Fragile Nights:

A collection of ideas
on light, darkness, and
human behavior

By
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September 1974

Submitted to the Department of Architecture in partial fulfillment of the degree of Master of Science in Visual Studies at Massachusetts Institute of Technology
September 1984

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To Blanche

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Abstract

The night -- particularly its constitutive darkness -- poses a formidable challenge to the human mind, which operates primarily on visual evidence. Indeed, the active channels connecting the cognitive and visual systems are dominant features of brain activity overall: As a result, blacking out the visual field has a profound impact on how the brain construes the environment. This study presents a general perspective on the traffic between mind and reality via the visual channel, and proffers the notion that the most important factor in the visual process is the extent, at any given moment, to which whatever happens to be present is visible; that is, not the object, but the amount of available light by which we may see them.

It is further suggested that darkness can be a positive environmental condition: that it can act as a stretcher and enhancer of insight -- in contrast to light, by which the environment penetrates an attentive mind from without. By implication, if light stimulates the body, darkness will in turn stimulate the mind; furthermore, at a given moment, visual stimulation and imaginary output are inversely proportional.

The point of view expressed here offers a perspective on light-related design problems, for which might be developed a new approach that would use light intensities as a language directly addressing behavior.

Thesis Advisor: Otto Piene
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Acknowledgments

I am grateful to Gyorgy Kepes and Otto Piene for having established and maintained the Center for Advanced Visual Studies, a place of thinking and doing in conditions of freedom within one of the most stimulating and challenging environments I have ever encountered. That the Center existed meant there was an incentive for me to return to an academic environment, and an opportunity to explore the least obvious aspects of my most important interests. My deepest thanks to Genise Schnitman and Martin Bressani, Ellen Sebring, Bob Rosinsky and Todd Siler, Gloriana Davenport, Mario Montalbetti, and others: They shared their presence, warmth, intelligence, and spirit and nourished the author and the thesis. Genise Schnitman was midwife to the ideas as they struggled to be born into verbal form. I am beholden, finally, to the reader's kindness in accepting the exertions demanded by a fast-paced tour on a rough terrain, with a rather unexperienced guide.

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Lux est umbra dei
-- Thomas Browne (1605-1682)

What of the night?

In Djuna Barnes's 1937 novel Nightwood, the character Nora, pays a visit to someone whose "favorite topic, and one which he talked on whenever he had a chance, was the night." (1) Entering a room where "every object seems to be battling its own compression" she demands: "Doctor,...tell me everything you know about the night."

"Well, I....will tell you how the day and the night are related by their division. The very constitution of twilight is a fabulous reconstruction of fear, fear bottom-out and wrong side up. Every day is thought upon and calculated, but the night is not premeditated. The Bible lies the one way, but the night-gown the other. The night, 'Beware of the dark door!'" (1)

Illustration by John Tenniel from Lewis Caroll's novel Alices's Adventures in Wonderland

(1) Djuna Barnes, Nightwood (New York: New Directions, 1946) pp.79-80

My earliest memory is that of waking up in the middle of the night, alone in what seemed the most unhospitable environment. I remember how difficult it was, exposed as I was by the lack of walls or anything to shield me, to call for some light without upsetting the seemingly precarious stillness of the dark from which anything -- including the wildest of beasts -- could suddenly appear. When finally my little voice had convinced someone downstairs of the opportunity to provide me with some light, I remember how exquisitely small my room appeared.

What distinguishes the night from the day is, of course, primarily the absence of light: the dark. Yet, these two states of reality appear to be so different from each other that it is a conceptual challenge to make sense of both at the same time. They are just not the same. Winston Churchill is said to have gotten up one night thinking he had discovered the "secret of the universe". The next morning, eager to read what he had written down he found: "The whole is pervaded by a strong smell of turpentine." (2)

(2) Steven Rose, <u>The Conscious Brain</u> (New York: Alfred A. Knopf, 1975) p.268

Yet this conceptual division between daytime and nighttime has proven instrumental for Freud for instance, when he proposed to interpret dreams, the quintessential nightime experience, as the expression of the unconscious, the very conception of which was born out of these speculations. Similarly for Breton, surrealism meant an enhanced realism, a result of the transfers between day and night in a system of "connecting vases".(4)

(3) Interestingly enough, the debates around whether any such thing as the unconscious exists -- in which Freud and William James were among the chief protagonists -- happened at about the time when, for the first time in history, the availability of artificial light exceeded by far what people had been accustomed to expect and desire. I like to think that as city councils debated the options of gas lighting versus electric for their nightscapes, and as the contest between gas and electric light was reaching the rural sectors of most of the industrial countries, a somewhat weakened night called on intellectuals to tap new sources of the mysterious.

(4) Andre Breton, Les vases communiquants (Paris: Editions des Cahiers Libres, 1932)

Bearing in mind these, from among countless available examples of perceived discontinuity between what appears like daytime and nighttime realities, it will be interesting to explore the connections between light (or its absence) and the operating modes of the brain. But first:

The idea of night itself comes from the visual specialization of the human organism and the felt consequences of the cyclical absence of light on the conduct of activities. For the human mind that relies mainly on visual evidence, a seen world is dramatically challenged when it disapears. What happens then is left to limitless speculation: Nighttime reality becomes a perfect stage for anything -- from the stillest emptiness, to the most nameless fears and wildest fantasies that imagination can generate. Anything goes in this external void that can be filled only from within -- and at the risk of losing all shape, name, and definition, and leaving only inchoate terror...or, limitless possibility. No wonder that night is also the time of sleep when we humans ordinarily get our rest as the brain switches to a different program.

Even though when we awaken we are still the same person as before, the problem of darkness remains nonetheless entire. The question of what to make of the night -- how to bridge conceptually the two grounds of light over the uncertain darkness -- has been among the first and most important challenges that humanity has had to face. We met the task of facing the night by finding a name for it; by measuring it; and by bringing light into it.

Paris (Boulevard Edgar Quinet) in daytime...

...and at night.

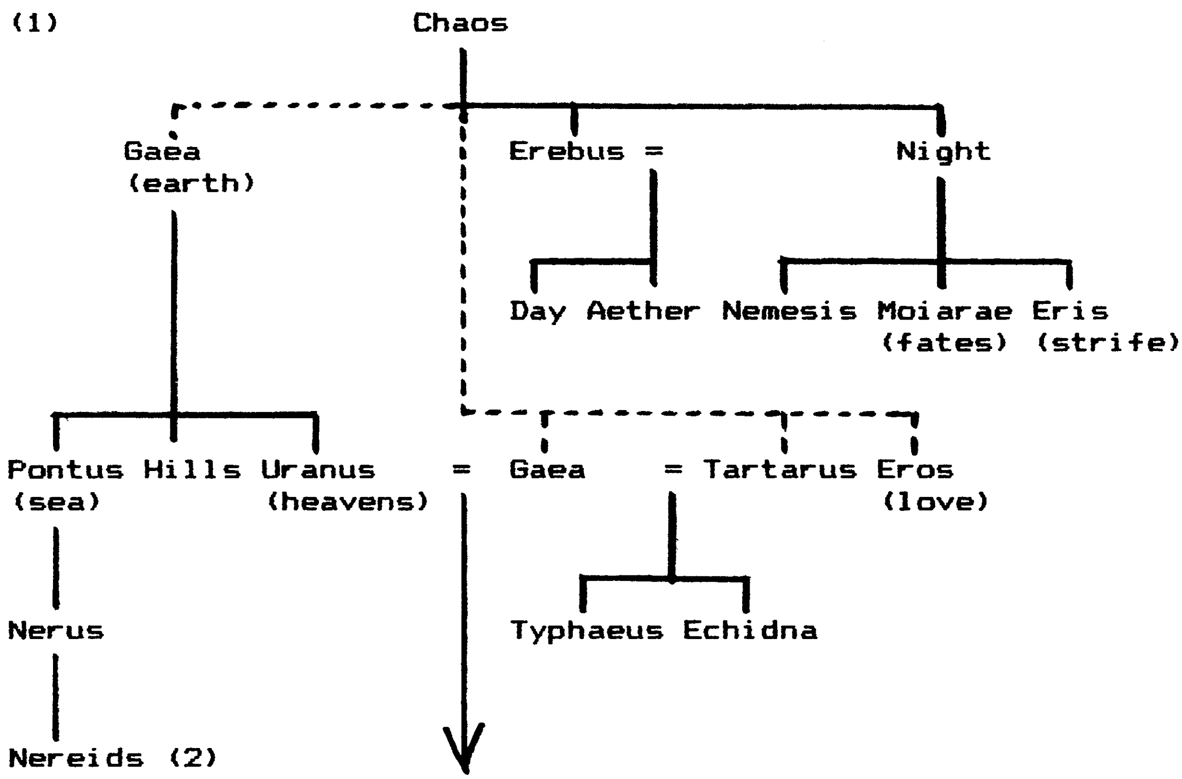
The name of the night

Before the cosmic phenomenon of recurrent darkness by the occultation of the solar light could be explained, the world as experienced used to be created every morning and destroyed every night. The Babylonians (circa 1700 B.C.) saw their hero Marduk fight daily against the disorder engendered by Tiamak; and the Egyptian sun god Re regularly faced destruction at the hunds of the creatures of the underworld (myths dating from circa 1500 B.C.). The Greek theogony is different in that night itself is personified as the mother of day, ensuring, from sunset to sunset, a smooth transition. (1)

