NOTES ON PICTURES

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I originally wrote this small booklet as background reading for a lecture given at Yale in the spring of 2001, the University's Tercentennial year. The lecture was on the subject of pictures and democracy, and there seemed to be no available reference material that concisely outlined the history of pictures and their technical development.

For our European cruise, in the fall of 2002, I have prepared four lectures, and the final one is about pictures in general, and how they work. I decided that this monograph remains useful as reference material for this lecture, and so this new edition of 200 copies has been prepared specifically for those joining us on the cruise. This small booklet is noteworthy for containing no pictures! My lecture will be illustrated with many, culminating in a historical show of important photographs and other pictures that have had strong impact on our society. I hope the cruise members can enjoy the theoretical issues brought up by the booklet, and find it rewarding to connect these to the enjoyable images we will see on our travels. You should feel free, of course, to ignore the whole thing, toss this booklet into a suitcase, and just enjoy the trip.

RICHARD BENSON *August 2002*

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DEFINITIONS

It is almost impossible to find a decent definition for the word "picture." The older a dictionary is, the more the definition is linked to a particular technology. The Century Cyclopedia, my favorite dictionary, was published in the 1890's, and its primary definition for pictures is "The art or work of a painter." This is not surprising, because the latin root for "picture" relates to painting. A more recent dictionary, such as Webster's New Ninth Collegiate, published in 1985, manages to admit photography into its first definition, but electronics (the source of most of our pictures today) appears nowhere. I have taken some liberties and use the term "picture" rather broadly, and do so because of my own experience and understanding of the word and what it means.

"Technology," which is continually referred to in the following text, is an easier word to define. My old favorite the Century defines it thus:

"That branch of knowledge which deals with the various industrial arts; the science or systematic knowledge of the industrial arts and crafts...."

The definitions of both these words are careful to make no reference to specific content, and that will be true of much of what follows in this monograph.

INTRODUCTION

Pictures pervade our world. They exist in a wide variety of physical types– as photographs in books and magazines, as fleeting images on a theater or computer screen, and even as the efficient and standardized tiny symbolic pictures of the very letters of which this writing is comprised. The pictures we use on a daily basis have their origins in a dizzying array of technologies, which each have a long lineage. A writer might look at a digitally driven flat panel display in a portable computer while simultaneously using a reference book printed with ink and lead type, in a technology virtually unchanged since its invention 500 years ago. The wide diversity of picture types and their varied technologies make for a rich subject of study, but one that is largely ignored. There seems to be no comprehensive overview of pictures, and my aim here is to sketch the outlines of such a study.

These extraordinarily versatile tools, visual in nature but inextricably connected to their physical presence, form a broad underpinning for society today. Without them human cooperation would be disrupted almost to the point of complete breakdown, and social structures on any sort of large scale would be impossible. Our culture would collapse without the sea of data bearing pictures through which our present enterprises move. For all this, the public understanding of pictures– how they are made, how they developed and what they can do– is astonishingly limited. We use them as they hang on kitchen walls and tell of foreign places, as they

help us drive through town and not collide with oncoming traffic, and as they flicker past in streaming video on the local late night news show. But, mystifyingly, we pay little attention to their types and ancient roots, and we take for granted their ability to hold the content that flows so effortlessly through the eye and into the mind.

It is impossible to know the origin of pictures. We can safely assume that there were many starting points in picture making, but we can't even be sure whether or not the first pictures were made for their makers or for the use of others. We can be sure, though, that pictures from earliest times were made available to audiences of many individuals. This is in itself a remarkable fact. When we speak our audience is limited to those within earshot, at the moment of the speaking, and when we use a picture the audience needs to be within sight of the picture to use it. The viewing audience, however, can come and go, and partake of the picture's influence for as long as it physically exists. The picture has a clear advantage over speech in this respect, and this advantage was probably the original impulse for the development of the symbolic pictures which constitute written language.

Writing developed early on, and it could do so, in relatively crude technological times, because the pictures which comprise letters and numbers are very easy to make. Letters and the words they form are a pictorial system that can vary in detail with the individual writer, and yet still retain legibility for the reader, and so remain useful. This is not the case with

more complex pictures. The paintings on the cave walls at Lascaux, made more than 30,000 years ago, are exceedingly hard to reproduce, and no attempt at this, aside from a virtual full scale replica, could contain the same meaning as the originals.

There are a number of technical innovations that had to be made for pictures to evolve from these early stone-based originals to the billions of copies that flood our lives today.

The first necessary shift was that the support for pictures– that is the physical substrate upon which the picture data was held– had to change and become cheap, common and, above all, portable. The image made in sand, or carved in rock gave way to the inscription on a clay tablet, or the drawing on papyrus or paper. When this happened the power of the picture grew because it could be brought to the viewer, and so its potential to influence a wide audience was increased. These new pictures were cheap, available to more users, and easier to make; as a result of this they were used for more mundane tasks than formal and grand display. The moveable and inexpensive picture, typified by the sketch or note written on paper, enjoyed thousands of years of dominance, and it was a central tool in the creation of society as we know it. Commercial transactions and personal communications were recorded on paper, diagrams of inventions and representations of divinity were all set down for mass consumption, and the stability and pervasiveness of these images allowed the work of successive generations to accu-

mulate in long-lived social structures. Whether words, letters, numbers, drawings or diagrams, the stuff laid down on paper was usually pictorial, consisting of visual patterns and forms carrying impact to the viewer through the three fundamental techniques of representation, symbolism and decoration.

While cheap and simple pictures like those on paper reached wide audiences, they never became effective in multiple copies until the age of printing. Printing is distinguished by the presence of a matrix, such as a printing block or plate, that can hold the data of a picture and place it onto multiple copies through the transfer of a pigment bearing medium such as ink. Printing came after the invention of books, but before the invention of moveable type. For centuries pictures had been transferred onto fabric and paper from printing blocks, and moveable type was a refinement of these earlier processes. Woodblock prints in both east and west carried linear representational pictures in multiple copies to multiple viewers, and it is ironic that complex representational pictures like these were easier to make than the simple letters of words that hand and pen so effortlessly produced.

We think of printing as being an underpinning of civilization, and it is surely so; a printing press in the year 1600 could produce 100 copies of a book in a minute fraction of the time that a contemporary copyist would have needed to make a similar edition. Because of this dramatic step, we tend to think of the power of the press as residing in its abil-

ity to make many copies, but this is only half the story. Equally important is the often overlooked fact that these copies, for the very first time in history, were identical. The printed page or picture didn't just go to a lot of people, but it indiscriminately passed the same information to everyone regardless of class distinction, location, or education. The fact of these printed sheets being identical raised the possibility that the varied users of printing might also be equal; if king and commoner had access to the same woodcut of a poisonous plant then they suddenly were equals in this accessibility to knowledge.

During the past 500 years the technology of printing has remained fairly stable. Presses became faster, type setting shifted from lead to film, and pictorial techniques were refined, but still, from the mid 1500's until the middle of the 20th century, the same old ink and paper dominated multiple editions. With the advent of electronics all this changed, and we are now living through a period when new technologies appear with astonishing speed. Those of us who are young today will still have books throughout their lives, but there is a good chance that the vital workings of society will abandon paper in favor of the powerful electronic forms that have so recently come into use.

In the next sections I will trace a history of picture techniques and types, and attempt to outline the most significant stages in their evolution. Before doing that I need to point out that the development of multiple copies, which was per-

haps the most remarkable step in the growth of pictures, did not mean that unique, one-of-a-kind pictures ceased to exist. This co-existence of types– some newly developed and others more like the old– is a fundamental aspect of evolution of any kind, and it is particularly important here. As printing was developed, so too were systems for continuing and refining the production of unique picture forms. Today we use a wide variety of pictures, and all their types are as modern as can be, but they represent branches of development that split from one another at different times in the past. We still on occasion write words in the sand with a stick, using a technology as ancient as society itself, and this way of making a picture holds its own alongside the laptop that accompanies us on our academic journeys.

