A Happy Octopus

CHARLES AND RAY LEARN SCIENCE AND TEACH IT WITH IMAGES

Philip and Phylis Morrison

Tops at the Eames Office, 1966

To the Screening Room

The ocean was out of sight behind low dunes paved over long ago, but on occasion its tumult could still be heard. The train tracks at the next corner that mark Electric Avenue were by those years deserted, an old change strongly underlined by the sight of two gas stations. The visitor rang at the office door to alert the lively receptionists, walked in past the *faux* palace background from a Bombay photographer's studio, down the long corridor, across the space of the big exhibit models and their busy modelers, on to the screening room, stopping just before reaching the active shop where the furniture prototypes found their form.

The small screening room was windowless, with a welcoming, comfortable, and diverse choice of the office's own chairs. In that room the entire optical path, projector lamp to screen, was just as flawless as the sound reproduction, both given devoted attention by one or another of the local experts at hand, prepared to make up at any moment for the deficiencies of work in progress. This was not Hollywood, pomp and pretense were absent, but that room was plainly the domain of technical mastery over a powerful technology. Only the results appeared effortless. Lights out, the films would begin. Usually an old one or two were offered as openers upon eager request, and then the current work was shown at whatever level of completion it had reached.

This essay—no substitute at all for the silvery screen—will outline some of the films (there are nearly one hundred of them) in which we see the secure basis for the admiring claim we make in the subtitle of our essay. Because the films are so widely accessible, the most enduring gift of this celebrated workshop is the two dozen of their films that move toward enhancing the public understanding of science. That need is greater today than ever. In later pages we shall give some account of the exhibitions and other Eames creations that address the same need.

Pure Cinema

The Eameses' film *Tops* (1969) is a rare specimen of pure cinema, only seven and a half minutes long. It has an apt and original musical score that partners the intricate dance of images. (The talented composer for this and most of the films was Elmer Bernstein, an old friend and understanding collaborator.) But the film speaks out not at all, not even one murmuring word, nor does it show any text (other than the title and credits) or diagram (a few printed words can be made out among the familiar markings of toys). Without symbols it transmits a depth of instruction in real science that is hard to match, a charming view of one striking portion of physical reality, transmitted with unspoken but gripping internal drama made plain by the sharp and steady view. Most shots are tight close-ups, their field of view desktop size or smaller. The pageant of these diverse toys seen in action becomes a riveting display of the unexpected, everywhere in engaging ceaseless flow.

Plenty of tops! A top or two is made of transparent plastic, a cavity filled with colorful liquids that separate like cream from milk in the little spinning centrifuge. Tiny bells made by the hand of some dexterous Indian silversmith spring stiffly out from the whirling carrier, to make even more tangible the very same forces. An elegant little ballerina of metal pirouettes past; does she come from some Danish ballet? A plump and self-satisfied top of sheet metal, in gold, red, and blue and a foot high, grand enough for any Victorian drawing room, hums loudly. A toy gyroscope is wound for spin with loving care, a common thumbtack magnified on the screen stands steadfast on its sharp point, set artfully spinning as if a draftsman had paused to launch it across his own tidy

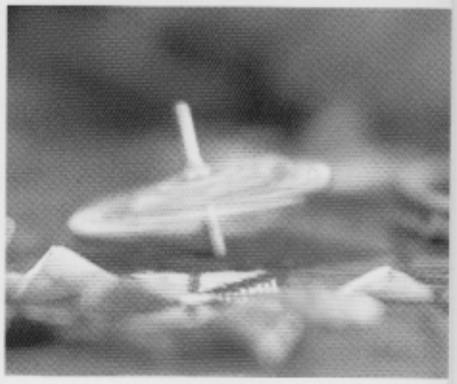
lettering. A trickier top inverts itself before our eyes, and a matched squad of conical tops weaves its way toward us. Half a dozen of the people from the Eames studio, ready for any playful task, had rehearsed their cooperative skills until they were able to set the tops spinning all at once. Cameraman and editor completed the wonderful shot with no sign on camera of human presence, though deft hands were only inches away.

The visual narrative of this wordless little epic is strong. Tops are born in spin, then they enjoy their life in motion, until the spin begins to fail. They gyrate aimlessly for a while as the once-decisive whirl dwindles to its wobbling, rolling end. A few human beings, youthful masters of the top, initially share the screen, launching and steering tops they know well. One is a charmer too young for school; others, more adept still, surprise us with their smooth skills. The actors remind us by dress and appearance that the tops come from far-flung cultures; some may be as old-fashioned as a few disks of low-fired clay, some are novel industrial products of our own times. Altogether several dozen tops perform before us, with the most disparate of origins, materials, designs, and scale.