Michelangelo. The Night (detail from the tomb of Giuliano de 'Medici) Florence

"From Chaos came forth Erebus and Black Night, of Night were born Aether and Day (whom she brought forth after intercourse with Erebus), and Doom, Fate, Death, Sleep, Dreams." (2)

(1)



(2) Michael Grant, Myths of the Greeks and Romans (Cleveland, Ohio: The World Publishing Co., 1962) pp.100, 128

In a very scholarly essay, Clemence Ramnoux -- a French philosopher that I happened on when searching for rare books under the heading "night" in the card catalogues of many libraries -- establishes that "Night and her children" comprised the negative pole in the recurrent pattern of thwarted couples belonging to ancients' family of gods (3). She goes on to suggest that, having represented at first the divine figure of the Greek theogony shown in the diagram above, the notion of night gradually evolved to refer to the physical phenomenon itself when, in the pre-socratic age, the forms of nature became objects of science (in the 6th century B.C.).

(3) Clemence Ramnoux, La Nuit et les Enfants de la nuit dans la tradition grecque (Paris: Flammarion, 1959)

Around that time, the compilers of the Book of Genesis held that "in the beginning...God said 'let there be light: and there was light'"; that he "separated light from darkness"; and that "there was evening and there was morning, the first day" -- thus conceiving of a "nature" separated, as a set of phenomena, from divinity. Light and dark, day and night, and the rest, were seen henceforth as acts of god, rather than gods themselves.

The measure of the night

Before the invention of units of time shorter than the duration of daylight, day and night constituted separate environments, completely uncorrelated. Daytime was for activity. It was the only useful period, whose every occurence was separated by an uncertain time of darkness. The development of time-measuring instruments other than sun dials helped bridge day and night, thus establishing a daytime and a nighttime. A day went from sunrise to sunrise for the Babylonians and early Hindus; from sunset to sunset for the Athenians, Romans, Jews, and Muslims. The first mechanical clocks in the 14th century still placed sunset at the end (and the beginning) of their daily cycle.

The day of 24 units, 12 each for daytime and nighttime, goes back to the Egyptian sundial (circa 1500 B.C.), which featured 12 divisions. The hour was then an elastic unit, since it had to adapt to seasonal changes in the duration of sunlight. The Egyptian water clock (1000 B.C.) and its further Greek and Roman refinements, made it possible to free the measure of time from the tyranny of the sun. However, it remained in thrall to the variable solar hour, and included complicated accessories that enabled it to mark the 12 flexible hours necessary to measure time from sunrise to sunset. The instant of the rising and the setting of the sun were indeed crucial moments, which dictated the appropriate human tasks and activities around the cycle of night and day.

With the first mechanical clocks came the equal hour: 1/24th of an equinoctial day (1). Together with the increased availability of artificial light that came with the 13th century's "industrial revolution", a new notion of time -- where an hour of daytime equalled in lenght an hour of nighttime -- made the night more like the day. "The new'day' included the night" (2); a night, however, broken into two halves belonging to two different days. The whole of the 24-hour cycle was beginning to be seen as a long moment of mixed light and darkness. If the new day and its domesticated night had to break, it had to be in its most fragile place, at midnight.

(1) "There are few greater revolutions in human experience than this movement from the seasonal or 'temporary' hour to the equal hour. Here was...[a] declaration [on the part of human beings of their] independence from the sun." (2)

(2) Daniel J. Boorstin, The Discoverers (New York: Random House, 1983), p.39

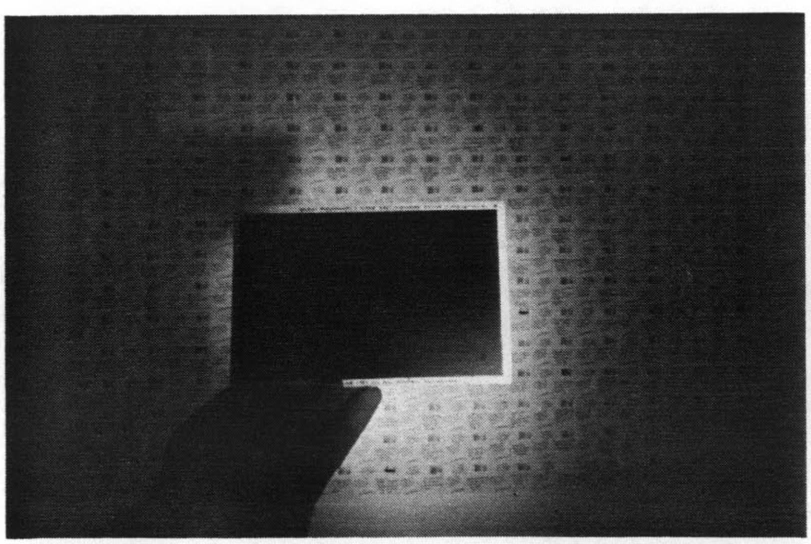
Midnight at the Massachusetts Institute of Technology

With the fractionalization of days into universal time units, the "recipe for action" (2) could be understood anywhere at any time. The uniform hour was divided into minutes with the development of mechanical clocks featuring dials, and seconds appeared on the scene, "created" by the noise from the escapement in weight-driven clocks: Every increment of precision in units of time reflected on humanity's growing understanding of reality and its ability to act upon it.(3)

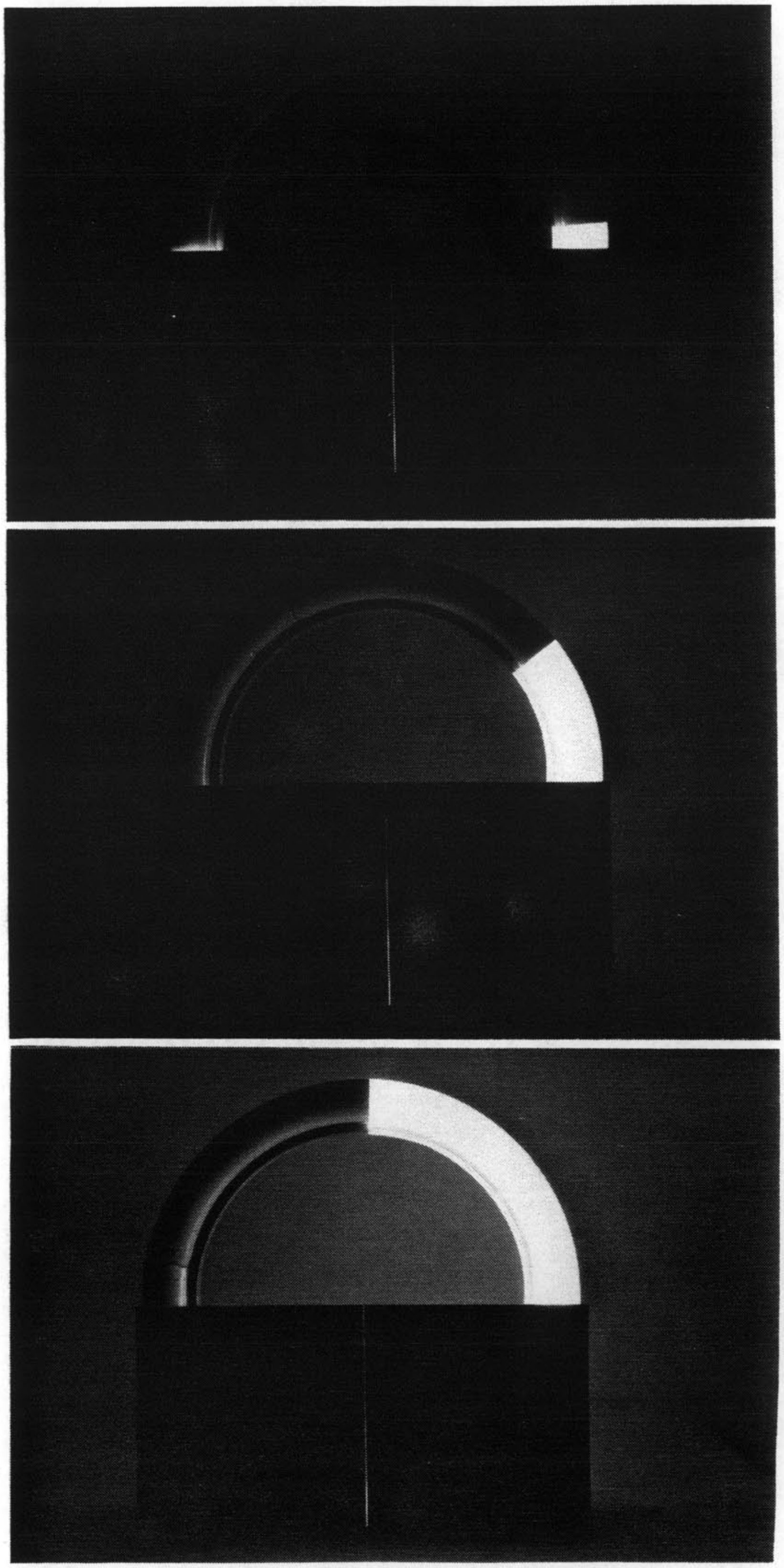
(3) Today's smallest useful unit of time is the femtosecond. One femtosecond is one-millionth of one-billionth of a second, a unit that has become necessary because fiber-optics technology deals with entities and processes at that fantastically small scale.