PICTURES AS DEVELOPMENTAL TOOLS

The underlying assumption of the writer of this document is a questionable one– that social structures such as democracy are only possible because of pictures. I believe that these pervasive visual structures lie at the root of human cooperation and that their technical growth has preceded and enabled the development of much of human culture. This premise can also be described as the notion that the tool (in this case pictures) might precede the understanding of its possible use (for example the enabling of democracy). We don't have to look far to find demonstrations of this principle at work in these complex technological times, and the following is one example.

As computers were being developed in mid-century, before the advent of the transistor, they were based upon vacuum tube switching, and seemed destined to be large immobile machines set up in centralized locations. Upon its invention the transistor, (and its descendant the integrated circuit), made computation possible at a scale undreamed of by the scientists of the vacuum tube era, and in a very brief period, really only from about 1970 to the present, the age of distributed computation was created. Word processing, the internet, e-mail, and now home-made digital pictures have all blossomed in this digital pre-Cambrian age. This burst of innovation, changing the very fabric of our society, did not happen because of anyone's bright idea envisioning this future; instead it took place in large part because scientists

and engineers tackled the problem of solid state amplification, as a way of circumventing the drawbacks of the energy intensive and undependable vacuum tube. The transistor, invented as a result of this effort, had the surprising potential for a high degree of miniaturization and mass production, and the integrated circuits which resulted (themselves beyond the imagination of anyone a few decades earlier) set the stage for the computer culture of today.

It is possible to imagine that most technological innovation happens this way. If we can shed the old human habit of giving ourselves credit for everything, we can then come to accept that there is a way in which technology, built in simple small steps by lots of drudgery and perhaps a little inspiration, can produce tools which would allow even the most moronic among us to generate dramatic social and technical innovation. The human being has always sought center stage in any description of the universe, but we have had to steadily accept the erosion of this idea.

It becomes increasingly clear that astonishingly complex organisms– living, reproducing and thinking abstractly– have developed through the mechanism of genetic variation and natural selection, without the benefit of any sort of intelligent guidance (divine or otherwise). The biological machines that support life are probably pure technical devices, answering to the laws of physics and chemistry, and doing so without any apparent external assistance. My suspicion is that our steadily developing human culture has the

same sort of source– not from the technical origins of organic chemistry, but rather from the multiple technical innovations of humanity as the maker of physical tools. Pictures, seen in this context, are but one aspect of the technical fertility of the human being, but one that has had a formative impact on the social structures within which we live.

FUNDAMENTAL PICTURE TYPES

The earliest pictures we know of are on rock. There are a number of painted images on the walls of caves, where they have been protected from the elements for many thousands of years. There also are scratched, or even incised, pictures on rock surfaces throughout the world, made at many different times in many different cultures. Most of these pictures show an obvious effort at representation; The cave walls hold brilliantly outlined drawings of animals whose species can easily be identified, and there is little question that the artists labored to make a representation of the observed creatures. There are, however, other sorts of pictures that often accompany the representational types, and these appear to be purely symbolic. In a stone petroglyph we might find stick figures of people, representational art at a basic level, but often accompanied by patterns and designs that we assume must have symbolized something either unobservable (such as the human spirit) or too difficult to depict. At this very root of picture making, where materials are limited and physical possibilities are constrained, we find picture making of two distinct types– the representational and the symbolic.

It can be argued that no picture can purely be of one type or the other, that of necessity the difference between the world and its visual representation demands symbolism to some degree. The obverse, however, does not necessarily follow; the symbol need have no visual connection to its root, and so

we can have any pattern representing any subject, as long as the users agree upon the connection. This is the most basic and fundamental magic of the symbolic picture. It can only have power and functionality in the context of social structure. All who use the symbol– the makers and viewers– must communicate and reach a level of agreement before the symbol can be effective. But which comes first? Does the maker of the scratched design create the symbol, out of some urge to set down a record of the internal life, and only afterward does the social structure form, in response to the convenience of the possibility of shared meaning that the frozen pattern permits? I think our society today assumes that this is not so, that instead the social group needs the symbol, and creates it to satisfy this need. But we must question this assumption. Perhaps the power of the symbol– as a bearer of agreed upon meaning– is the tool that draws the relevant population together. Maybe the picture powers the cultural jump, rather than the other way around.

Pictures inevitably hold varying degrees of representation and symbolism, but there is another aspect of pictures that must be included, and this is their power as decorative objects. They tend, when well made, to please the eye and mind, and this quality is not necessarily linked to either representation or symbolism. We find all around us many pictures that are purely decorative: patterned wall paper, pinstriped cars, tiled floors and walls, and even, perhaps, abstract art. This last category might be included if we accept the argument that symbolic meaning cannot exist without

agreement on that meaning among its users. If that is the case then often the abstract artist is creating symbols accessible only to him or herself, and then it becomes hard to give meaning to this art outside the realm of decoration. I would propose that pictures always carry some balance of these three natures in their makeup. We can find pictures that are purely of one kind or another, but in the majority of cases the three aspects– representation, symbolism and decoration– are joined in an organic way

The representative aspect

If we try to make a picture that accurately represents something observed, then we must accept at the outset that the effort is doomed to incomplete success. Representation is not the same as reproduction; the latter is about duplication, while the former demands that only some aspects of the thing observed are portrayed in the representation. Representation also almost always involves the transference of appearance from one physical medium to another– the artist sees a flower, a delicate organic construction, and attempts to render it in a different medium such as paint. Observation must be processed intellectually and decisions must be made concerning the essence of the thing portrayed, because only limited aspects of anything can be contained in a picture, and those rendered must get to the nature of the subject if the picture is to be successful. As this is done the understanding on the part of the picture maker must be transferred out of the mind and into a different physical medium.

This is the mechanism by which picture making develops understanding on the part of the maker. We simply cannot make an effective picture without some intellectual development as the process is going on. If pictures functioned in this way alone– as mental stimulants to the artist– they would have substantial power, but this is only the start of the story. In fact we make pictures for the use of others as much as we do for ourselves. If any of the artists among us woke up one morning to find that the rest of humanity had disappeared overnight, then I suggest that that person would no longer make pictures. We make them for others, as a mechanism of communication.

The wonderful thing about representation in pictures is that it communicates the artist's understanding to the viewer. The animal on the cave wall isn't the creature itself, but rather one person's understanding of the essence of that creature. If the picture is successful the viewers of it comprehend the nature of this essence, and so a shared meaning and understanding is developed in the community of the picture's users. The same thing is true of a modern photograph. A snapshot of Aunt Betty at Christmas dinner, sitting in front of the decorated tree, conveys the nature of this ritual, and by the choices of what is included and what is left out of the picture, the maker and viewer further define the shared understanding of the nature of the ritual.

The symbolic aspect

Symbolism in pictures can grow out of representational roots– the Star of David, or the Christian Cross are both good examples of this. However, the symbolic picture can move to another completely different level, and convey meaning with no connection whatever to representation. No example of this is better than visual language, the letters and numbers with which we communicate.

Written language probably originated in representation, and this is borne out by early writing done with pictographs. After some thousands of years of unbroken development written language has become completely symbolic. All of us who read this text have agreed upon the use of the letters, numbers and punctuation marks in the writing (although many would quibble with the order in which I have chosen to use them). Letter groupings form word pictures on this printed page that have specific, though usually complex, meanings, and these can link together in grammatical structures to convey ideas that are often clear and unambiguous. Writer and reader share a culture that has long since set standards of meaning for these symbolic word pictures.

Language is a subject of tremendous complexity, far beyond the scope of my understanding, or the embrace of this document, but there are two points relevant to our subject that need to be mentioned.

The first point, which I am already repeating for emphasis, is that the power of language stems directly from the agreed upon meanings that it requires in the population that uses it. There is no stronger social glue, and no more powerful cultural builder than the use of language. We need to ask the question, once again, whether the ideas we have communicated with language drove society's development or whether it was the other way around? Did the bits and pieces of this communication tool develop, and only then could the ideas they handle have the ability to be formed?