The human ingenuity and variety of tastes displayed throughout this lighthearted processional is complemented by the sure unity of top behavior. That unity is inbuilt; it owes much less to the choices of the designer-craftsman than it does to the universal laws of gravity and motion. The close views are compelling. Side events abound, from musical sounds and centrifugal action to the psychological phenomenon of persistence of vision seen both in form and in color mixing. These trials are not austere lab experiments with a single end; rather, they open a rich and enjoyable world, long singled out by the playful. Innocents can hardly miss the wonder of tops even when they do not yet perceive the ordering principles. The more experienced will find cause and meaning sharply revealed amid larger implications.

The film is always well received by physicists and astronomers, who find in it examples of the same spin that is everywhere, in sea and air, in planets, comets, stars, galaxies—in every proton. In 1995 we showed *Tops* to a number of school audiences in South Africa. After one showing a boy asked why we felt the film was part of science. We began an awkward reply by saying that, after all, doesn't the earth spin? "Oh," he broke in, "I see: the planets are tops, too."

Frames from the film *Tops* (1969)



Powers of Ten: A Journey Across the Modern Cosmos

The 1977 film *Powers of Ten*, almost the last one the office produced, has become their most widely viewed production. It is much used in high schools and colleges, and travelers often report that they hear it playing all day long—automatically repeated—on little screens in the corners of science museums from Sydney to the Washington Mall. Since nearly all of it is carefully made animation, it is among the most ambitious, labor-intensive, and costly of all the films the Eameses made. It deserves its global acceptance as a miniature masterpiece, its screening time nearly nine minutes.

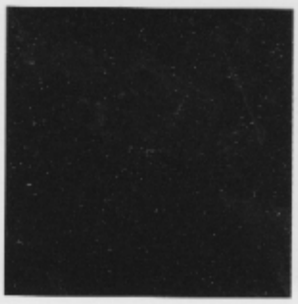
As with *Tops*, we will describe *Powers* to offer some sense of what is in it. We worked hard on the script and the narration. It engrossed Charles and Ray, who devoted a great deal of thought to this work. (Alex Funke, assisted by Michael Wiener, did the shooting, frame-by-frame, over the course of a year on a forty-foot-long animation stand. The two recorded their heroic efforts in an exposure log with nearly fourteen thousand frames.)

Powers is a superb science-teaching film. The intellectual and temporal structures are remarkably tightly disciplined. All is animation, except half a minute of live cinema that shows the two picnickers who are implicitly at the center of every screen. Most of the images on the screen are color photographs of artwork. In this way the entire film is indirect, reflexive: photos of photos, photos of composites, or photos of original paintings based on scientific photos. The final artwork—about forty meticulously prepared images, repeatedly photographed in precise register to produce the unbroken animated motion we follow—embodies the cosmic synthesis by Ray and Charles that comprises the final film. The artists used many scientific images and drew on the technical judgment of a number of advisors, all working scientists from a variety of disciplines.

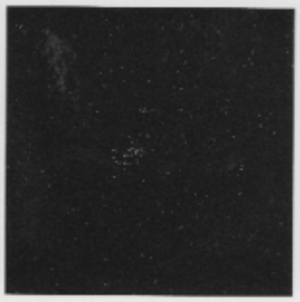
The film is rigidly designed, almost sculptured. Clock tick by clock tick we share a metronomic journey moving along one straight line in space, out from the hand of one of the picnickers to the far galaxies, then back to tiny quarks deep within an atom of that same hand. Each step either expands or contracts the previous field of view by a factor of ten. Discipline is unbroken, not only in the meaning and position of what we see, but also in the time allowed to view it. Only the picnic is shot from life; the rest is all art.

Tops is a quite different enterprise. Every shot in *Tops* records a real physical scene of real motion, though sometimes filmed at a magnified scale not available even to eyewitnesses. Without words or text, diagrams or exposition, by the powerful processes of cutting and ordering alone, *Tops* was given a subtly structured narrative. No symbolic basis is present. The revealed unity is implicit. Both great unifying topics, the physics of rotation and the worldwide ethnography of top-making, go unmentioned.

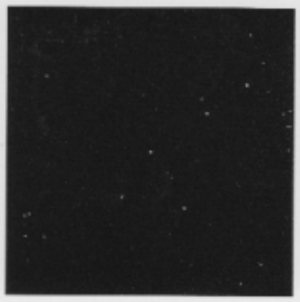
Powers, less poetic, throws us into a realistic yet imaginary journey that can be taken only thanks to images created with the help of expert handwork informed by mapping, calculation, and photography. It would be too strong to say that the two films are polar opposites in terms of pedagogy, but they do lie rather far apart. One reports an open-eyed view of a very limited world as seen through the camera, with scale and time comparable from one scene to the next. The other uses the motion picture



