is achieved, the operator needs simply to place the yellow plate (which appears as a b/w image) on the platen of the copier and make a print with yellow only ink. This yellow print that was just produced is then placed back into the paper tray. The magenta plate is then placed on the platen and printed in magenta ink. Now the print will have two colors of ink printed one over the other. The process is continued with the cyan plate and finally with the black plate in the same manner as the yellow and magenta plates. The final result should be color, but it won't be registered. The problem of registration cannot be overcome with this method of proofing simply because the copier feeds the paper mechanically and is not critical enough for perfect registration. The colors remain true to PMS matching, however, and can then be evaluated for aesthetic considerations. It is safe to assume that the registration marks placed by the computer will be accurate enough so this method of proofing can be of use even though it is out of registration. In comparison with a 3M Chromlin

\textbf{Color Proofing}
Developing Images

pre-press color proof, the Canon proof was comparable in value, and in hue. Its saturation was somewhat denser than the screen display or the Chromlin proof, however. This technique is limited in its application since it is practical only when the laserprinter is used for the masters. The low resolution of the Laserwriter precludes most commercial printing uses however it may be suitable for in house use. Using Linotronic output is not practical because its line pattern cannot be resolved by the copier and the colors block in.

Developing an image is accomplished in the same way as working with vector or raster lines. Time can be saved if the image is drawn in line, then color added. There also may be an option within the specific software that allows for limited re-draw. This will save considerable time in the long run because the screen re-draws after changes or additions are made.

Because of the ease of altering an image once it is drawn, either by changing the layout or colors used, the computer speeds the process of design. This can be a useful tool even if the image is not actually completed on the computer. For example, an artist who was creating editorial art with some text could mock up the image and change its colors and layout quickly to sample different designs.
V. PRINTING

The process of printing artwork prepared on a computer is often confusing and difficult. There are several reasons for this including a multitude of file formats and software quirks as well as simply getting the files to a printer. Since the step of getting some usable hard copy is the essence of preparing artwork, the process of achieving output should not be underestimated. It is often quick and relatively easy to arrive at a finished image on the computer only to have myriad problems in getting the job on paper. This is true not only on the Linotronic printers but on the Laserwriter as well.

If the artist does not have a Laserwriter printer dedicated to their computer, some preparation is necessary. A common problem is that of font substitution. The fonts themselves are stored in the ROM (Read Only Memory) of the printer. Each version and model of the Laserwriter will have a different set of fonts. While all Laserwriter printers have some of the basic fonts such as Helvetica and Times, there are numerous other fonts and styles available. It is important to note which fonts are resident in the printer being used. If the artist is not using the specific software and system file used in the creation of the artwork to print the same artwork, problems may be encountered in the recognition of fonts. This may occur even if the same fonts are available on both disks and on both system files.

For example if artwork is created by the artist and stored as a file in ReadySetGo!, then taken to a Laserwriter and printed with a copy of
the service bureau’s ReadySetGo!, unwanted font substitution may occur. This is because the fonts used are identified by the computer according to the order in which they appear on the font menu on the specific system file of the disk they were created on. Therefore, if the font lists do not contain the same fonts in the same order on both disks, font substitution may occur.

There are three solutions: Print from the same exact disk the images were created on. Arrange your font menu with the same fonts in the same order as the disk that will used for printing. Send your files to the printer in postscript format. The first two solutions are rather obvious, the third may require some explanation.

As mentioned previously, Postscript is a page description language that is employed by most of the high-resolution software discussed herein. Several of the software programs allow the file to be stored in a postscript format by selecting a menu item. So files saved in postscript, then taken to the printer and downloaded as postscript will remain exactly as they were created. This is a critical advantage. First of all the service bureau may not have the software that is being used which may require leaving the software with the bureau. This can present unnecessary problems for both the artist and the service bureau. Saving files in postscript format alleviates any problems of font substitution that may otherwise occur.

Page setup

It is also important to set up the page you are printing correctly before starting the artwork. If the artwork is created first, then page layout de-
cisions made later, the artwork will seldom fit the page. Most software programs have menu items that allow the artist to specify the size and arrangement of the paper used. Letter and legal sizes are available on the Laserwriter and both these sizes plus ledger are available on the Linotronic.