The second point is that human language has two dominant technical forms: spoken and written. The spoken word is transitory, with a brief life, and it was historically unable to exist for extended periods without the danger of serious alteration in repetition. Written language, the intricate fabric of linked symbolic pictures, has the extraordinary ability to be permanent, and transcend the lifetime of the writer. We need only mention here that written records are the most powerful source of accumulated knowledge, and they are a tool of immense effect that separates the human being from all other biological creatures. These little pictures, frozen on their supports, provide cultural stability, and sit as the underpinnings of intellectual structures built over long periods of time. They form the intellectual DNA of human cultural development.

The decorative aspect

Decoration seems as old as humanity, and this is no wonder, because visual structure impacts us so strongly. We get pleasure from the appearance of things even when they are unrelated to representation or even symbolic meaning. Decoration surrounds us in our day to day lives, and virtually nothing is manufactured today without attention paid to its appearance, whether a coffee cup, automobile or article of clothing. Decorative pictures are everywhere, and we can even make the case that much art, pretending to be representative or symbolic, ends up in our lives because its decorative power makes it nice to be around.

The pleasing (or even unsettling) nature of decoration is one thing, but it also has a powerful role in pictures that carry meaning in other ways. A painting made to represent something, for example a portrait, can be dull and un-engaging while portraying the subject well (perhaps this subject is also dull). Yet the best art, and the most effective pictures in general, depend upon decorative strength to draw in and impact the viewer. Napoleon's red ribbon, diagonal across his chest, holding the gold star, contrasts brilliantly with the black and white suit. The impact of these decorative colors and forms holds our eyes and minds, and acts like the flavors of some good meal, giving us a reason to eat beyond simply gaining sustenance.

Decoration gets a bad rap from many picture makers. It is often seen as shallow and easy, window dressing for tableaus with no content, but the human being yearns for the presence of pleasing decoration, and no picture can be made without attention to it. Graphic designers strive for legibility in their arrangements of information, but simultaneously obsess on the specific way things look beyond the basic chore of literal communication. Photographers seek out form and gesture as holders of meaning but also as a mechanism of attracting attention, and painters create intricate structures of color that often have little to do with the specific subject being portrayed. All of this is the decorative potential of the picture affirming its right as a fundamental visual aspect of these powerful tools.

TECHNICAL CHARACTERISTICS OF PICTURES

Pictures of all types utilize one or more of 6 distinct techniques for holding content, or describing the subject matter portrayed. These are (1) line, (2) form, (3) color, (4) tone, (5) scale, and (6) duration. Each of these aspects of pictures works in different ways and this variety is further complicated by the materials of which the picture is made, the uses to which it is put and the skill with which it is produced.

Line

Virtually all the tools with which we make pictures are capable of making lines, from the fine, pointed steel pen to the wide, dripping 6 inch paintbrush. Lines tend, in pictures, to show the edges of things, and the surprising fact is that much of nature has no linear quality at all. When we take pencil and paper and make a linear drawing of a person we can do it in either of two ways. One is to make a stick figure, in which each limb and body part is depicted as a line, and the other is to use lines to define the outer limits of the shapes of the figure. Both sorts of drawing have existed for centuries, and both kinds can make unmistakable renderings of a human being. In both cases, however, the lines do not accurately describe what is out in the world; an arm or leg is not simply a line, and the edge of that same arm only appears to have a linear edge due to the viewpoint and vision of the artist. Lines in pictures are the single most extraordinary invention in the toolbox of picture making techniques.

Form

Form, or shape, is a second absolutely basic picture technique. The perceived outline of an object can be filled in, and then it is described in a completely different way than with linear description. The shape we see in the picture separates itself from the ground of the image, and the illusion of solidity and coherence of the subject is strengthened. We can imagine the earliest extant pictures, on cave walls, to have been basically linear, but images of the human hand appear as well, and these are usually made by using the hand as a stencil (placing it on the rock and blowing a pigment onto the uncovered areas), or by putting pigment on the hand and then transferring it to the surface through contact (a basic form of printing). Neither of these techniques are linear.

Color

The use of color in pictures is as ancient as any other technique. Naturally occurring materials, both organic and inorganic, can form stable pigments which vary in color. The smoke from a burning stick contains carbon black, and naturally occurring iron compounds make superb red and brown pigments; these same colorants are present through the entire history of picture making, from cave wall to the modern printing plant. Color has a dual personality in picture making. One use is to make a more accurate transcription of the world than is possible in monochrome. It says a lot about human perception that monochromatic pictures

can be so effective; that we can see a purely black and white image, such as a photograph, and be convinced of its reality even though the colors of the world are absent. When color is added, particularly in photography, the confusion between world and picture becomes even stronger. The other side of color is that it has the potential for tremendous symbolic power. What more stirring color is there than deep red, which echoes our commonly held familiarity with life sustaining blood?

Tone

Tone is a surprisingly minor player in the picture world, and it has always been in the back seat until the invention of photography. When a budding young artist begins to learn to draw the first lessons are always about line and form, and their scale on the page. Shading– the creation of tone through various techniques of application such as cross-hatching– is usually forbidden to the student until later in the learning process. The difficulty with the use of tonality in hand-made pictures is that it almost always points out flaws in the line and forms being depicted. Tone is integral to the great works of art in the past, but it is a difficult aspect of pictures to master.

Scale

Scale, or simply size, has a substantial impact on people. We stand at the edge of the Grand Canyon, and are exhilarated

by its immensity, and every young man knows he is unlikely to become President of the United States unless he is well over six feet tall (we could even argue that this might be a substantial barrier to women attaining positions of power). The same is true of pictures. Whether representative, symbolic or decorative, pictures used by those in power always utilize scale in some way or another. Imperial inscriptions in Rome could have letters over a foot tall, billboards on the roadside are immense in order to shrink the apparent distance between them and the driver, and furtive notes passed in math class are on little crumpled bits of paper.

Duration

Duration can have two meanings. One, already touched upon, is the remarkable way in which pictures can outlast their makers, and so form a social fabric through their capacity to engage populations separated by time. The other is a very different way: this is through the use of pictures of extremely brief duration, which vary, from one to the next, and which appear to depict movement when viewed sequentially. Pictures displayed (or existing), for very brief intervals are the foundation of film, television and the computer screen, and by being linked in a series they create the pictorial innovation of being able to depict the passage of time in the scene viewed.

A WALK THROUGH THE HISTORY OF PICTURES

It would be folly to think we could set down a nice orderly and accurate lineage to the picture. The past is too murky, the types are too complex and, above all, picture forms have not evolved with the rigid linking of steps that we are accustomed to from the evolution of biological forms. In spite of this, though, we can try to make a rough historical outline, because the techniques of picture making have developed through the years. We all use the computer screen in our daily lives, and this is a categorically different beast than the illuminated manuscript page, or the carved relief honoring some long dead emperor. There has been a steadily increasing technical complexity to pictures, and we can trace its outline and try to understand the watersheds that have been passed.

An outline of the lineage of picture types

Pictures on fixed supports
Pictures that can change location
Books
Printing
Photography
The industrial revolution in pictures
Electronically displayed pictures
The analog and the digital

In what follows I will try to expand upon this outline to provide a story of the development of pictures. The reader will notice that an inordinate amount of attention has been given to printing and photography. This might have happened because the author is both printer and photographer, but emphasis is also given to these two stages of picture evolution because they seem to me to be central to the transforming power of images in our present society.

Pictures on fixed supports

I seem to continually refer back in time to paintings on cave walls as an example of the origin of pictures. This is because these paintings, occurring in many parts of the world, have in some cases come down to us in nearly perfect condition despite the passage of many thousands of years. They can be breathtaking in their impact, completeness and beauty, and so the best of prehistoric art holds the same remarkable sort of place in history as the Gutenberg 42 line Bible– among the first known objects of their type, and yet, astonishingly, among the best as well. The most revered cave paintings of all are in southern France, at Lascaux, and the creatures depicted on the walls have a grace and perfection that makes it clear that art of this sort was already old when these pictures were made. The painted animals have great symbolic as well as representative force, and they are almost unmistakably the evocation of the source of sustenance for the users of the cave. These powerful paintings have been created for the use of a group of people, and their social importance must have been tremendous.