Days were first aggregated into years when horizon-based astronomy observed that seasonal changes came in regular cycles. Next came months, first as a moon-based measure, then reevaluated to conform to the more vital yearly cycle. The week, a more arbitrary unit, was instituted as a practical cycle of activity that provided periodic rest from labor. The ancient Greeks had no weeks; the Romans at first had one of eight days, which by the third century A.D. was reduced to seven.

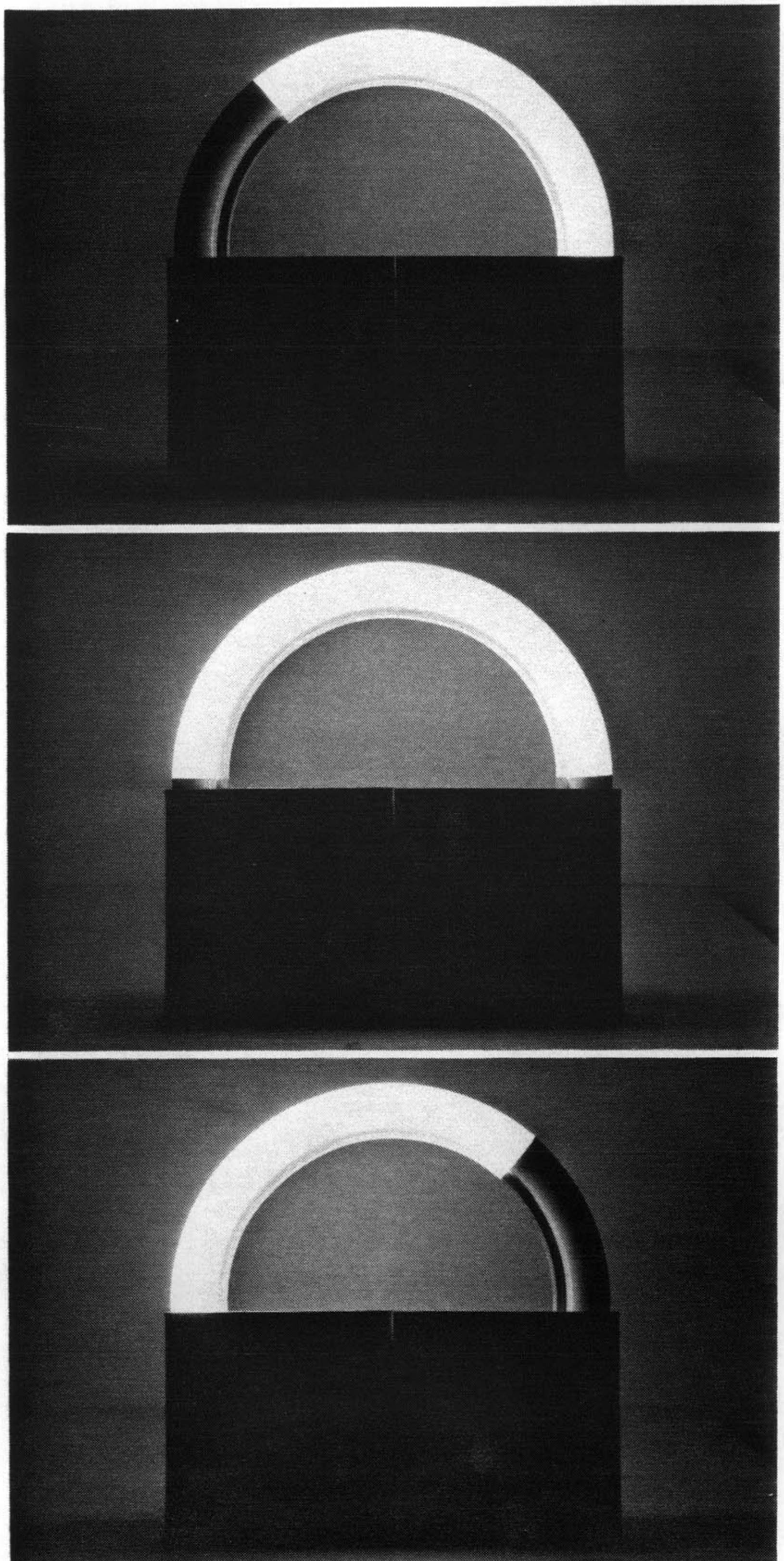
In our northern hemisphere, where these rules were established, a day dies and another is born in the middle of the night; and one year supercedes the last, around the winter's solstice. Again, the night is a fragile thing.