Many software programs will allow larger paper sizes through the use of tiling smaller pages together. This procedure differs on each software program, so tests should be accomplished before attempting the final output, especially when printing on the Linotronic. Linotronic output may run from $10-$30 for an 8.5x11" illustration.

Once a print is accomplished on the Laserwriter or Linotronic printers, it can be used as a master for traditional reproduction. Obviously a copier can provide reasonably good reproduction of line art. Copiers do not reproduce tonal areas as well, especially when Linotronic output is used as a master. Tonal areas tend to block in or drop out unexpectedly. Laserwriter output performed reasonable well on the copier with both line and tone art, although the coarseness of the Laserwriter halftone assignment was distracting. Offset printing is a reasonable alternative since it’s costs drop dramatically with respect to the quantity of prints. The printer may also be able to produce spot or line color on an offset press.

In evaluating the offset process, three different masters were printed on the same stock for comparison. The device used for printing was a Davidson 500 offset printing press. The three
masters were; Laserwriter hard copy (55 lines), Linotronic 300 hard copy (110 lines), and Linotronic 300 film negative (110 lines). Hard copy is used to define those plates which needed to be photostated and burned onto the plate, film negative refers to the plate which was output directly on film and bypasses the need for a photostat. (see appendix for examples of each of these processes)

The Laserwriter master did not perform well in offset printing. First of all is the coarseness which was also a problem with photocopier reproduction. Secondly the Laserwriter master seemed to be much too dense once printed. Much of the contrast, which was attractive in the original illustration, was lost. This may be due to the interim step of photostating the master onto film. In any event, the Laserwriter master was to be a base of comparison since its halftone was considered easily reproduced. Since the Laserwriter master was output onto inexpensive stock, there may have been bleeding that occurred. At this time there are several papers which are being marketed for the Laserwriters which are said to be suitable for use as a master (such as Hammermill's Laser Plus). These new papers reduce bleeding and may have corrected the problems encountered with offset printing from Laserwriter masters, had they been available for use in this test.

Of the two masters produced on the Linotronic, they were vastly dissimilar. The master which was output as a film negative was expected to provide the best copy since its use eliminated the need for the interim step of photostatic re-
versal. It performed poorly. Upon evaluation of the image (which was a negative image) it can be seen that the original had dropped out in the highlight areas. This is most likely due to a problem within the Linotronic printer itself since all masters were produced from the same electronic image.

The master which was produced from Linotronic hard copy then photostatically reversed prior to making the plate, performed exceptionally well. The image is clear, the contrast held true to the original and there appears to be only a minimum of blocking in the darkest areas.

Although this test is inconclusive with respect to which type of master is best for use in offset printing, it does confirm that reasonably good results can be achieved through the use of Linotronic output. It was thought that the highest resolution (2450dpi/110 lpi) would be difficult to reproduce on an offset press. That is not the case.
VI. Areas for Future Exploration

In the process of completing this research, several new directions for exploration have become apparent. Since the personal computer is still relatively unexplored from the standpoint of its relation to traditional methods and materials, there appear to be many areas left to be examined. Artists seem to either use the computer to produce finished art or do not use the computer to produce finished art. There seems little interest in using the computer to perform a step in the process of traditional art.

An example of how the computer may be used to accomplish a single step is the preparation of friskets for airbrush art. The Laserwriter printers will print on adhesive-backed acetate for copiers. This enables the artist to prepare his image in vector lines on the personal computer, then print each of the elements separately on to the acetate. The acetate can then be scored or cut and used as a mask or dodge. This would expedite the tracing and preparation of the masks. In addition the artist would be able to use the same templates to see the images in color (on the MacII) by simply assigning colors to them. Many software programs support PMS matching, therefore the screen view could be useful for determining the exact colors to be used in the final rendering.

Another direction for exploration would be in the area of imaging and computer enhancement of video images. Technology already exists that allows images to be "grabbed" from existing video tape or a live video camera which would allow direct enhancement of existing images or the use of these images as templates for further
Video Enhancement

development into line, tone or color art.