Many other sorts of early immobile pictures were made, and most of these types still exist. Ancient designs scratched or carved in rock surfaces have their counterparts in initialed dining tables (a number of which are in New Haven), or in lover's names cut in tree trunks, complete with an outlined heart. Intricate designs in colored sand, used in religious rituals for centuries, persist in tourist stops in the American southwest. The stone tablet, bronze relief, and glazed tile all carried pictures of one sort or another, and they are all still produced today. And, for untold generations, human beings have been making patterns in the dirt, sand or vegetation, to create a makeshift map, write 6-foot letters on the beach, or even delude people into thinking that folks from other worlds were cutting designs in a farmer's field. All these picture types are ancient, and all persist today, but none of them have had the impact of other forms that evolved to become small, lightweight and cheap; communicative structures that could move around as needed, and be accessible to every level of society.

Pictures that can change location

In order for pictures to move around they had to become small in size and light in weight. There is a likelihood that this practice started with clothing and body decoration, that would move with the wearer. Other types of pictures also became portable at a very early date, in different forms, and among the most common were written inscriptions, and images on coins. Examples of writing exist on fragile

papyrus leaves and primitive paper, and also on small clay tablets, inscribed with cuneiform lettering from the middle east. These solid and permanent records were made by impressing a tool into the clay surface which, when hardened, was a rugged and tough record that provided invariable information to its users. Clay also carried pictures that were not directly produced by hand, but instead through the action of a cylindrical roller (which itself was hand-made) which held a negative carving of the pictorial information. When rolled across the flat clay surface an impression was produced which would be permanent when the surface hardened. This remarkable innovation, developed thousands of years ago, permitted the production of virtually identical multiple copies, and is an extremely early instance of a matrix, similar to a modern printing plate, carrying visual information that could be produced in editions. The action of a roller, carrying a picture, moving across a flat surface to impart its impression, is almost identical to the first flatbed/roller presses which bridged the gap between the hand printing of the 18th century and the steam driven work of the 19th.

Writing and drawing on paper and its antecedents was extremely fragile. but a number of examples exist which hold early copies of the classical Greek writings. Most of these come from arid regions where ancient objects have been preserved through dryness. The earliest examples are highly developed, and so even though rare, they hint at a long history before these objects themselves were made. Modern

paper was probably invented in China at least 2000 years ago, and by 1000 A.D. its use had spread to western cultures.

Coins seemed to depend upon representative pictures more than symbolic ones. The lumps of precious metal that became coins were gradually standardized in weight and purity, and carried the impression of a picture representing the entity that issued them and a notation of the value attached. We can argue that the profile of a ruler on a coin is, to all extents and purposes, symbolic, but it is less so than a series of letters. Early coins, like the roll impressed clay tablets, were generated through the means of a matrix that carried the relief information. By stamping metal under high pressure the relief in the mold was transferred, in the negative, to the coin blank, and many identical copies from the mold could be made. Metal coins and clay tablets thus set the stage for printing, which was to come many centuries later.

Books

Writing and drawing on paper was such a powerful innovation that it drove the development of scrolls and books which could hold and preserve far more information than any single sheet. The earliest of these were entirely made by hand, but they had such importance that multiple copies were often made. In the West, intricate books on vellum and paper were copied down through the years so the practice developed for a particular book to have a set form, which could be made available to multiple viewers. It is important

to emphasize the duality of this multiple use; a single copy could be viewed by many users, sequentially through time, and also any given book could reach an expanded audience by being physically duplicated in numerous copies.

Protected by tough bindings, and disseminated far and wide among diverse populations, these early books started to form the informational net that would ultimately draw innumerable small cultural groups into larger and larger social units. This far reaching change began to occur well before the invention of printing from moveable type, which we commonly date as having occurred in the mid-sixteenth century.

Printing

The revolutionary aspect of printing was that it could place visual information into a stable matrix which could then generate multiple identical copies. The matrix is the printing plate, the direct descendant of the coin-stamping die. Printing presses used metal type, wood blocks and metal engravings to manipulate pigmented ink onto the surface of paper, and the power of efficient replication, cheapness of materials and dependable repetition took the world by storm. If we could imagine viewing the last 500 years as a time lapse film of the earth's surface, made from a great height, and each book showed up as a small light, then the first twinklings in Asia and northern Europe in the middle ages would turn into a literal flood of light that spreads irresistibly to cover most of the world's surface. Printed books have bound

humanity together as tightly as their own pages are stitched into a greater entity.

The technical innovations of printing seem immediately apparent. First, we have information set down in one place (the printing matrix), to be reproduced faithfully in another in multiple copies (the many pages of any given edition). Next we have the economic innovation of changing the enormously expensive (and rare) hand-made book into a cheap yet equally intelligible one made through mechanical means. And finally, we have the solidifying of the practice of a fixed edition– when we print we must, at some point, stop refining and changing the information and let the press go ahead and do its job. These three remarkable developments were accompanied by two others which are much less recognized, and I want to mention them now because they stand out as the most long-reaching harbingers of change established through the invention of printing.

The first of these innovations was that printing insured, for the very first time, that the information disseminated through multiple copies was identical. As long as letters, numbers and drawings were copied manually, the possibility– indeed the likelihood– of errors existed. We can copy the written word with some dependability, and usually preserve exact meaning, but when it comes to reproducing a representational picture the hand does a terrible job. The fact that multiple copies are identical has the immediate effect of treating all users as equals, and this is the truly revolutionary

aspect of printing. If we wish to speak of democracy, then we must recognize that its very underpinning is the fact that king and commoner receive the same data from the printed page. A technical treatise or a pulp novel, produced in an edition on a printing press, cares not whether its reader is rich or poor, black or white, Hindu or Muslim. There is no greater support to the democratic ideal than this fact.

The second great innovation of printing is that it marks the beginning of the disappearance of the hand as a transmitter of information. The invention of moveable type does this in one simple step– the letters printed are still selected by hand by the typesetter, but their shapes– and hence meanings– become mechanically defined. No longer does the copyist mistakenly write the letter "o" such that it can be misread as the letter "d," and introduce an error into the particular copy that is being made. Representational pictures also became stabilized, and less hand-made, by the invention of printing. While the printing matrix (say, for example, an engraved plate) was still generated by hand, the image, while being printed, came out in mechanically identical copies. This distancing of the hand from the transmission of information was to become virtually complete with the invention of photography in the 19th century and the development of digitization in the 20th. What we witness in the 16th century is the start of what will prove to be the single greatest change in the relationship between people and the knowledge they share through the power of those visual pictorial structures we group together under the title of pictures.

Books printed from moveable type often contained representational pictures as well as the symbolic ones of letters and words. In fancy volumes these illustrations were sometimes done by hand, as illumination similar to that which accompanied the older manuscript books, but there was an obvious problem with this practice because the very nature of printing was to leave the hand behind, and seek greater speeds and reduced cost. Metal type settled into a standard height, and so it became possible to cut hardwood blocks to this same height, engrave pictures on them and print these at the same time as the lettering. The technological fit between metal type and wood pictures was a difficult one, due to the strict size requirements of all elements that needed to be locked together and placed on the bed of the press. The metal body of type could be produced with great accuracy, so an entire page of letters could be clamped in the press "chase" and each would be tightly held by its neighbors. If a wooden block with a picture was introduced into this group then it, too, had to be cut to a high degree of precision in order to play its part in the locked up form. Pictures on wood did work, and they turned up on many printed pages, so that by the time book printing was 300 years old the technology of producing and printing delicate "wood engraving" was well established.

The primary challenge that the wood engraving solved was to print representational pictures along with letters and numbers. If printing was to be widespread, and contain illustrations, then all the printing on any given page had to be done at once, in a single operation. Other systems of illustration printing had evolved, but these used a different technology than type, and so a sheet had to be printed twice for them to be used– once for the words and then again for the picture. Another option was to print the illustration on a separate sheet and then bind this into the book in the correct place. Books made this way were more expensive, but the practice was followed because these alternate illustration printing techniques produced a far more complex and finely described picture than the wood engraving.