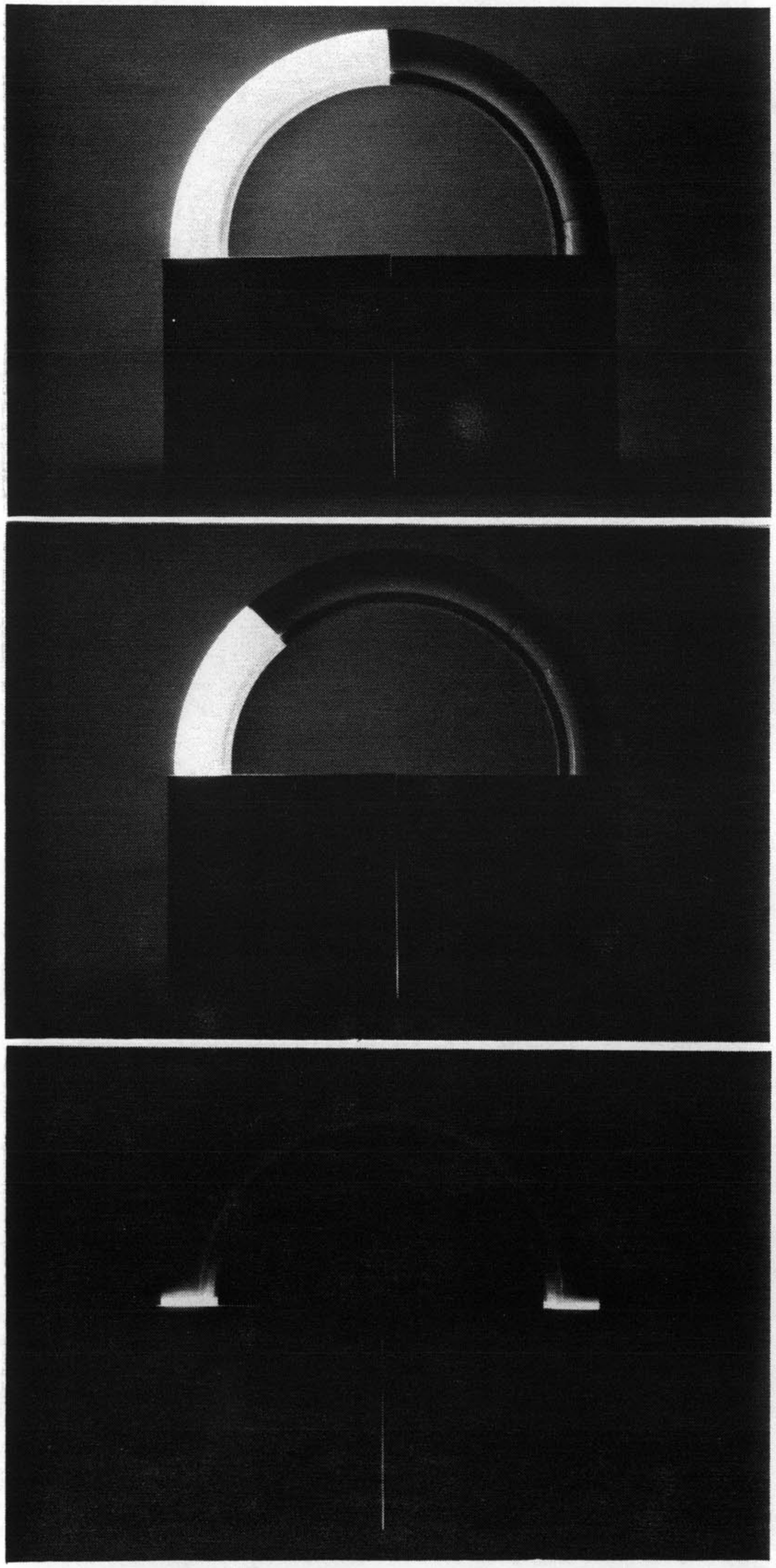


Luc Courchesne. Best wishes on the occasion of the longest night -- Offset on cover stock. 1983



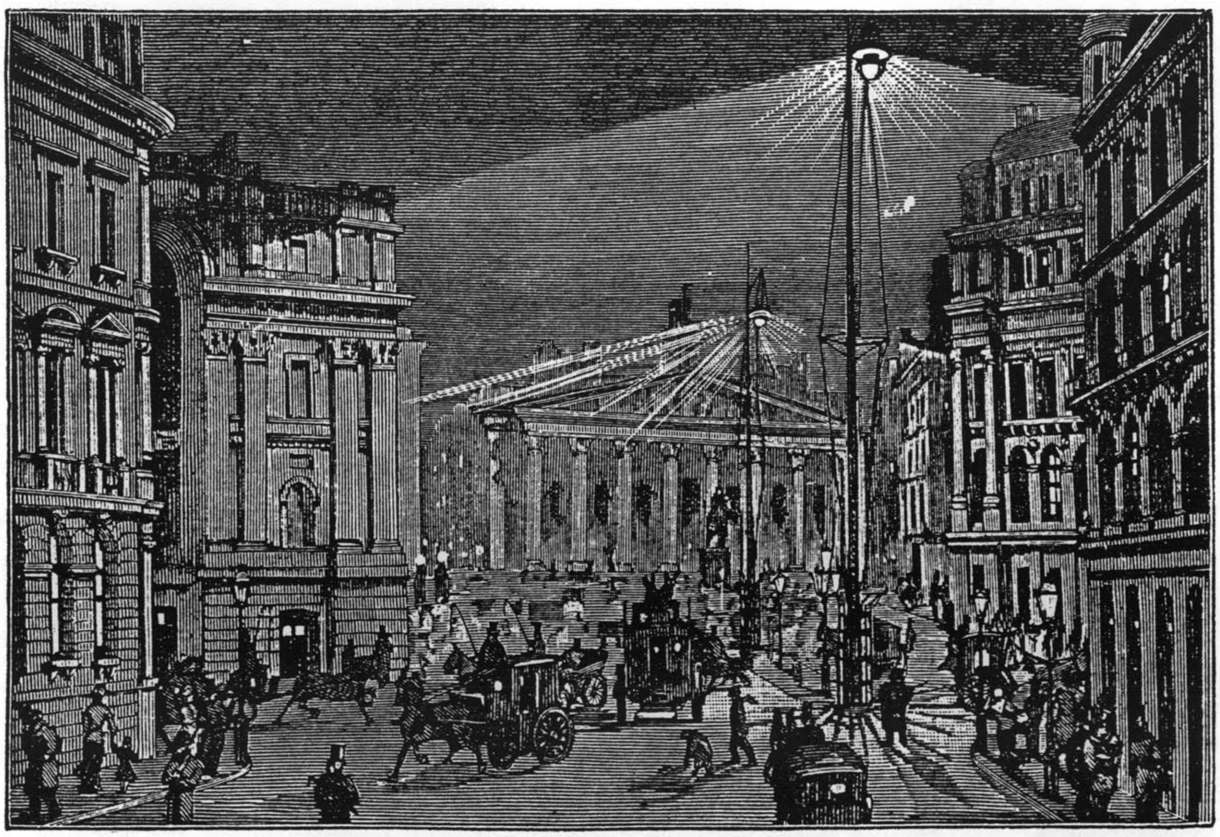
Luc Courchesne.
Sunlike Lamp
-- rotating circular
fluorescent tube
in acrylic case.
1983





The use of artificial light.

The practice of noctambulism -- that is, strolling around at night for its own sake -- appeared when gaslights were installed along city streets. In the writings post-humously collected into a book on Baudelaire, Walter Benjamin describes the new gas-lit nighttime phantasmagoria experienced by the Parisian "flaneur." "In the heyday of the Second Empire, the shops on the main streets did not close before ten o'clock at night. It was the great period of 'noctambulisme'." (1)



From Lumiere Electrique, p.69

(1) Walter Benjamin, Charles Baudelaire: A Lyric Poet in the Era of High Capitalism (London: New Left Books, 1973), p.50

The basis for nightlife was laid in the Paris of the 1660s. This is when the first permanent public lighting was established. It came as a necessary measure against groups of "mauvais garcons" who roamed the city at night, setting fires and vandalizing. Several attempts had been made earlier to provide some light to discourage crime but the costs were too high and the necessary commitment on the part of law-abiding citizens was never secured. The success of an idea by a priest named Laudati to provide torchbearers to accompany those who needed to be abroad at night gave Louis XIVth the idea of raising new taxes to install in Paris permanent street lighting. "Nettete, Clarte, Surete": This is the program he gave to De La Reynie (the chief of police), who devised and organized the lighting of Paris by lanterns. From then on, citizens considered public lighting a necessity. It could be expected only to improve. A 17th century Parisian commented (my close translation from the French preserves the quaintness of the original expression) that "formerly, in fear of assasination, people went home early for the benefit of work but now, with people staying outside at night, the work doesn't get done anymore." (2) Among the first things proclaimed by the French Revolution a century later was "the citizen's right to light" and the Directorate extended the maintenance of "reverberes" -- the newly designed fixtures that reflected the light downward -- throughout the night and all year round.

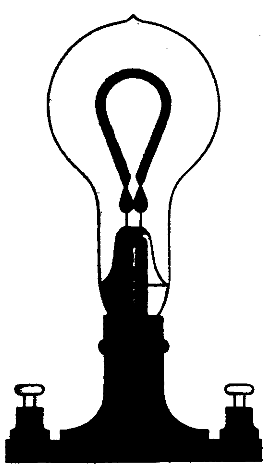
(2) H. R. D'Allemagne, Histoire du luminaire, depuis l'epoque romaine jusqu'au XIXe siecle (Paris: Alphonse Picard, 1891), p.322

In the 18th century, public lighting switched to oil. Somewhat less bright than candlelight, oil lamps were nevertheless much easier to maintain, and the introduction of reflectors in fixture design effected a better distribution of the available light. When Argand introduced in 1784 his double-air-stream burner for oil lamps, he accomplished what no one else had done since the domestication of fire: dramatically increase the brightness of a single flame. The Argand burner, 10 to 12 times brighter, met an enthousiastic welcome, as the idea of public lighting became more firmly entrenched, and the new industrial enterprises sought to operate around the clock.

In 1809, gas obtained from the distillation of coal was first used for public lighting in London. The advantages of this means of distribution (over the individual oil burners formerly used) established gas as the new standard for public lighting. Although it was used for industrial lighting as well, gas presented problems for the more confined interiors. Chevreul's research on fatty acids and the discovery of large supplies of mineral oil -- from which paraffin could be extracted -- in Pennsylvania (1860) transformed the candle-making industry. As they became cheap and care-free, they grew in popularity. Similarly, lamp designs were simplified, and lamps themselves evolved into affordable objects imbued with a new aesthetic characteristic to the industrial age. Candles and oil lamps found their way into almost every household. In the 19th century, it was held, "all things have their philosophy" -- in the sense in which the term was commonly understood: that is, "the rational application of principles to useful purposes". The "philosophy of illumination" (3), which studied the means of obtaining the best possible light with gas, oil, and candles, was yet unable to cope with the electric light, which appeared at first to be uselessly strong.