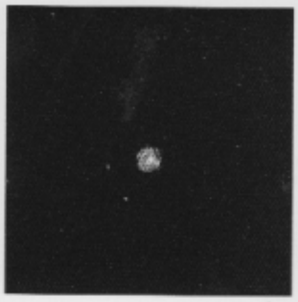
10^{+25} meters
~1 billion light years



10^{+24} meters
~100 million light years



10^{+23} meters
~10 million light years

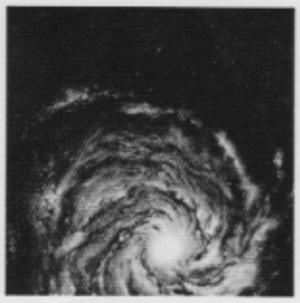


10^{+22} meters
~1 million light years

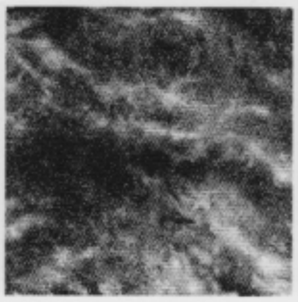
Frames from the film *Powers of Ten: A Film Dealing with the Relative Size of Things in the Universe and the Effect of Adding Another Zero* (1977)

camera to induce the illusion of smooth motion among a large number of contrived, still scenes based on well-founded inference. We see so much: a picnic, a city, streets of clouds that are the "day's weather in the Middle West," the blue sea of earth, the planets in their orbits, the stars of our galaxy, and whole clusters of galaxies far beyond. We see the intimate world within, from the red and white cells of the blood to the cell nucleus and the tangled helix of DNA. Then we are carried into the abstract particle clouds of the atom, down to the end of our present understanding, among the quarks. What will we see some day at still more distant scales?

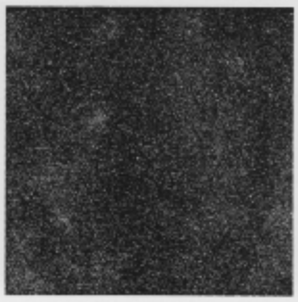
Scenes made through an electron microscope often simulate the visible even when they differ very much from the human scale, for they resemble a direct view of forms and boundary surfaces, albeit strange ones. But in *Powers of Ten* the final seven main images, each one approached steadily over a ten-second viewing time, present what can never be seen by human eyes. Mostly they cannot even be given a uniquely compelling diagrammatic image. We see what is beyond color, forms without defined boundaries, structures constantly in swift random motion. We are thus given to "see" electrons in the atom, the nucleons in a nucleus, finally even some representation of transient quarks within a nucleon. All of these views use visual conventions to describe the remarkably unfamiliar quantum properties. Those conventions are more or less evident, and they have wide appeal, but they do reflect deliberate choices of the filmmakers. The filmmaker's conventions turn out to be plausible ones for the scientist-viewer as well. Only instruments and not the human senses enable us to grasp every step of that long journey out and back again. It is the unbroken coherence of the entire context that carries us credibly into the invisible. That idea of a cosmic journey, made quantitative in an astonishing and widely acceptable way over the magnitudes of all the cosmos, we—the Eameses included—owe to the Dutch educator Kees Boeke. He and his middle-school students first worked out such a journey of tenfold steps not on film but in drawings, during the first years after World War II. The final credit of the Eames film is a tribute to Boeke.