ImageStudio software, which was previously discussed under tone art, offers the artist the ability to retouch, enhance or isolate images brought into the Mac from a video source. This would seem to be a valuable consideration for the institution which already has in-house video resources. An artist could take video tape and convert it to print in an accurate and time efficient manner by simply eliminating extraneous information and further defining the information needed for clarity.

Of course, software already exists that allows for the tracing of scanned images. This software can be used in conjunction with video input, allowing the artist to work directly from the images created with video camera. This would be especially advantageous in the preparation of a series of illustrations.

Presentations

Another, often overlooked, use for the personal computer is that of presentation device. Why go to the expense and trouble of converting the computer images into slide form when large color monitors (up to 35" dia.) are available. The expense here would be the one-time investment required for the larger screen and video card that drives it, as opposed to the continuous cost of slide conversion from screen images. This would also allow animation and other interactive types of instruction. Software for creating presentations on the Mac is available at a reasonable cost as is software for animation purposes.
VII. CONCLUSIONS

All of this research seems to lead to the same conclusion insofar as its application to medical illustration, that is, an area of further specialization for the illustrator. Certainly personal computers, and the Macintosh line in particular, have applications useful to both the free-lance illustrator and the institutional illustrator as well.

The Macintosh is certainly being used in the training and education of illustration candidates in most every institution that offers a program in medical illustration. However the computer is seldom used to its fullest extent, in fact it is seldom used for anything other than word processing. There are students who are using Macintosh computers for advanced projects within each of these institutions. They are doing so at their own expense, however, and without the benefit of instruction in the specific areas of computer usage which apply to the creation of images or the use of imaging. This is unfortunate. It is also understandable. The rapidly advancing area of computer illustration is difficult to keep abreast of. Within the last year (1987/1988) have come most of the advancements in hardware and software that makes medical illustration on computers feasible. However, this new technology will not advance any less rapidly in the near future. Now is the time for educators and department heads to become familiar, to hire those that are familiar, and to invest in the technology and training required to integrate the personal computer into the field of medical illustration.

Not too many years back came the advent of photography into the field of medical illustration. Now there are photographic illustrators and
programs that educate these illustrators, as well as departments devoted to photo-illustration. It is time to integrate computer illustration into the curriculum, to train computer illustrators and time for computer illustration departments within institutions.
Appendix A - Glossary

**Byte** - one unit of information. In a binary system a byte is identified as either a 0 or a 1. A term used to describe the size of electronic files; $400k=400$ kilobytes=$400,000$ bytes; $20$ megas=$20$ megabytes=$20,000,000$ bytes.

**CPU** - Central Processing Unit or the main body or portion of a computer which holds the memory chips and other essential components.

**Digitizer** - refers to a device which scans and converts images into file formats which can be displayed on a computer.

**Encapsulated Postscript (EPSF)** - a format used to allow the inclusion of postscript images into other documents.

**Grayscale** - a term used primarily to indicate that a monitor or screen is able to display a pixel in a shade of gray as opposed to only black or white.

**Hard Disk** - a magnetic storage device that is not removable. Hard disks are usually specified as to the number of megabytes of information they can store.

**Hardware** - those items of equipment which comprise the tangible part of a computer system, the screen, keyboard, disk drive, etc.

**Kilobyte** - see *Byte*.

**Laserwriter** - a 300dpi laser printer manufactured by Apple Corp. Used as a benchmark standard for other laser printers which use the same or similar technology in the printing process.

**Linotronic** - a high resolution printing device manufactured by Allied Linotype Corp. which addresses files stored in Postscript format. Two models are available, 100 and 300.

**Megabyte** - see *Byte*.

**Monitor** - the viewing screen, sometimes these are built in to the computer and sometimes they are options. Monitors are one of three types, monochrome (b/w), gray scale, or color.

**Pixel** - one dot on a monitor. The open area in a screen matrix where light emits from.

**Postscript** - a page description language developed by Adobe Systems, Inc. which is used by developers to ensure compatibility between hardware and software.

**RAM** - Random Access Memory, that memory in a computer that is available for use in the creation and manipulation of files. RAM is usually volatile meaning those items stored in RAM will be lost if not saved to disk prior to shutdown. RAM is also expandable, most personal computers allow the addition of extra RAM which allows the creation of larger or more complicated files.