(3) "The Philosophy of Illumination" in <u>The Journal of Gas Lighting</u> (London: February 10, 1855), p.23

Sir Humphrey Davy first demonstrated his electric-arc lamp, powered by Volta's battery, in 1810. Inviting immediate comparison to the sun, this spectacular new light source remained impractical until the Gramme generator became available in 1860, providing a constant electric supply. Initially used in lighthouses and for war applications, the electric-arc light became a serious challenger to gas light in 1878, when it was tested in the streets of St. Petersburg, Paris, and London. Its excessive brightness did not entirely win over a society already well pleased with the adequately distributed gaslight, cheap and odorless candles, and fashionable oil lamps. The real challenge to the flame as principal light source would come only when the problem of the "division of electric light" into smaller units could be solved.



Edison's light bulb
(marketted in 1881)

In its edition of December 21, 1879, the New York Herald announced that Edison had succesfully demonstrated his invention to "divide" electric light. Relating as it did to the inventor already known for his phonograph, the news was taken seriously -- and before long, the gas shares on the London market lost a significant number of points. Edison's invention comprised not only an incandescent-filament-in-a-vacuumed-light-bulb, but a whole concept of production and distribution of electricity which constituted a genuine challenge to gaslight. From then on gas and electricity would compete for recognition as the best light -- and also for the biggest share of the market. As a result, the availability of artificial light increased dramatically. Scientific American, for its part, ran at that time a long series of articles on "The Art of Preserving the Eyesight." (4)

(4) "The Art of Preserving the Eyesight," in Scientific American Supplement no.125 to 147 (New York: 1878)

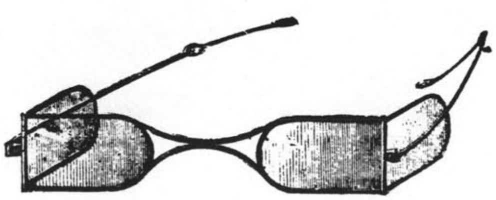


FIG. 71.—COMPOUND SPECTACLES.

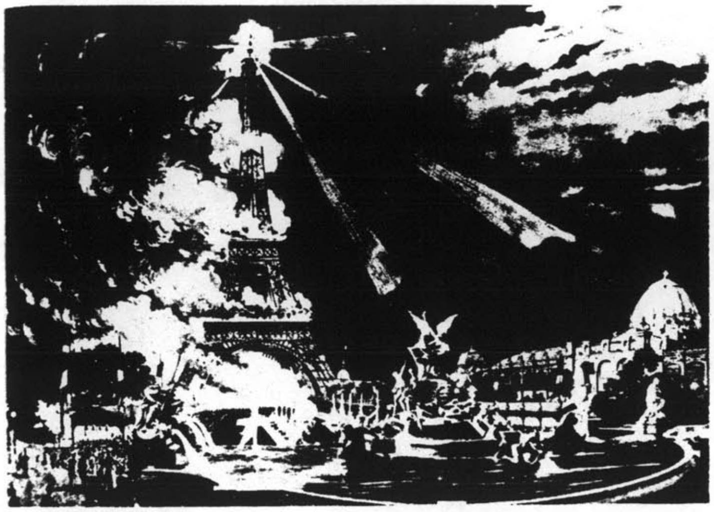
Scientific American, p. 2155

"Enter your room and suffer yourself to press a button analogous to the doorbell to have, immediately and as if by wizardry, your room all lit.... Leave your room, simply touch the same switch and it is all extinguished. We can almost say that a mere effort of will suffices, just like the Creator when he declared "let there be light!" Morever, you have the ability to turn it off when you wish."(5)

(5) "Tout a l'electricite", in La construction moderne (Paris: 14 October 1893), p.21

Although it represented some advantages over other modes of lighting, electric light nonetheless met some opposition in a society that still felt ill at ease with any light source other than the burning flame. As Stevenson puts it, "such a light as this [electric] should shine only on murderers and public crime, or along the corridors of lunatic asylums, a horror to heighten horror. To look at it once is to fall in love with gas, which gives a warm domestic radiance fit to eat by." (6)

(6) R. L. Stevenson, Virginibus Puerisque and Other Papers (New York: Charles Scribner's and Son, 1893), p.223



The Paris Exhibition of 1889 (Oppositions 8, 1977, p.72)

The domestication of fire 60,000 years ago is often considered as marking the true beginning of humanity (7). Those promethean societies had acquired the energy by which the world would be transformed to become their own. The newly available light and heat gave, from that time on, a new meaning to the night. Early on, torches were taken from the camp fires; and by the time Neolithic cavedwellers committed the famous renderings of animals to the walls of the inner chambers of their caves 15,000 years ago, lamps made of burning fibers in animal grease were being used. The Greeks in 600 B.C. had an important industry fabricating clay oil lamps, and it is assumed that the availability of light at night was unprecendented. The further multiplication of oil lamps, and torches, and the development of candles enabled Roman citizens to pursue activities at night -- a great boon, as they loved to socialize.

(7) Maurice Deribere and Paulette Deribere, Prehistoire et histoire de la lumiere (Paris: Editions France-Empire, 1979), p.16

Once these technologies were developed, there was a long lull in the evolution of light sources. The means by which light could be produced -- wood fire, torch, candle, oil lamp -- remained, with minor modifications, unchanged -- until the Argand lamp in the late 1700s afforded a new standard of brightness. Oil-lamps were a necessity for the secret underground meetings of the early christians. The church later perpetuated the privileged use of artificial light by keeping a lamp burning in every sanctuary. The sanctuary lamp was often the only light burning at night. The use of wax candles developed by the Romans was the exclusive privilege of the church. Not until the 13th century was this privilege extended to the nobles.

By that time, candle-makers, "chandeliers" (candlestick-makers), and makers of copper-oil-lamps had formed guilds. It was then still difficult -- and even forbidden -- to work after sunset. Nevertheless, light at night became a more widely accessible good; a necessary one, moreover, because of the growing need to circulate by night in the midst of the agitation that marked the Middle Ages.

The glass lantern industry in the mid-16th century prepared the way for the first permanent public-lighting system, in Paris under Louis XIV, mentioned earlier. The previous three centuries had seen increasing violence as organized gangs raided cities under the cover of night. Several attempts to organize public lighting as well as a system of watches proved unsuccesful, and it took the impetus of a new concentration of wealth among the bourgeoisie of the mid-17th century to finally achieve a system. In 1667, a medal to celebrate the new night was minted. It showed on one side a woman bearing a lantern, and on the other, Louis XIV, the "Sun King."

D'Allemagne, p.319

The 19th century succeeded in providing society with the means by which the night could be defined sufficiently so that its overwhelming uncertainty could be managed, if not overcome. Billboards, the first mass -- and commercial -- medium, came to the scene at this time, to the horror of Parisians, who were appalled at seeing the city's architectural beauty eclipsed by the visual clamor and crass commercial messages. It was in those days that the emerging mass media got their final impetus with the combined impact of large outdoor advertising, new printing equipment, cinematography, and the new exuberance of city lights. The 20th century would make use of those nascent means. The 19th century "philosophy of lighting" was replaced by photometry, an applied science largely controlled by light manufacturers, who operated by the principle that the more light, the better.