At the risk of becoming too technical, I would like to briefly describe these printing techniques in order to understand the state of printing at the moment when photography was invented. The developed world had become completely dependent on printing through the centuries, and the transmission of knowledge through ink on paper, in the form of letters, numbers and illustrations had reached a high level. Education and culture supported by books involved the use of printed language but it also depended upon representational pictures being accessible to a wide audience. How many texts say "see illustration such and such" as a way of clarifying a ponderous verbal description? The extraordinary steps that occurred in the mid 19th century were the invention of photography, the adaptation of traditional illustration printing techniques to the photographic image and the linking of these new hybrid forms to high speed presses driven by steam power. Printing had developed at a nice comfortable pace through the three hundred years between

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Gutenberg and Daguerre but as soon as the industrial revolution hit its stride pictures and books were swept up in the flood of innovation, and our modern world was created almost overnight.

Printing can be done in only four ways. These can be classified as relief, intaglio, planographic and stencil. There are some additional minor systems, but virtually all printed pictures– whether representational, symbolic or decorative– are produced in one of these four ways.

Relief printing is the technique of type, woodblocks and wood engravings. It also is the method of the linoleum block and the kindergarten child's potato print. The nature of relief printing is that ink is placed on a high surface, and this is then impressed upon the paper to transfer the image. The parts of the pictures that are to print stand above the picture's supporting base. Relief printing has produced the overwhelming majority of books containing words, all the newspapers up until the 1960's, most of the magazines of the twentieth century and probably half of all the other designs produced through printing of some sort or another. Relief printing is also the simplest and oldest technique, and it is commonly referred to as "letterpress" printing.

Intaglio printing is the technique of engraving and etching; it made many of the pictures of royalty and famous folks, and its lush tonalities and fine detail far exceeded that of relief printing. The nature of intaglio printing is that a plate (usually copper) is engraved or chemically etched to produce a linear design, and the lines of the design are then filled with ink. If an inked plate is wiped clean, but in such a way that the ink-filled lines are not emptied, then it can be printed under high pressure and the ink will be transferred to the paper. Intaglio printing can be described as printing from the "low," as opposed to the "high" of relief printing.

Planographic printing is a relatively new technique, one invented at the end of the 18th century. It depends upon the fact that oil and water tend not to mix, and so a printing surface can be treated so that some areas accept oil (the body material of printing ink) while other areas take water (and hence reject ink). A surface so treated can then print onto paper, even though the printing surface is at one level. The information of the picture is held by the chemical distinction between printing and non-printing areas, rather than through variations in the height of the surface. Planographic printing is commonly known as lithography, and it produced much wonderful art in the 1800's, printed from the surfaces of smoothly ground limestone blocks which could take ink and water according to an artist's drawing.

Stencil is a technique that controls the application of ink through the simple expedient of passing it through holes in the printing matrix. Endless packing cases have been identified through stenciled letters. Fancy wallpaper and fabric often receive their designs this way and even the white painted crosswalks on our city streets usually are applied

through stenciling. In the realm of printed paper, stenciling has reached its high point in silkscreen printing, which achieves its miracles through the use of a delicate open fabric which can accurately hold complex stencils in which the parts need not be otherwise connected.

I have felt the need to describe these techniques because they have had tremendous impact through their adaptation to photography. By the 1830's, at the moment when photography was just coming into the world, these techniques had reached a remarkably high degree of development. Line and tone, fundamental to picture structure, could be described with such perfection by the intaglio and planographic processes that their capacity to render information had finally exceeded the human hand's ability to generate it. This is the astonishing innovation of the union of printing and photography; that picture data could be generated through non-manual means (the lens and its recorded description), and be transformed into multiple identical copies (through the practice of printing) which could then spread visual information world-wide with an efficiency undreamed of a few years before.

Photography

Photography, like evolutionary theory, was invented more than once. Jacques Louis Daguerre in France and William Henry Fox-Talbot in England each developed a workable photographic system in the late 1830's. Daguerre made pictures on metal, Fox Talbot on paper, but both used the sensitivity of silver salts as a recorder of light energy, and the chemical sodium thiosulfate to render these records permanent. Photography's time had come, and if we look back it is possible to see that chemistry was ready to unravel photography's secrets, traditional art was full of pictures made according to the optical description of lenses, and printing was ready to handle information that was finer and more complex that the hand could generate. The invention of photography was inevitable.

Photography began as a chemical process, entirely dependent upon the light sensitivity of a small group of silver salts. Both Daguerre and Fox-Talbot, and a host of other innovators, used the same limited group of chemicals as their recording mechanism. Negatives made in cameras and prints viewed by the public were all based upon silver images. There were a small number of obscure printing processes that created images on paper with different chemical means, but the recording of information about the world, through the means of light, was limited exclusively to silver. As photography flourished its exquisite small images found a limited audience in those who purchased or viewed these original chemical prints, but soon after its invention photography became an informational source for printing presses. If we trace this medium's history, we would have to note 3 great steps taken in its development. The first is the invention of the means of capturing lens images through the mechanism of silver sensitivity. The second is the adaptation of these

images to ink on paper through the modification of the already existing printing techniques. The third is the replacement of silver as the primary recording mechanism for photography; this last step is only taking place today.

Photography produced images that were stunning in their depiction of reality. This is not surprising, since the lenses used to make pictures were close relatives of the organic lenses that provide us with eyesight; it is no wonder that pictures made this way look so much like the world we see. A difficult side effect of this similarity is that the viewers of photographs almost always confuse the pictures with some idea of truth about the world. A clear and minutely perfect daguerreotype of an ancestor reeks of reality, and it is hard not to believe that it depicts the person with absolute accuracy. A printed color photograph on an advertising page of a national magazine derives its power from this same confusion– the grinning driver of a sleek new automobile must actually own it and be experiencing the pleasure so clearly visible in the picture. In fact, photographs, like any other pictures, are fictional objects. They can dispense truth and falsehood with equal ease, in the same way that their literal cousins, letters and words, can also enlighten or deceive.

Photography adapted to the printing press in 3 separate ways. Letterpress printing, the ancient relief system that was used for lead type, handled photographs through the means of the halftone block, which transformed photographic tonality into a grid of regularly spaced black dots which gave

the eye the illusion of tonal description. The relief halftone dominated illustration printing from the end of the 19th century until the 1960's, when it was supplanted by photo-offset lithography. Offset was a planographic process, descended from the stone lithographs of French newspaper printing, and it was cheap, versatile and perfectly suited to the multi-layered printing required to produce color images. Offset killed letterpress with an astonishing speed, and millions of tons of printing equipment went to the scrap heap in a few short decades. By 1980 photo-offset lithography was making the overwhelming majority of the printed photographs in existence; books, newspapers, magazines and technical publications all moved over to this new medium, and today offset remains the dominant printing process in use. Intaglio, the earlier process that was used for engraving and etching, also changed its form to accommodate photographic description, and the result was photo-gravure. This process was, without question, the most beautiful of all the ink printing techniques, and it produced rich and smooth tonalities that would often surpass those in the original photograph which was being reproduced. Gravure, however, was expensive, and in the 20th century its costly beauty didn't have a chance against the cheap utilitarian nature of letterpress and offset printing. Photogravure has had a good long life, but always on the fringes of the ink-image revolution; beautiful and tempting, it has occupied the sidelines while the battle for social influence was being fought and won by its cheaper counterparts.

There was yet another tremendous innovation that came out of the invention of photography, and this was the moving picture. It turned out that a sequence of briefly displayed images, altering slightly from one to the next, could create the illusion of motion. This was discovered long before photography was invented, but as soon as photographic images could be recorded on long flexible strips of film it became possible to make records of movement– and the passage of time– through photographic means. Film, commonly called "the movies," had the same odd relationship to truth that still photography enjoyed. A newsreel seemed to be irrefutably true, and a Hollywood production, artfully constructed, also appeared to be imbedded in reality. In fact, both are completely fictional, and must be regarded with a jaundiced eye as far as accuracy is concerned. The irony of all photography is that it has had a huge impact on the social structures of those who use it– the readers and watchers of photographic news and fiction– and yet this same photography is unconnected to the reality from which it seems to spring. There is no more truth in a family snapshot than there is in a formal painted portrait, and it is remarkable that this is not more universally understood.