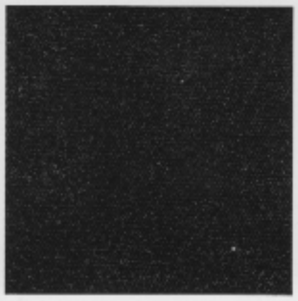
10^{+21} meters
~100,000 light years



10^{+20} meters
~10,000 light years

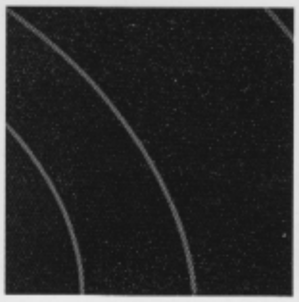


10^{+19} meters
~1,000 light years

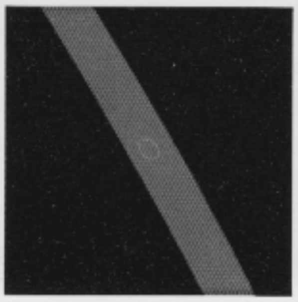


10^{+18} meters
~100 light years

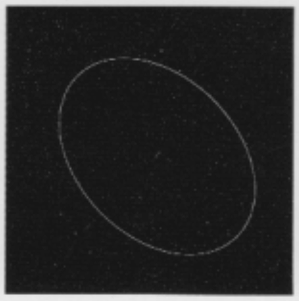
10^{+17} meters
~10 light years



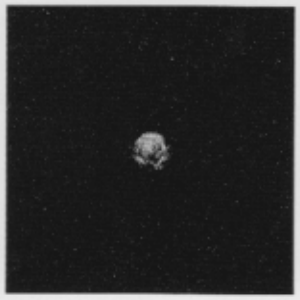
10^{+11} meters
100 million kilometers



10^{+10} meters
10 million kilometers



10^{+9} meters
1 million kilometers

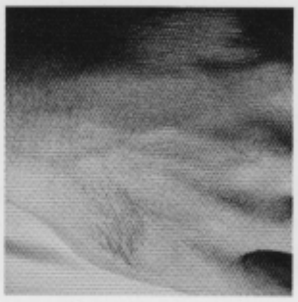


10^{+8} meters
100,000 kilometers

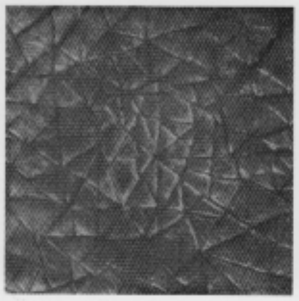
10^{+7} meters
10,000 kilometers

10^{+1} meters
10 meters

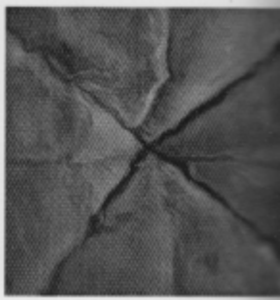
10^{0} meters
1 meter



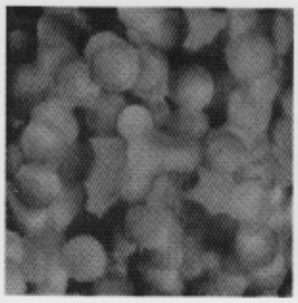
10^{-1} meters
10 centimeters



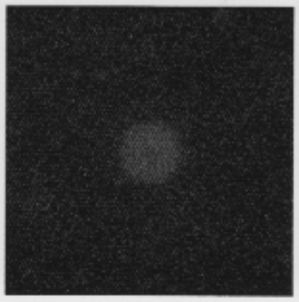
10^{-2} meters
1 centimeter



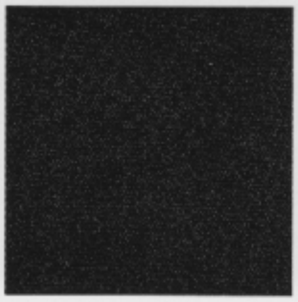
10^{-3} meters
1 millimeter



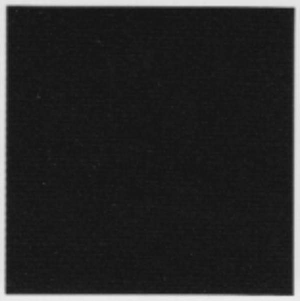
10^{-9} meters
10 angstroms
(1 nanometer)



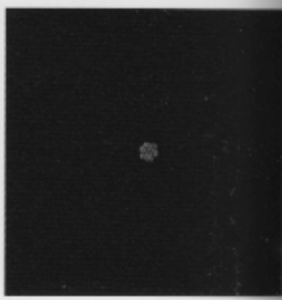
10^{-10} meters
1 angstrom
(100 picometers)