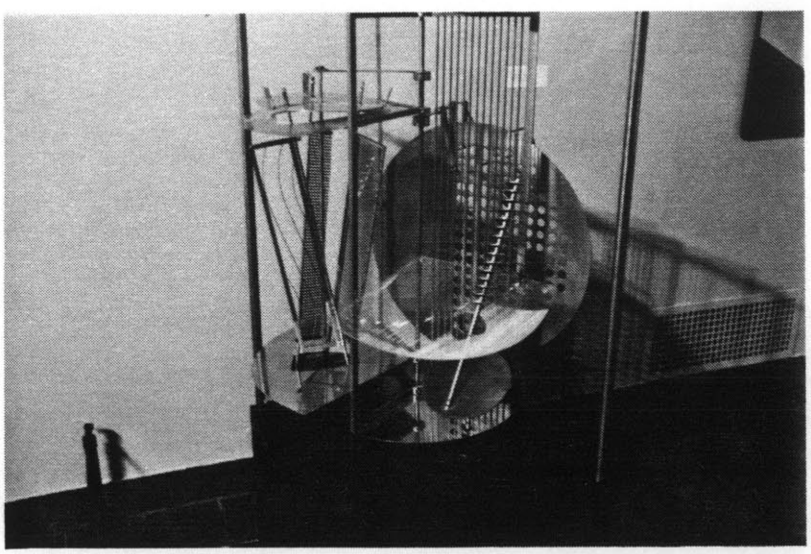
Following the decisive improvement of the incandescent light bulb in 1910, came the mercury-discharge lamps for street lighting in 1932, and in 1940, the fluorescent tubes which provided more light at less cost. But the luminous ceiling, like most other illumination engineers' dreams of high levels of luminosity, proved nevertheless unpleasant and counter-productive: "Most new buildings tended to be saturated with light and the skills in its use (which was once dictated by scarcity) had been lost." (8) As a result -- and with some help from the energy shortage in the 1970s -- a new photometry, one that promoted quality rather than quantity, was embraced by architects and interior designers.

(8) Peter Jay, "Seeing light" in The Architects Journal (Information Library, 4 Jan. 1967 - SfBAb 7:UDC 628,9001)

The definition of a night space has been another significant aspect of the use of artificial light in this century. Outdoors, the final electrification of cities; the buildings of the International Style, lit from the inside and flooded from the outside; and the use of neon and other lit signs and advertisments have created a nightscape which, in its most extreme expression -- Las Vegas -- (9), has been compared to Versailles: In the attempt to restructure space, light acheived in both instances a comparable architectural consistency. (10) Indoors; light-emitting diodes, electroluminescent materials; and cathode-ray tubes and other self-lit visual displays are similarly restructuring interior environments: The dark and the opportunity it provides for the creation of a noiseless visual message has not only inspired new forms of theater, cinema, and Moholy-Nagian light architecture, but it is now becomming a symbol of the new computer age. Office buildings, control rooms, and shopping centers grow darker to accommodate a new furniture that provides its own light.

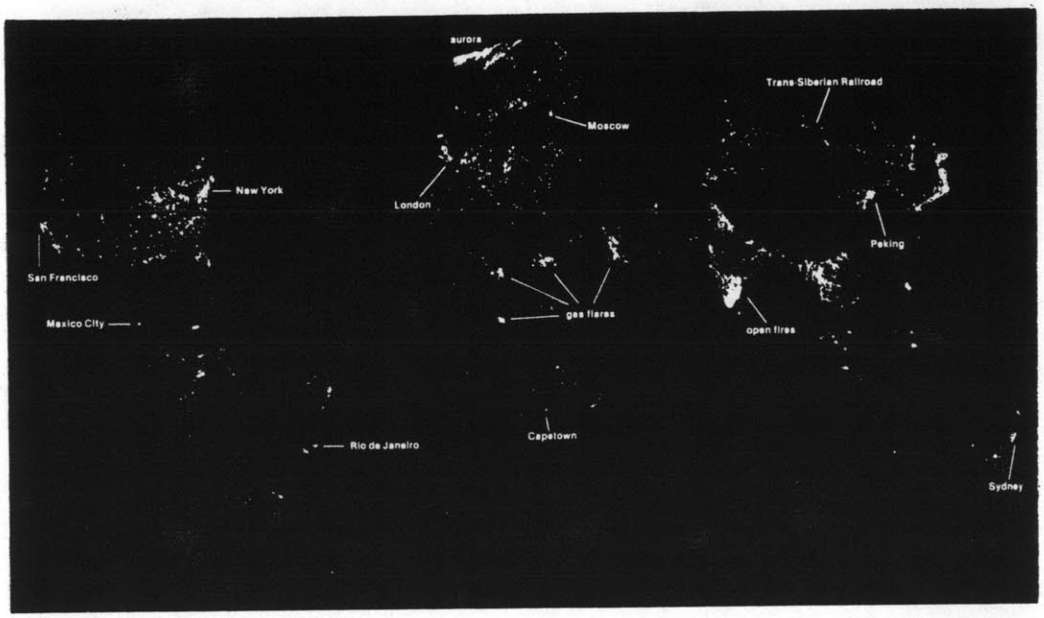
(9) Tom Wolfe, The Kandy-Kolored Tangerine Flake Streamline Baby, quoted in Reyner Banham, The Architecture of the Well Tempered Environment.

(10) Reyner Banham, The Architecture of the Well Tempered Environment (London: The Architectural Press, 1969), p.269



Laszlo Moholy-Nagy. Light-Space Modulator. 1923-30

The World at Night (from Sky and Telescope, May 1984, p. 412)



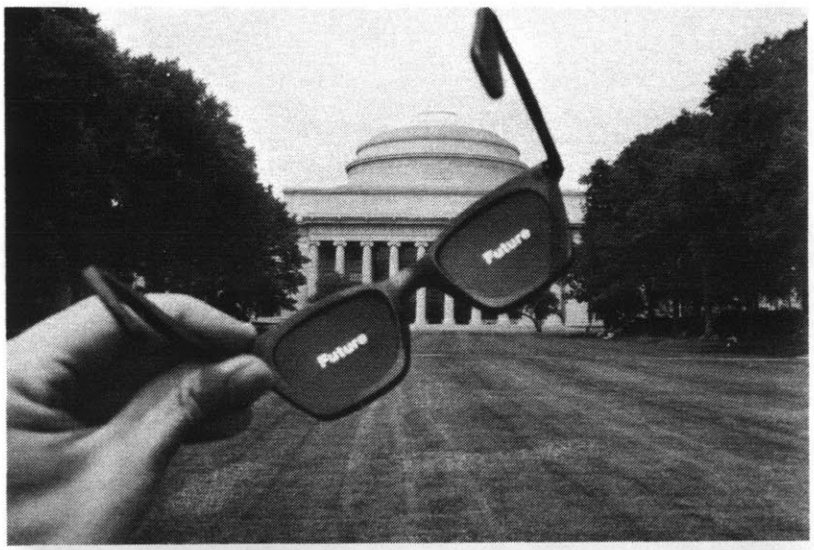
The nature of darkness

It would be convenient to state that darkness is everything that light is not; that it is light's opposite, its absence. But unfortunately, we are not yet sure of the nature of light. We are told that its nature is uncertain and will likely remain so since we can't look at it without altreing its nature. Darkness, then, is "everything but (the uncertainty) of light"? nothing is less certain. Nevertheless, relative darkness is part of our daily experience. Although -- faute de artificial lighting -- not as dramatic as in the past, nightfall and daybreak hardly goes unnoticed.

Kepler in the early 17th century was puzzled as to why, if all stars are indeed suns, the sky was not brighter at night. This was about the time when humanity was discovering the immensity of the sky. The mystery of the darkness of night was solved at the beginning of the 20th century with the new understanding of an expanding universe: At night, the sky becomes transparent and the observing eye watches the emptiness all around. An originally smaller universe -- brighter and warmer, packed with more concentrated energy -- expands, growing emptier the larger it becomes. Then, when we see stars we are looking backward in time: the further away, the further in the past up to a limit -- the big bang -- before which seemingly, no light was emitted at all. When on the other hand we look at the space in between stars (the darkness), we are seeing the future of the universe's outward-reaching matter.