Film has been considered the great art form of the 20th century. This might be true, but it also is an art form that absolutely demands the cooperation of large groups of people in its creation. The singular artist working in a garret cannot produce a film; instead the medium, as it settled into its final form, became one of cooperative effort. Movies are

made by highly organized groups of people, at great expense, and they are then disseminated to large groups through theaters. Even the gritty black and white newsreel of the 1960s was often based upon planning and reenactment, and always depended upon processing laboratories and final editors in order to be made.

The industrial revolution in picture making

If we try to understand the developments that took place between the pictures of the early 19th century and those of the late 20th, we are confronted with an astonishing degree of change. Photography and film both revolutionized picture usage, but electronics also created a huge shift; if we regard the images on a television screen as discrete still pictures displayed sequentially, then a few weeks of national television exceeds in quantity everything produced in the history of printing on paper. In order to understand how this change took place, we must put it in the context of the industrial revolution itself.

The industrial revolution was so broad reaching and momentous that it can be described from many different viewpoints. Nominally beginning in the 18th century in Europe, it was a technological upheaval based upon energy supplies such as coal and moving water and engineering developments involving interchangeable parts and mass production. Tremendous social change occurred as cities and towns developed rapidly into manufacturing centers. It is

beyond the scope of our examination of pictures to describe this turmoil, but we can find a developmental thread through the technological chaos in order to understand how the staid and permanent hand-made print on paper was transformed into the resilient electronic one that faces me on the word processor as I write this.

Central to the activity of the industrial revolution was the development of energy supplies that shifted the burden of labor from muscle to machine. Waterwheels were able to rotate machinery in ways that the hand could not, and early machinery, such as the printing press and loom, adapted new and powerful rotary energy sources to their inherently reciprocal motion. The presses of Gutenberg and Aldus depended upon a stop and start motion perfectly suited to manual labor, whereas the steam driven presses of later years did their work by rotating smoothly at speeds whole orders of magnitude higher. Steam power created industries that did not depend upon the biological machinery of muscle power, and this was achieved through the great innovation of rotation.

When James Watt refined the steam engine into a practical form he did so by improving the energy cycle for added efficiency, and by expanding upon the original principle of reciprocation. Most engines before Watt pumped water through the slow action of a steam cylinder working a pump rod, back and forth, up and down. Watt added a condenser to this process, greatly boosting the work generated per

pound of coal burned, but he also designed different systems for converting the back and forth action of the piston into the smooth rotary motion of a shaft. It must seem odd that I dwell on this basic technological fact in a discussion of pictures, but powerful rotation opened the door to technological processes unimagined before. The one that concerns us most is the innovation of electrical generation.

The earlier waterwheel was absolutely confined to the location of falling water; the steam engine was freed of this restriction, because coal, the most common source of the heat that produced steam, could be moved from the location of the mine. Even more remarkable was the possibility that an engine could move, and carry the coal with it, and this became the basis for the railroad. The industrial revolution, and the wealth, poverty and environmental destruction that went with it, could move and spread beyond its original locations.

Anyone who has stood on a rail platform and witnessed a train going by at full tilt has a genuine understanding of the power and inhumanity of energy unleashed at this level. This was the problem with steam– it thrived when implemented on a massive scale. When the rotative motion of the steam engine was linked to the generation of electricity, at the end of the 19th century, then the power released from coal was turned into a form that could be distributed far and wide through transmission lines. By the middle of the 20th century this silent and clean source of power (clean only

because the dirt was confined to the generating plant), was being used throughout the developed world. The giant generators were relatively few in number, yet power at a scale suitable to the household became widespread. Today the steam engine has receded into the background, and lives on as the prime mover responsible for creating the overwhelming majority of our electrical power. The central plants that light our cities and turn the machines of industry do so by using the steam turbine, a distant descendant of James Watt's engines, and this fact holds even when the energy source is atomic fission instead of conventional combustion.

We seem to have moved a long way from the subjects of democracy and pictures, and how they are linked, but in our lives today our very connection to others is predicated upon the interconnectivity of the electrical system. The industrial revolution can be thought of as one of energy, manufacture and transportation but it also has been a revolution of communication, and the basis of communication is interconnectivity and the transmission of information.

Electronic pictures

Electricity is such a miracle, because it can handle power with great efficiency and practicality but it can also carry information. When electrical energy is used to turn motors it is a willing slave in the power department, but if we reduce its energy level way down, far below that needed to move the heavy stuff of our society, then it becomes "electronics," and

has the capacity to handle information. It is truly miraculous that electricity should be so two-sided; it turns the beater in our kitchen mixer, and creates the images on the ubiquitous television blaring in the next room. It comes into the desktop computer through the common power cable, which each of us, at some time or another, has wrestled to plug in, but once unleashed inside the beige box, it powers the cooling fan and simultaneously moves in unimaginably small discrete packets through the processor to manipulate information. This is how we have moved from the slow-paced (though often bloody) age of manuscript and painted portrait into the today of MTV and the world wide web.

Electronics first handled information through the transmission of non-visual language. The telegraph began the process, using the machine language of Morse code (invented by Samuel F. B. Morse, a painter who graduated from Yale). This was followed by the invention of the telephone, in which the human voice was converted into a variable electronic signal, transmitted through wires and then reconverted back into sound. After this came radio, which worked through a similar conversion of sound into an electronic form, but one which could be transmitted through electromagnetic waves without the need of wires as the carrier. These three technologies all preceded the development of the electronic display of pictures on television.

Television certainly changed the world. Well after the establishment of radio, the TV came along, and within a few

decades became an indispensable part of American life. The pictures displayed carried 3 sorts of information, produced in 3 separate ways. The first was the " TV show," whether live or recorded, which was a descendant of the film genre. Produced by large groups of people, both players and support staff, these fictional narratives, whether drama, comedy or game show, had tremendous social effect. The second sort of information brought into the home was visual "news." This might be weather, newsreels, talking heads reporting local events, or any other kinds of reporting. The dissemination of news on the television remains live to this day, and while the content might be as fictional as the situation comedy, predicated upon a reporter reading a teleprompter, there still is a presumed connection to reality that the programmed show lacks. The third type of content carried by the television is the advertisement. These remarkable visual (and audio) structures consume a huge percentage of air time, and they are aggressively visual. The energy put into the creation of advertising on the small screen is extraordinary, and it taps the hand made image, the still photograph, and the moving picture all to do its bidding. We are united through our immersion in a visual environment that no one really likes or approves of, but one which is woven inextricably into the fabric of other broadcasting that we cannot tear our eyes away from.

For all its faults, the television shapes much of our social self-awareness. An assassination, a trip to the moon, or a sporting event each can grip us with their drama, as we witness passing events in a way impossible a few years before. We watched, from our living rooms, as Neil Armstrong stepped onto the moon, and saw it with a clarity denied to the very people in the ship who were to come down the ladder right after him. While a few citizens believe the whole thing was made up, virtually all of us accept those images as some aspect of the truth, and we accept the burden of our taxes in small part because technology allows us to participate in the drama of how the money gets spent.

The technology of the television is radically different than that of the desktop computer, which followed it by only a few decades. Most children born in the 1950's had TVs in their childhood, and their children, born in the 70's had computers (and the television) in theirs. Both machines use the glowing cathode ray tube as their picture display device, and both had brief early lives as monochromatic displays, but soon shifted over to full color output. The images on both screens– television and computer– are what we call "analog," but the informational sources they make available differ drastically. The television displays information that is also analog in its nature, while the computer display is driven by information that is "digital" instead. In order to go further we must examine the meaning of these two words.