10^{-11} meters
10 picometers

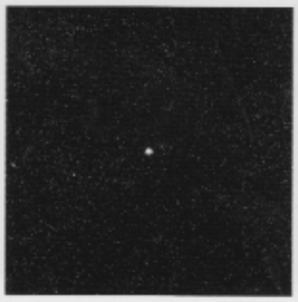


10^{-12} meters
1 picometer

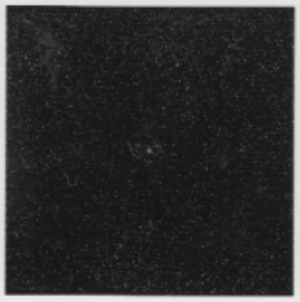


10^{-13} meters
100 fermis

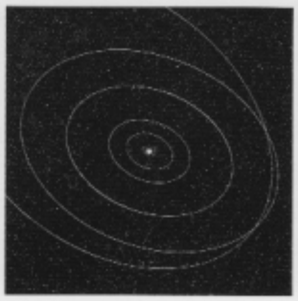
meters
ght year



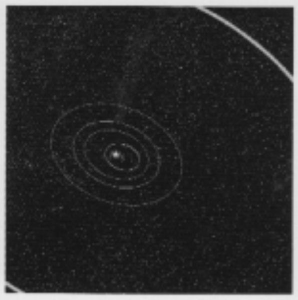
10^{+15} meters
~1 trillion kilometers



10^{+14} meters
~100 billion kilometers

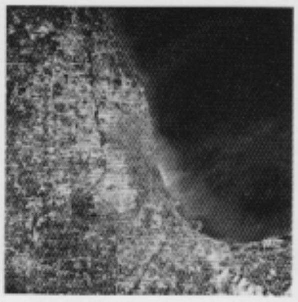


10^{+13} meters
~10 billion kilometers

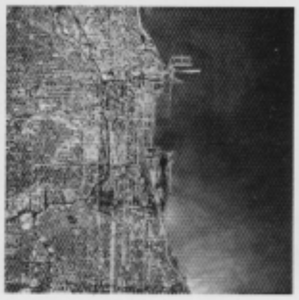


10^{+12} meters
~1 billion kilometers

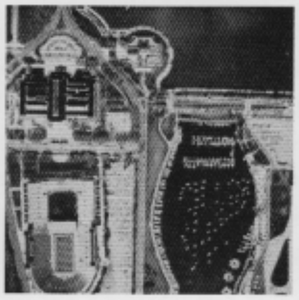
meters
0 kilometers



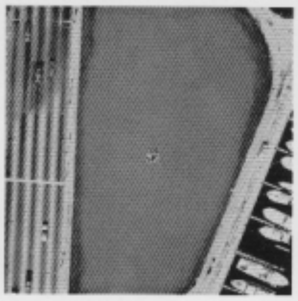
10^{+5} meters
100 kilometers



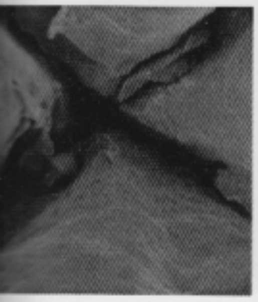
10^{+4} meters
10 kilometers



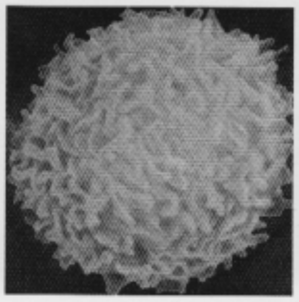
10^{+3} meters
1 kilometer



10^{+2} meters
100 meters

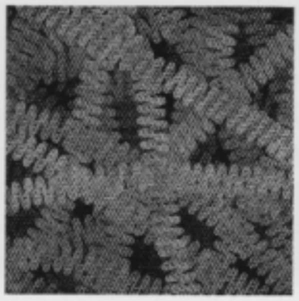


meters
microns

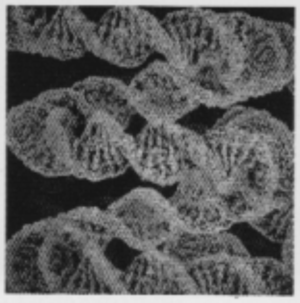


10^{-5} meters
10 microns

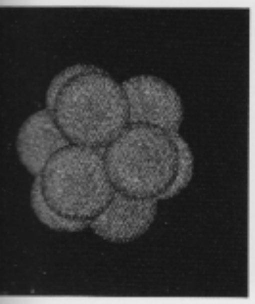
10^{-6} meters
1 micron



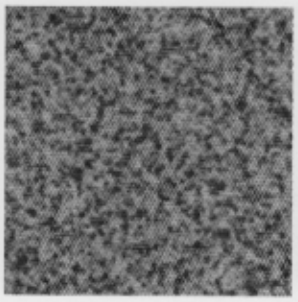
10^{-7} meters
1,000 angstroms
(100 nanometers)



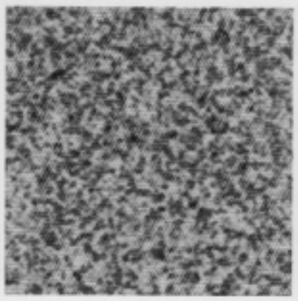
10^{-8} meters
100 angstroms
(10 nanometers)



meters
ermis



10^{-15} meters
1 fermi



10^{-16} meters
0.1 fermis

10^{-17} meters
0.01 fermis

10^{-18} meters
0.001 fermis

A Communications Primer

The third film we examine is *A Communications Primer* (1953). It is an early film for the Eameses, the fifth of all the films they would make. It is striking that this clear and cogent account of the brand-new theory of information came out four years after Claude Shannon's defining book, *The Mathematical Theory of Communication*. While the ideas were still new even to the scientists, this film explained and illustrated such notions as signal, channel, noise, code, redundancy, even the bit. (The byte was not yet current.) It thanks as sources, among others, the pioneers of these concepts, mathematicians Shannon, Norbert Wiener, and John von Neumann.

Seriousness of purpose does not make this film sober. It is full of simpler images and symbols. The Eameses' icons, the heart and the rose, are here already well used. Noise is extended into a general concept from merely an auditory one. We see the carbon copies of a single typed text, a first carbon, a second...until the sixth becomes quite illegible from the distortions by the padded pages above it. Redundancy is made lucid by a brief text on the screen, modified step-by-step by omission, but retains meaning. As worth watching more than four decades later as it ever was, the work illumines today's world, where its terms have become common parlance.

While they worked they learned. Perhaps that was their surest genius; they grasped this science faster than almost any outsider to the profession. This early film records the strength with which they entered purposeful teaching of current science. It is more theoretical and didactic, and draws on less experiential evidence than most of their films. The topic, applied mathematics, was then a source of new conceptual order of great importance. *Primer* does not lack for winning and imaginative examples, and the power and generality of the ideas are made quite real. It is a foreshadowing of the *Mathematica* exhibitions, but centered on novel mathematics.