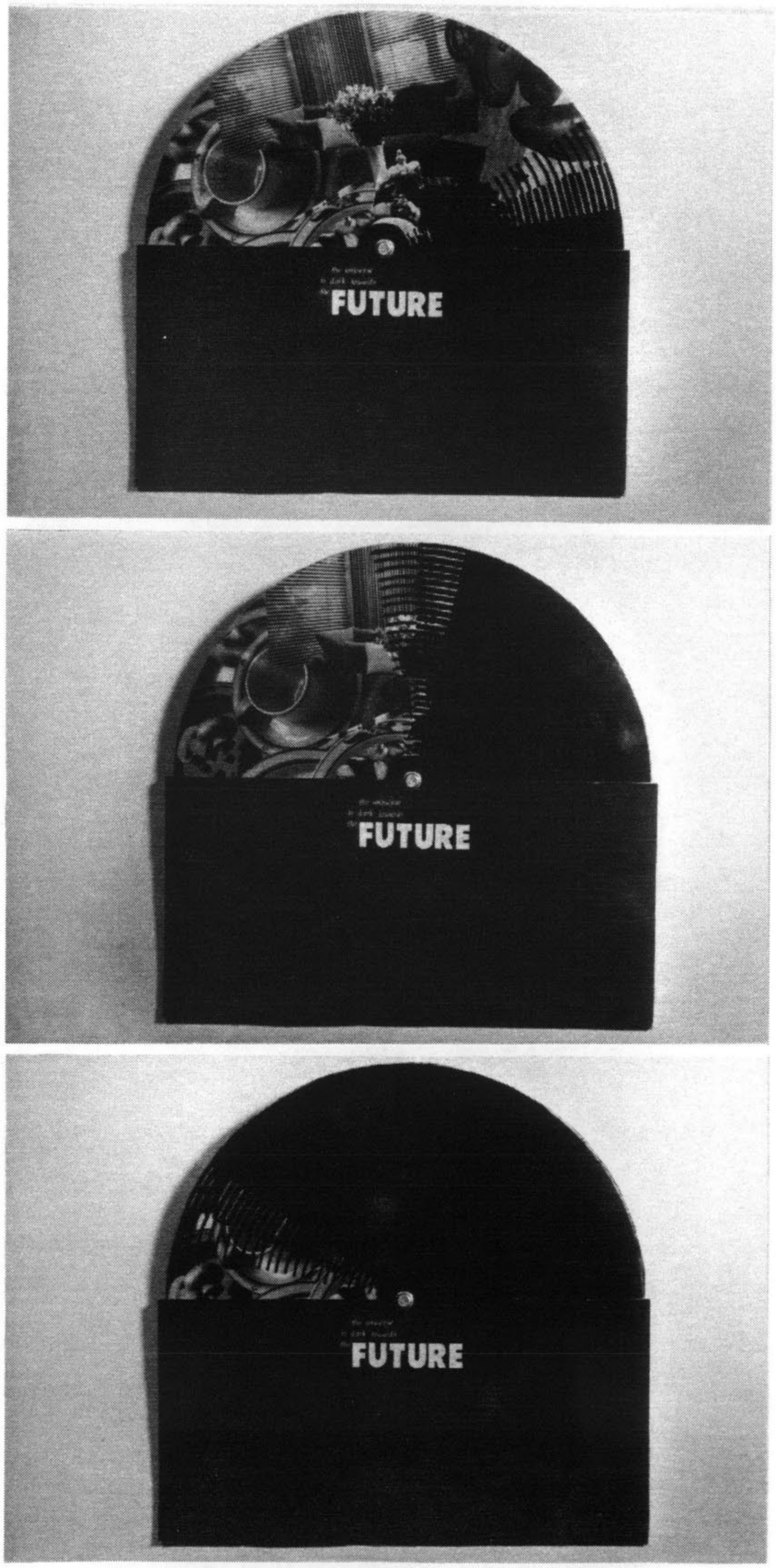
Summer night sky

But it is hard to look at the sky for its darkness: Conscious vision is a focused sense and the eye cannot resist the stars. This irrestible lure of light shows itself also in our tendency to privilege contour, definition, certainty, and labels over openness, indefiniteness, uncertainty, and experience that has not been neatly categorized. Indeed, it is worth remarking how much humanity's perspective on reality has been biased toward a diurnal viewpoint that considered the night as potential day; the dark as potential light; and the unknown as potential knowledge.

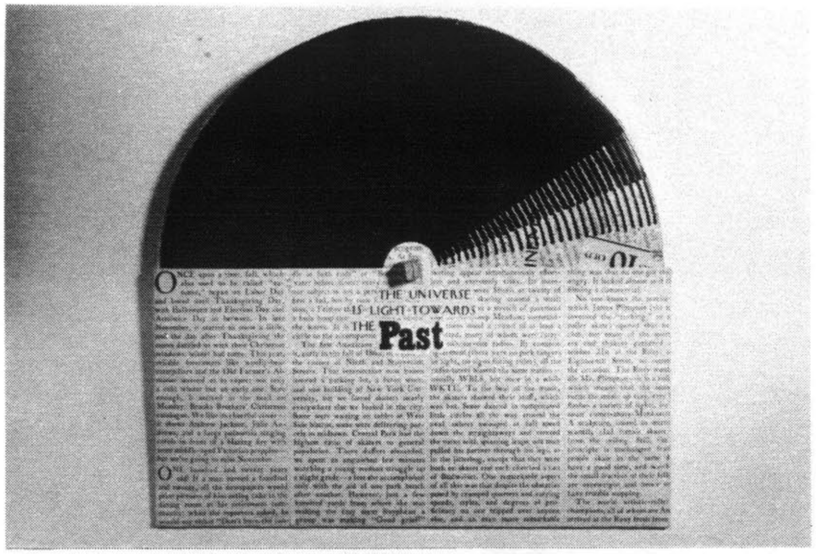


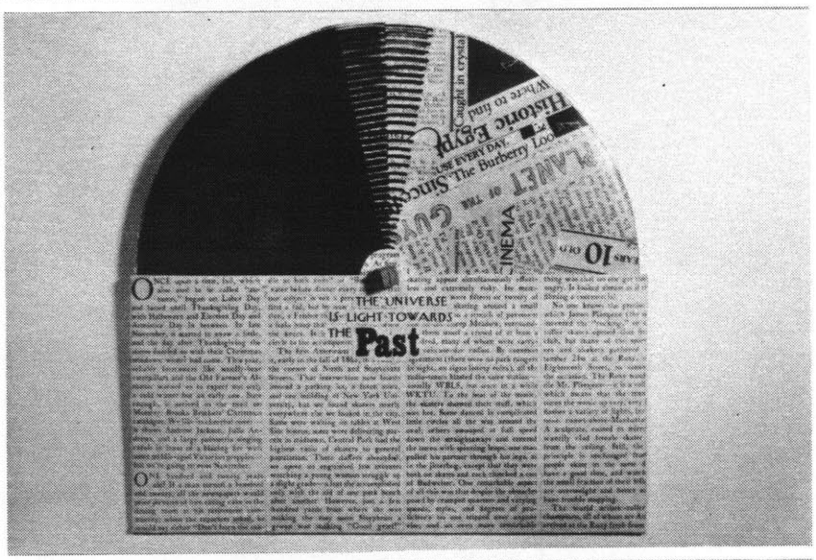
Luc Courchesne. Spectacles for looking at the future. 1984

Luc Courchesne. Portable light for looking at the past. 1982



Luc Courchesne. Past and Future Wheel (collage on folded cover stock and acetate). 1982


THE UNIVERSE
IS LIGHT TOWARDS
THE Past


Historic Egypt
PLANET
CINEMA
THE UNIVERSE
IS LIGHT TOWARDS
THE Past


Historic Egypt
Where to find
PLANET
CINEMA
THE UNIVERSE
IS LIGHT TOWARDS
THE Past

The nature of light

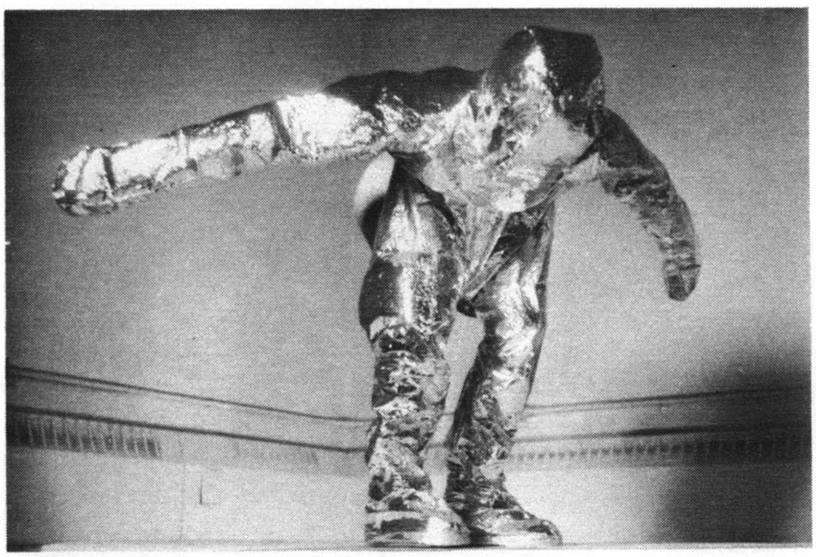
The question of the nature of light has not yet been definitively solved, even though the long debate as to whether it is a wave or a particle has, thanks to the quantum theory, come to some conclusion: Light can be a wave or a particle or both, depending on how we look at it. What this uncertain nature of light suggests is that it could also be much more, provided we discovered new ways to explain and conceptualize light. Chances are we will, and endlessly, since it seems clearer all the time that our knowledge of everything is a matter of infinite unfoldings.