The analog and the digital

Analog systems have been the traditional means through which something is represented. An analog of a physical

object is another physical object which contains similar internal relationships to the thing which it copies. The silver in a photographic negative varies in proportion from one part of the picture to another in the same way that the light in the original scene varied. The silver deposit is an analog of the original light. In a similar fashion the groove on a vinyl audio record wavers back and forth to hold the information of sound, and these waverings vary within themselves in the same ratios that the sound does in pitch and frequency. Analogs have become powerful in our technological world because there are a host of mechanical means for creating them. The silver deposit in the negative has not been built by hand; it has instead been laid down through the techniques of photography. The record groove also was not created manually– a delicate electromechanical device converted sound energy into the movement of a cutting head that created the original groove from which an edition of records could be pressed. Analog structures are one of the prime means through which we have been making things without the use of the human hand.

Digital stuff is completely different. The premise of the digital is that we can take some physical structure, such as the illumination in a scene, and break it down into discrete particles, and assign to each one a number which is a measure of the quality we wish to portray. A digital camera has no negative, but instead assigns to the picture a grid of theoretical points (called pixels), measures the illumination at each point, converts these measurements each into a particular

number on a scale that has been assigned as going from dark to bright, and then stores these numbers and the location of the points which they represent. Digital information is numerical, and when aspects of something are converted into digital form this information can then be re-translated into some other form without regard for the data's origin. We could digitize a picture and output it as sound, or record temperature digitally and display the data as a picture. Information in the digital arena, in the form of numerical data, has been freed from the physical particulars of its source. The digital and analog have an intertwined relationship. Television has traditionally displayed analog information. If a video tape is being played, the information coming from the tape is stored in a magnetic analog in the tape coating. In the last decade, however, the technology of digital video has been developed, and so a tape can now hold a magnetic record of digital information instead. When this is the case the television images might look the same, but the data source has shifted from one type to the other. Our eyes are built to perceive analog information because the visual character of the world in which we evolved varies smoothly, without distinct steps from color to color or tone to tone. When we use digital data we need the numerical division to be fine enough that the eye, when viewing a digitally displayed image, doesn't see the minute steps which the data records. This means that we usually cannot tell whether or not the data source for a displayed picture, in print or on a screen, is digital or analog.

If we look beneath the electronic displays which produce digital pictures on computer and TV, and view the data itself, it is unintelligible. This opaqueness of digital data is of tremendous significance. It is only opaque to the human viewer, but not to the machine which handles it. A picture stored in a computer is in the form of a string numbers using the binary system, in which 1 and 0 are the only digits present. A run of the mill small color picture displayed on a computer screen, say one that is 6 by 8 inches in size, contains roughly 300,000 pixels, and each of these points has a 24 digit number assigned to it. If we printed these numbers out on paper they would be utterly incomprehensible as a picture. We could certainly find the number for pixel such and such, and read its 24 digits and make a pretty good guess of the color and intensity of that point, but the digital data would not present itself to us as a picture. When displayed by the computer, however, this mass of data is clear as a bell, and shows up as a readily comprehensible picture. The truth of the matter is that the computer is perfectly content with the numbers (if I can be forgiven, and assign it such a feeling), and the monitor display has only been made for the poor handicapped human being who is using the machine. The data itself has been recorded and will be processed in ways that are inaccessible to us. The significance of this is that it represents a major step in the distancing of technologically held information away from the human being. As the hand has receded from the making of pictures (and from the making of many other things as well) so too has complex information gathered from the world begun to pull away

from the human being. Our machines speak a language we do not, and they increasingly handle material that is beyond our capacity to comprehend in its actual form.

Digital data supports more and more of the pictures we use. Movies and TV shows, even though often filmed with analog means, are increasingly translated into digital form (we say "digitized), so that they can be stored and manipulated with the new technologies. The images in printed books have been made from photographically produced plates for years. Type rendered as perfect optical copies of the old metal shapes and photographs and other pictures have been printed with the fine dots of the hundred year old halftone screen. These older analog forms are now being recreated by the means of extraordinarily fine digital grids. Words and photographs are exposed together onto film in a dot pattern that is often as fine as 3000 dots per linear inch, so the eye sees smooth curves in letters like "O" and "R," and the relatively coarse halftone dot used for tonal description can be perfectly recreated in the finer digital grid. Even our music, far from the picture world, is digitized, but with such skill that our ears hear continuous sound. The use of digitization doesn't just pervade the production of the things we make, but plays a major role in other activities. The ignition switch in our car, which once passed current from battery to distributor now turns on a digital computer, and that binary machine does the work of controlling the vehicle's electrical system.

The revolution that is taking place in all this change is not that the car runs better, or the picture looks clearer; rather the great change we are witnessing is that the work being done has reached a level of complexity that is beyond our capacity to execute or even understand. The car has an ignition switch as a deference to its human users; the switch is a dumbed-down device put there so we can interface with the otherwise inaccessible technology that makes the car run. The same thing is true of the digitally derived halftone dot and the computer-drawn PostScript letter used in printing. They both are simplifications of the digital data, produced for the convenience of the human user. The revolutionary point is that the machines handle more information than we can use, and the content of this information is only accessible to us when it is doled out in relatively small quantities.
I don't mean there to be a flavor of negativity about this description of digital forms. In my brief and extremely limited description of them I have left out the fact that almost everything made or done with digital means is "better" that those carried out through analog systems. Printed books of today have clearer type and more tonally complex pictures than they ever have had, and the images on TV, computer, and, theater screen are sharper and more colorful than was ever possible in earlier times. If we made the technologies of today available to any practitioners in the past they would adopt them instantly, without a moments hesitation, because the capacity of our modern tools overshadows anything available before. I put the word "better" in quotation marks, however, because there is one major reservation that needs to be noted about the digital world.

This qualification to the benefits of digitization is a simple one. It is that digital forms only can handle information that can be translated into numbers in a practical way. Because of this much of what we sense in the world around us is missing from the surrogates that our technology produces through digital means. Pictures made with the newest technologies are clear, colorful, cheap and plentiful. When the images originate in photography or video, then their connection to reality appears stronger than ever. But, as these new forms thrive and multiply throughout our society, the older complex analog types of pictures, such as painting, falter in their cultural influence. Whole realms of rich visual description slip away from our daily use as digitization becomes the foundation of more and more of what we see.

PRESENT AND FUTURE TRENDS

In the brief history of picture development described above I occasionally refer to a few major changes that are taking place in the realm of picture production and use. It is appropriate to end this monograph with a further look at some of these. What follows might sound a bit like a prediction of the future in this field, but it would be folly of me to think this is possible. Nothing makes a bigger fool of a student than describing things to come. Rather I want to point to changes that we can already see, and attempt to note their possible significance for the future of pictures and the societies they sustain.

The reduction of mass

One interesting phenomenon that can be seen in the history of pictures is a steady reduction in the mass of picture production tools, picture data and image support. Because we are earth-bound, this means that everything involved in pictures is getting lighter. Printing matrices, from which ink multiples are produced, have moved from massive locked-up forms of lead type to the paper-thin aluminum plate used in photo-offset lithography. Photographic supports went from metal to glass to polyester film, (although there were some early forms that used paper for the negative material). Inscriptions moved from the living rock of petroglyph to tablets of smooth stone, from clay cuneiform tablets to the paper pages in books and finally to the virtually weightless

structure of the electronic image. These displayed electronic versions of words and pictures have depended upon the heavy cathode ray tube, but now even that device is being replaced by lightweight flat panel displays. If the cathode ray tube is interpreted to be a reversion to massive structures, then we need to remember that a single one can display an almost infinite number of different pictures– something a single printed page cannot possibly do. If we wish to get technical about our accounting of mass versus picture and divide the weight of a monitor by the number of pictures it can display, then these electronic displays become the lightest of all.

The primary reason for this steady reduction of mass is that manufactured goods are expensive in large measure as a function of their weight. Manufacturing can be costly when it involves purchasing and moving heavy stuff , and so a good part of the cost we bear when purchasing something can be connected to the physical material that had to go into its manufacture. Another part of the pattern is that manufacturing adds value to material, and if we can change the ratio of added value to raw material then the manufacturer can usually earn more profit for the thing sold. Selling a lightweight manufactured object tends to be a more lucrative endeavor than dealing in heavy ones.