Primer set the office on a new path. Certainly, the Eameses, who had met at Cranbrook, had long felt the attraction of teaching and had tried their hand at it. They knew that this film was a pioneering piece of exposition, and Charles published a letter in an architectural journal to point out how relevant the new mathematical discipline was for students of design and architecture. The film was widely shown, and it reinforced the value of Eames films in the professions' schools. The Eames name carried most easily to that sort of classroom, and it is in the design community that their teaching films are still best known.

Frame from the film *A Communications Primer* (1953)

IBM at once found in *A Communications Primer* a way to introduce its employees to the new ideas in the field. The film's quality seems to have been responsible for beginning the Eameses' long relationship with the most generous and influential of their clients. For a long time IBM was the loaning source of Eames films for public use in the schools. Most of the films the office made were closely related to various proposals, projects, or exhibitions in the United States and overseas, and some were not even released for outside use. Fewer—but some of the best known—like the second version of *Powers*, were financed by IBM or another wealthy corporation and were intended from the start for wide educational use in classroom, museum, even theater. Television was never a major exhibitor of their swift, thoughtful style. Even today the science films are not all easy to obtain, though the most successful have become ubiquitous.

The Dual Goals of Science

How can we purport to put forward such distinct styles of presentation as admirable models for the visual teaching of science? Our reason is clear, but perhaps not as familiar as it should be. It is that the Eameses' styles are artfully suited to the aims of science as a whole, for those aims are not single but dual. The opening sentence of a reflective essay by the celebrated Danish physicist Niels Bohr is a statement of what science in fact attempts. In 1929 this leader of the quantum interpretation of the microworld wrote, "The task of science is both to extend the range of our experience and to reduce it to order." Both—not one task, but two.

The task usually assigned to science is the ordering one. That is what the philosophers say. Of course, that is exactly their own task in the world of the mind. But what beginners in particular must have—and this is truly central to the understanding of science as part of human activity—is not mainly an ordering of what they know about the world. What they thrive on is the new experiences science brings, those that pass beyond the scope of the everyday. For example, if we regard only the face of the TV screen and its content, and give no thought whatever to what lies behind it, both physical and purposeful, we will never know much about television or the world in which it has such appeal. The schoolbooks and the examinations are complacent in their emphasis on a single goal of order. Order is compact, ready to be well expressed in words or other symbols. It stands still for examination. But new experience is the reverse. It changes, enters anew through every perceptual channel, and demands more clearheaded reasoning, which in the end must include each novelty, minor or major, as part of a widened order. Most of what science orders was once unknown and was newly grasped while it remained in a more or less extended period of doubt and uncertainty.

Consider a few of the discoveries and concepts of science. Take the once controversial moons of Jupiter. Now we list new ones, probe them one by one, and admire a few erupting volcanoes on little Io. Take the idea of energy. Kids who have learned the narrow definition in the texts—"Energy is the capacity for doing work"—know little indeed until they have expanded the idea by experience, used the power of the constancy of energy throughout all its transformations, and recounted the experience in a variety of contexts.

As painter and architect Ray and Charles Eames were devoted builders of the new. As filmmakers they worked from the beginning not with words and icons only but with the world's image in detail. The three films we have discussed are examples of high achievements in meeting the dual goals of science, of course to differing degrees. It was the Eameses' own understanding and their joy in it that led them to present anew the evidence they had grasped, and to share their sense of wonder, which they never ignored.

The Design Setting

The kind of understanding of science that the Eameses shared was not professional; they were not scientists, though they knew and enjoyed the company of many. Indeed, the same is true of their relationship with specialists of many kinds, from opticians to bakers, tailors, artists, historians, film producers, and authors. What seems to have been theirs is the belief that knowing what we have learned is not the most useful test of learning. Rather, our new knowledge should be productive, that is, it should allow us to make something new, if only small, with what we learn.

The Eameses' gift of design implies that style of learning. The setting of any design, its wide context, lies around and underneath it; successful designers must know more than the work shows. The Achilles' heel of many an effort at popular science instruction is that the producer's understanding does not go far beyond the exposition itself; the consequences, the origins, the preconditions, even the limitations, all escape us. A narrow display is all we get; it is usually topical, timely, perhaps memorable, but it fails the stringent test of long-run utility, just what good education should provide.

As designers the Eameses always recognized the need for real depth, even unseen depths. When they prepared their proposal for a National Fisheries Center and Aquarium near the Mall—an ambitious project that was never realized—they began to try out the husbandry of sea creatures for themselves. A fine little film soon came of it, a nearly three-minute close-up of the dance of a fingernail-sized marine creature, titled *A Small Hydromedusan: Polyorchis Haplus*. The joy of direct experience is here given its power by loving and beautiful visual details: the camera magnifies the crinkling of the double membrane that surrounds the little tentacled medusan swimmer, and sets out the relationship of this animated life to its symmetries of form. Only one of myriad examples in the sea, *Polyorchis* opens up for the viewer the teeming diversity of plankton life.