**ROM** - Read Only Memory, that memory which contains the codes which allow software to be recognized when it is inserted into a drive. This memory is not generally accessible to the user.

**Raster** - refers to images which are displayed as a group of dots or patterns.

**Resolution** - specifically refers to printing and scanning devices and indicates the number of dots used in the creation of images. (i.e. the Linotronic 300 has a resolution of 2450 dpi)

**RIFF** - Raster Image File Format. A format for storing raster image files, generally used in the storage of scanned images.

**Software** - programs that are written for computers which perform specific tasks. These programs exist only as electronic data stored on disks (hard or soft).

**TIFF** - Tagged Image File Format. A format for storing raster images, generally
used in storing scanned images.

**Vector**- refers to lines which are specified as a mathematical formula. Generally accepted to mean those lines whose curves are smooth and specific in width.

**Video Card**- a printed circuit board usually located in the CPU which controls the video output to the monitor. Different monitors require different video boards.

Eight bit video cards can display 256 of 6.5 million colors at once, 24 bit video cards can display a different color on every pixel on the screen (700,000) of 16.5 million colors.
INDEX OF ARTWORK

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   Laserwriter (hard copy)
   Linotronic (hard copy)
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The kidneys are a paired set of organs located dorsally and retroperitoneally in the abdomen. As part of the urinary system, the kidneys produce urine which is conveyed through the ureters, retained by the bladder, and discharged through the urethra. They are situated between the 12th thoracic and third lumbar vertebra with the right kidney 1-2 centimeters lower, due to the presence of the liver. Each kidney weighs approximately 115 to 170 grams depending on the sex and relative body size of the individual. Their combined weight as compared to overall body weight is approximately 1:240 in the adult and 1:80 in the newborn.

illustrations by Bobby Pitts
using Laserpaint® software
Ankle Reconstruction - lateral entry

Step 1
Peroneus Longus tendon is detached from the muscle and reattached taking up slack caused by chronic aversion of ankle

Step 2
Staple inserted to secure superior peroneal ligament to fibula

illustrations by B. Pitts ©
Abdominal Hysterectomy

plate 4, Birch Procedure

Uterus showing round ligament tied and severed

Birch Procedure the bladder is stabilized by attachment to periosteum of symphysis pubis

Illustrations by Bobby Pitts ©
Abdominal Hysterectomy

plate 4, Birch Procedure

Uterus showing round ligament tied and severed

Birch Procedure the bladder is stabilized by attachment to periosteum of symphysis pubis

Illustrations by Bobby Pitts ©
Cadaver Dissection
left shoulder joint exposed
(tendon of biceps enlarged for clarity)

A Deltoid (cut)
B Head of humerus
C Tendon of Biceps (cut)
D Articular capsule
E Clavicle

a lateral cord
b medial cord
c ulnar n.
d median n.
e musculocutaneous n.
The kidneys are a paired set of organs located dorsally and retroperitoneally in the abdomen. They are situated between the 12th thoracic and 3rd lumbar vertebra with the right kidney 1-2 centimeters lower due to the presence of the liver.

The renal pelvis (shown detached) collects urine from all the renal papilla. The urine enters the pelvis via the calyx and then flows through the ureter and into the bladder where it is stored, then emitted through the urethra.

The renal artery branches from the abdominal aorta and enters the kidney through the hilus. Its branches course between the renal pyramids as interlobar arteries and arch between the pyramids and the greater curvature of the kidney as arcuate arteries, supplying the glomeruli which in turn filter the urine from the blood.

Illustrations by Bobby Pitts using Laserpaint® software.
Plate 298. Abdominal Hysterectomy

fig. A  Round Ligament of Uterus tied then severed. Careful location and dissection of round & broad ligaments and ureter is essential.

fig. B  Birch Procedure. Bladder reattached to periosteum of symphysis pubis.
fig. A Round Ligament of Uterus tied then severed. Careful location and dissection of round & broad ligaments and ureter is essential.

fig. B Birch Procedure. Bladder reattached to periosteum of symphysis pubis.
**fig. A** Round Ligament of Uterus tied then severed. Careful location and dissection of round & broad ligaments and ureter is essential.

**fig. B** Birch Procedure. Bladder reattached to periosteum of symphysis pubis.