I am oversimplifying terribly in all this, but the march toward lighter weight and evanescent forms seems unstoppable. Fewer and fewer of our pictures are massive and stable

unchanging things that hang for generations on a wall, or even sit quietly in books on a library shelf. Instead we continually access rapidly refreshing images on computer screens or television sets, and as the years go by we have seen these images appearing on little devices that fit into our pockets. Society speeds up, and the picture follows suit– or is what really happens that the pictures have become more flexible and versatile, and so society now has a means at hand to catch up?

Two-way pictures

Pictures tend to be one-way. They are made by one party and viewed by another. Because picture forms have traditionally been static and fixed, this communication has flowed in one direction only– from maker into the picture and then from the picture into the viewer. This has not been true for the makers of pictures; they have always enjoyed a two way conversation with their creations, because as we make a picture we must continually look at it to see what is happening and as a result tailor the ongoing making to what is being seen to occur in the developing picture. The painter makes a mark on the canvas, and this mark, by its appearance, instructs the artist in how to make the next mark. The richness of this interchange is at the root of the smugness of artists; they have a relationship to their work that the viewer can never have. However, once the picture is done, and enters into its set role as a communicating device, then the flow has always been strictly one way– from picture to viewer.

If we expand the idea of a picture, and consider an object such as a chess board to be one, then we can find instances like this where pictures live and change and modulate an exchange between the users, who each become both "maker" and "reader." This notion of the living, changing picture did not fit well with the traditional means of picture production. Once printed, a page resists change, and once carved a letter cannot be redone. Electronic forms, on the other hand, are by their very nature changeable. Displays on theater screens set the stage for pictures of short duration, and once the information of the picture was removed from invariable film, and held instead as digital data, it became possible for viewers to interact with pictures in much the same way that a player does with a chessboard. The image on the computer screen appears to be static, but in reality it changes many times a second. Because of this we can display static images (by repeating the same image again and again), show movement (by slightly altering the image from frame to frame) and also do the brand new task of altering the picture in response to some signal sent to it by the viewer. The picture on the screen can become a two-way device.

This is an extraordinary development. Language has always been two way when spoken, but stubbornly one way when set down on paper. The letter written between parties tackled this problem, and became one of the mainstays of society, but the time lapsed between exchanges was an ever present restriction. Spoken words and their electronic versions such as telegraph and telephone did a far better job of allowing

rapid interchanges of information. Nowadays we have the remarkable ability to use a computer that is connected to a far reaching network, and we can communicate back and forth across this network through the mechanism of the changeable visual display on the screen. It is possible to open a page on the web that shows a camera mounted on a building on the opposite coast, signal to the page displayed and watch the camera image shift position to a direction we request.

As if this were not wonder enough, there is another remarkable fact about the new technology. This is that the most efficient communication we have using this new tool– the rapidly changeable, digitally driven, electronic picture– is not between people, but instead between a person and a machine. When we communicate instantaneously on the web, we often do so with a responsive machine on the other end. E-mail and chat rooms only move at the pace of the human writers, but arranging an airline schedule on a web page is incredibly rapid, and it can occur because we are accepting of the fact that a mechanism can be a worthy partner in our communication. The hand is disappearing from the making of our pictures and other artifacts, and here we see an instance of the human being itself also leaving the scene.

Pictures for machines

When a person, using a computer connected to the world wide web, communicates with a machine, the person is

probably doing so by means of a picture, but the machine, on the other end, is not. As we click on buttons on the screen, and type in our vital statistics, the machinery which digests this information does if through binary code and not through visual tools. The system works this way because we have not developed a technology for machines to use pictures that compares with that developed for people to use pictures. One reason for this is that the computer, which is the machine in question here, thrives on numbers, whereas the human being loves pictures. We have evolved with an extraordinary visual system, and so the picture was a natural for us. Digital technologies did not have this affinity for the visual, and so while we bent the new technologies to handle pictures for people, we did not make a corresponding effort for the machines to also become visual. It is possible that we are now on the brink of even this changing.

Light is making inroads into the machine/digital world on a number of fronts. The bar code is perhaps the most common and well established way. For many years now it has been more practical to use a machine to enter simple data in commercial transactions than to do it by hand, and it turned out that the simple quasi-binary picture of the bar code could be used to accomplish this visually. The visual receptors in the ubiquitous check-out counter are now so good that a package merely need be passed over the window in order to transmit an inventory number with complete accuracy.

While the bar code is simplicity itself, it is probably just the beginning. The electronic switches on integrated circuits

have long been known to have optically-based counterparts, and the delicate LED's and MEMS arrays used in digital projection set the stage for complex switching and informational transactions to be made visually instead of electronically. It is impossible to know how these will turn out, but since the human being has evolved to assess complex information through visual means, we have no reason to believe that the same thing won't happen in the realm of machines. The old saw of man made in imitation of God is outdated on many levels, but it is probably a good model for how machines will imitate humanity.

The departure of the hand

It is easy to tell that I am someone who has spent many hours making things by hand, because I continually lament the disappearance of the hand from modern times. The pictures made by hand have ranged from the simple to the enormously complex, and when we are confronted with a great painting it is hard to believe how superb the union of hand, mind and materials has been in its manufacture. Artists have long understood that the path to quality in their work is one of self modification, and so we find that years of training virtually always has preceded the making of the great works from the past. Hand based technologies have flourished because of the astonishingly refined connection between the physical tool of the hand and the intellectual tool of the mind; once trained the human being can achieve skills that are almost unimaginable.

The products of our long history of making are awe inspiring, but the hand and mind have also been bent toward the task of developing other ways in which things can be made. Hand tools have produced machines that replace the very hand tools that created them. As industry has developed, the benefits of mechanization have become so great that hand labor has steadily been applied to putting itself out of business. Tools for cutting and shaping metal and wood have steadily slipped out of the grip of human hands and become part of complex mechanisms that the human user controls indirectly. Back at the end of the 18th century a few folks hand scraped the ways of early milling machines and lathes, but they only did this until those very machines were good enough to produce their own descendants without the need for hand work. People made tools that then became capable of producing the next generations of tools.

In the realm of pictures this change can be seen in the invention of photography. In the span of a half century– from the 1840's until the 90's– the technologies of photography and printing developed and merged so that immense editions of pictures could appear in print that were entirely produced by non-manual means. People still did the work that made these images possible, but the data presented visually was derived from the lens, and the patterns of ink that carried this data were produced by chemistry and the mechanized printing press. Toward the end of the 20th century entire new technologies for creating digital data were developed, and the camera found itself sharing this task of information

gathering with new tools called "scanners." As we move into the 21st century the scanner and its relatives threaten to swallow the camera itself, so the hand is now two full generations behind the eight ball in the task of gathering information.

There is nothing wrong with these developments, and we can be sure that society as we know it could not possibly have evolved without the burgeoning of non-manual picture making. There is, however, the possibility that the departure of the hand is merely an early indicator of the disappearance of the human being from the sphere of technology. As our tools become more and more complex, and as they become capable of gathering, interpreting and acting upon information, then we the people recede from the actual playing field of physical activity. It is more practical to send a robot device to Mars, and view its achievements from a distance, in the same way that it is more practical to use a camera to record a great event than it is to paint it. As soon as we accept these facts– that our machines do much of the physical and informational work better than we do– a whole series of barriers disappear. We can record the impact of subatomic particles and make records that are simply impossible for the human eye to detect, in the same way that we can see galaxies running into each other through the tools of telescopes and extended photographic exposures. What is taking place is that the human barriers of time and scale disappear once technology takes the lead in interfacing with the physical world.

The benefit of this is immeasurable. The brief human life, and the limited reach of hand and mind, were already being surpassed many centuries ago through the use of written records and long lasting tools. Today virtually all our lives are spent in a state of technological elevation. We digest pictures and data concerning events that are far, far removed from the scale of the human being, and we routinely send our machines to places we simply cannot go. As this happens technology makes its own world, and the human reaps the benefits of this technology, but we still are restrained by our own biological restrictions. We can walk among the trees, and view the sunsets, but we are now accompanied by our fast-growing companion-child of technology, who already accesses the universe in ways impossible for us.

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NOTES ON PICTURES