Charles Eames and visitors observing an octopus in the Eames Office, 1968

There was more. A living half-pint octopus became a hero of the office, famous for being the longest-lived member of its species in tank captivity. They wanted it, too, to thrive in the office over time—no easy task! Sam Passalacqua, one of the office's graphic artists, became the caretaker who managed a dozen or more residential glass tanks of cool, airy, uncontaminated seawater. In one, there grew thumb-sized hermit crabs, who moved reclusively within their houses of shell. They became dinner for the octopus who dwelt grandly alone and declined to dine on anything less tasty than live crabs. The crabs fattened on algae in their tank, and the intelligent, fastidious little octopus enjoyed stalking and eating them, one after another.

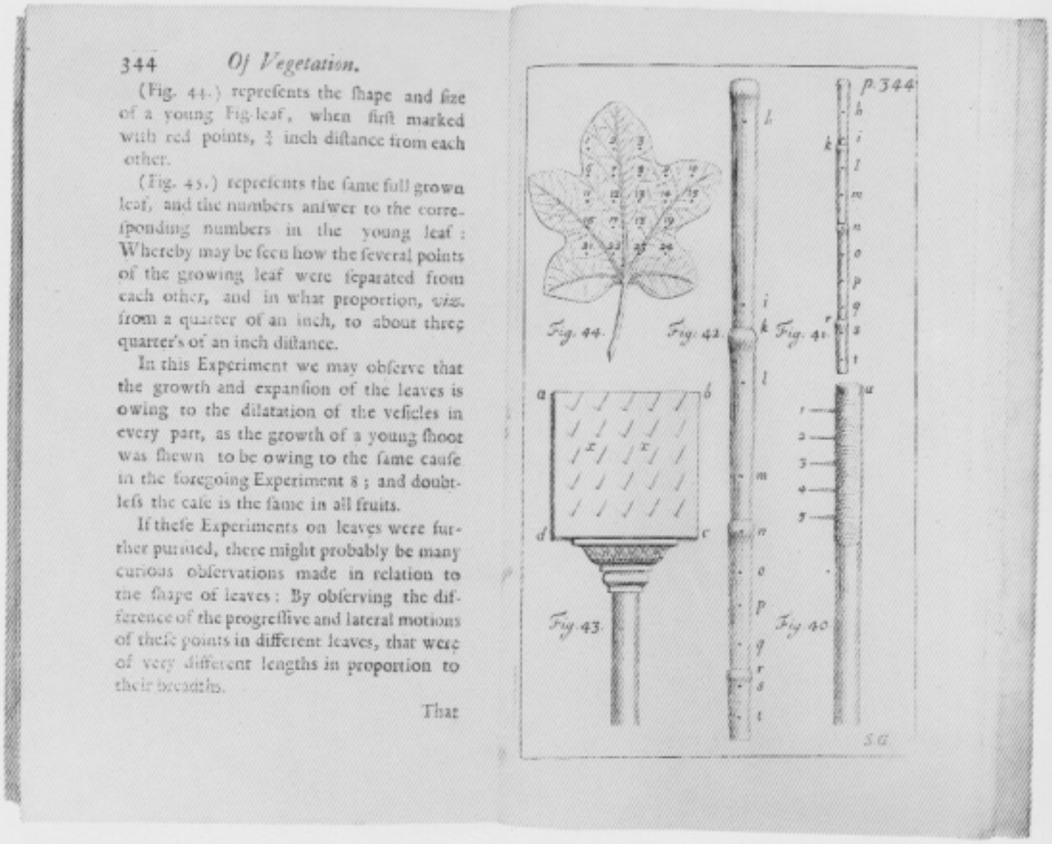
What a drama! We were soon persuaded by what we saw never again to eat octopus. The little creature in its tank would usually change color when anyone entered the room. (Phylis recalls that it turned pink whenever she came by.) When Sam entered the door of the room, the animal would first dance on curly tentacle tip along the tank bottom. As Sam came nearer, the octopus would adorn itself with a kind of peacock-eye pattern, a colorful work of invertebrate art to welcome the hand that fed him. Such was the intense engagement of the Eames Office in a project that never came to be, and such was their habit of design in depth. What an exhibit the octopus and its food chain would have made! It was from that sort of productive understanding that their best films emerged.

The Aesthetics of Finish

One authentic trait of the Eameses' work was what we may call the aesthetics of finish. This is quite apart from their strong attachment to meaning, or their admirable unwillingness to use filler, those empty images and soothing half-blank backgrounds. Instead, they packed their story lines with a richness of accessory information that amounts to deliberate overload, in particular from the viewpoint of those who seek a compact and easily learned formulation, even for complex ideas. The Eameses knew that richness is part of the universality of science to be encountered along every trail. But their concern for and their unfailing provision of high polish in every design is not part of the consistent regard for meaning. It is something they themselves brought to their expositions, part of what we can call taste. No picture lacked its frame, no edge was ignored, no visual implication was left unstated.

An example helps us see the nature of this commitment. For the IBM Corporate Exhibit Center in midtown Manhattan, the Eameses designed exhibitions large and small on topics in the history of science. Part of their aim was to amass a full-fledged museum of the subject over the long run. One small show (made to travel) sampled the English Enlightenment and was a miniature beauty, with the perfect title *Philosophical Gardens.* It is an ideal specimen for our look at finish.

The display presented in a very small area the "vegetable staticks" of Stephen Hales. The seventeenth-century naturalist had examined the growth of plants with the overall quantitative approach of physicists, through number, weight, and measure. In the exhibition the Eameses


344 *Of Vegetation.*

(Fig. 44.) repreſents the ſhape and ſize of a young Fig-leaf, when firſt marked with red points, ¼ inch diſtance from each other.

(Fig. 45.) repreſents the ſame full grown leaf, and the numbers anſwer to the correſponding numbers in the young leaf: Whereby may be ſeen how the ſeveral points of the growing leaf were ſeparated from each other, and in what proportion, *viz.* from a quarter of an inch, to about three quarter's of an inch diſtance.

In this Experiment we may obſerve that the growth and expanſion of the leaves is owing to the dilatation of the veſicles in every part, as the growth of a young ſhoot was ſhewn to be owing to the ſame cauſe in the foregoing Experiment 8; and doubtleſs the caſe is the ſame in all fruits.

If theſe Experiments on leaves were further purſued, there might probably be many curious obſervations made in relation to the ſhape of leaves: By obſerving the difference of the progreſſive and lateral motions of theſe points in different leaves, that were of very different lengths in proportion to their breadths.

That

Illustration from *Vegetable Staticks*, Stephen Hales's 1727 treatise on plant physiology, included in the 1974 exhibition *Philosophical Gardens* included a wonderful photo of a big green leaf, marked with a grid of red spots. As the leaf had increased in size the spots had moved apart to reveal directly the pattern of growth. This was Hales's own investigation brought alive. Of course the display also included information on Hales's era.

But the office provided more. They framed the sharp leaf picture: the small exhibition was organized around an airy gazebo with latticework panels. Fresh green plants and potted spring flowers sat at the base of the panels. The ensemble of visual motifs evoked the period. The result was beautiful, and hard to forget. The charm and detail of the display impressed passersby and scientists alike. Without clashing, always related in some honest way to the main ends, the aptness and pleasure offered by the Eameses' presentations often stood a little upstage from more sober and difficult issues.

This engaging style suited many people, but it imposed a burden, both visual and economic, that not everyone could appreciate and profit by. A rival approach, much more casual, was used in the large hall of the Exploratorium, the museum of art, science, and perception in San Francisco that was founded by Frank Oppenheimer. There a dazzlingly varied set of unfinished and roughly framed demonstrations and activities set an opposite course. Again, many visitors were put off by this presentation, but many were won over by its evident economy, simplicity, and inviting air.

Photograph of leaf painted with grid of red dots, featured in *Philosophical Gardens*

There is room for both styles. A wider look adds new meaning to the contrast. One might say that the issue is how involved the fine arts and the refined crafts should be in functional displays of experience and order in science. History has given its answer; the early scientists—with noble patrons—always found rich finish, even ornament, proper for their instruments. More to the point, the Exploratorium, though itself the home of the "casual" style, has had a half-dozen resident artists at work throughout the years. Their finished works of art, as diverse as glowing plasma columns and whirling balls of fluid currents, are benchmarks of the beautiful among the museum's examples of studied simplicity.

How hard Ray worked to achieve that fitting quality of finish—never slighted, never showy, always important! The Eameses carried on a lifelong campaign to bring scientists and specialists themselves directly into the design of expositions of their work. The best examples from the Eames Office are several brief and unusual films made by UCLA mathematician Raymond Redheffer, such as *Exponents* and *Alpha*.

"Q. To whom does design address itself...? A. To the need."

Such was Charles's response to a question posed to him in a laconic half-debate, half-interview that formed the basis of the 1972 film *Design Q & A*. In that spirit the office produced about twenty-five films out of their total of some one hundred that we judge as useful contributions to education in science and technology. Our sorting is a strict one: we excluded a handful of films that support specific architectural proposals, a number of slide shows, and a few films made outside the office for Hollywood or television. We omitted films like *Clown Face* and *Bread* because they seem to be part of an ethnography of our place and time, and not centered either on the natural sciences or on the technologies that derive from modern science. There are more than a dozen relevant exhibitions as well, recorded mainly in still photographs and drawings.

We see the corpus of the works of Ray and Charles and their large, shifting team as a loving gift to genuine education in science and technology. Plainly, the future holds a cornucopia of new media. Digital modularity is soon to unite all sensory channels. Interactivity is by now a major element of this new world (itself anticipated by the office in the 1960s). What we can hope for is the rise of designers in the Eames tradition: working out of understanding and not only out of technique, able to unite text and vision, art and science with attention "to the need."

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