The quest for an understanding of light has already yelded useful keys to nature: Euclid (circa 300 BC) told us that light travels in straight lines; Al Hazan (965-1039) established it as a phenomenon independent from both the eye it enters and the object from which it is reflected. Bacon (1214-1299) understood reflection and refraction; Leonardo da Vinci (1452-1519) compared the properties of light to the wave-like qualities of sound, and understood that light can be quantified, as when it is represented by incremental gradations in chiaroscuro; Grimaldi in 1665 understood diffraction.

Newton (1642-1727) showed that color is part of light itself; Roemer in 1675 determined the speed at which light travels; and Fresnel understood polarisation in 1819. In 1873, Maxwell defined visible light as part of the electromagnetic spectrum; Einstein in 1905 discovered that it is emitted in packets which he called "photons", and Bohr in 1913 explained that a photon is emitted or absorbed when the atom to which it belongs becomes excited, pinpointing whence comes what we experience as light.

Light exerts a fascination that appears to be universal. I was surprised at first when everyone with whom I spoke expressed a personal interest in the topic; everyone it seems has something to say about what darkness and light means to them. The subject of light has always been a spur to progress in science and technology, a stimulus to knowledge and action: The age of Enlightment, for instance, corresponds to the beginnings of permanent public lighting, and it is followed by... the age of Progress.

Light has not only provided a point of view on the world in which we live but, by our understanding of its secrets, has given us the power to transform... and destroy. After the atomic bombing of Hiroshima and Nagasaki, J. Robert Oppenheimer speaking for all the scientists who contributed to the enterprise, quoted the Bhagavad-Gitas Krishna: "I am become death, shaterer of worlds."

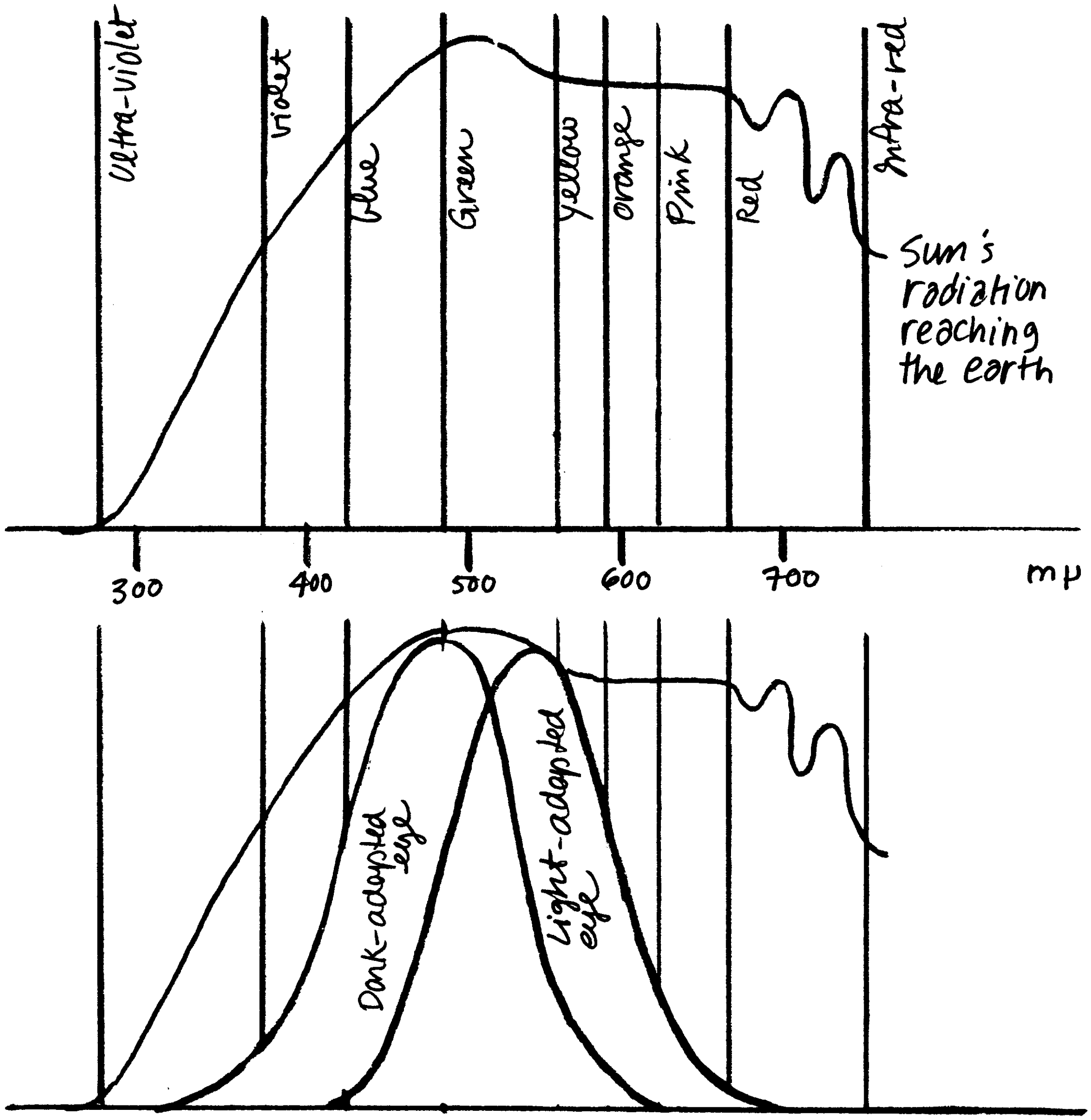


Luc Courchesne.
Lightproof Suit
-- made of mylar and black satin lining, and meant to protect the human body against excessive exposure to light and images.
1982

The composition of light.

For our purpose here, light is a radiation. What the human eye recognizes as visible light is in fact a very small portion (less than 1 percent) of Maxwell's electromagnetic spectrum -- between on one side the infra-reds, the micro waves, radar waves, and radio waves; and on the other, the ultra-violets, X-rays, and gamma rays. The most important source of visible light is the sun. Sunlight has been the energy by which life evolved and after which, therefore, photosensitivity modeled itself. It constitutes, then, the ultimate radiation, the one that makes the greatest possible use of the receptivity potential of circadian biological systems.

The energy spectrum emitted by the sun changes constantly hroughout the course of a day and over the year. It is nevertheless possible to establish the average spectral output of solar light, which can be used as a reference for evaluating other sources of light; to understand, for example, why things look different under other light sources, and how such sources might affect the performance of biological systems. Interesting facts about the sunlight spectrum are that it peaks in the blue-greens -- just about where the human dark-adapted eye is most sensitive -- and that it remains strong throughout the range of visual sensitivity, before dropping in the infra-reds and ultra-violets.



Human visual sensitivity thus nestles confortably within the range of stimulations the sun has to offer.

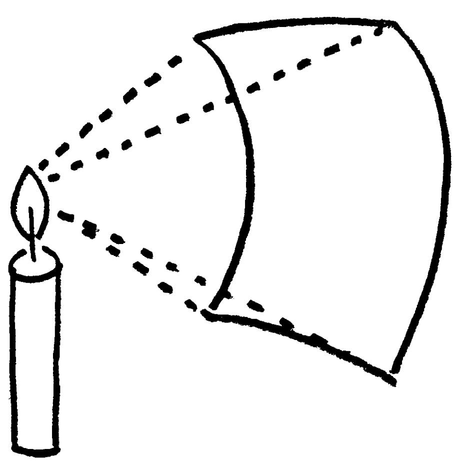
Researchers in photobiology believe that some of the sunlight entering the eye that does not result in visual sensation -- like the near ultra-violet -- have nevertheless significant impacts on the organisms, especially on the regulation of hormonal functions. John Ott in particular insists on the importance of ultra-violet radiations and the alternation of light and darkness in the the definition of sunlight-based photosensitivity. (1)

(1) John Ott, Health and Light (Old Greenwich, Conn.: The Devin-Adair Co., 1973)

The measure of light

Leonardo da Vinci introduced the idea of photometry as he developed chiaroscuro, a technique by which painters could render form and space by incremental gradation of tone between black and white. Practical minded Benjamin Thompson (Count Rumford, 1753-1814), besides inventing a kind of oil-lamp, devised a shadow photometer, which offered the first accurate means of measuring light intensity, and introduced the concept of a standard candle. This was accepted as the international standard of luminosity until the 20th century. (1)

(1) James F. Maurer, et al, ed. Concise Dictionary of Scientific Biography (New York: Charles Scribners' Sons, 1981)

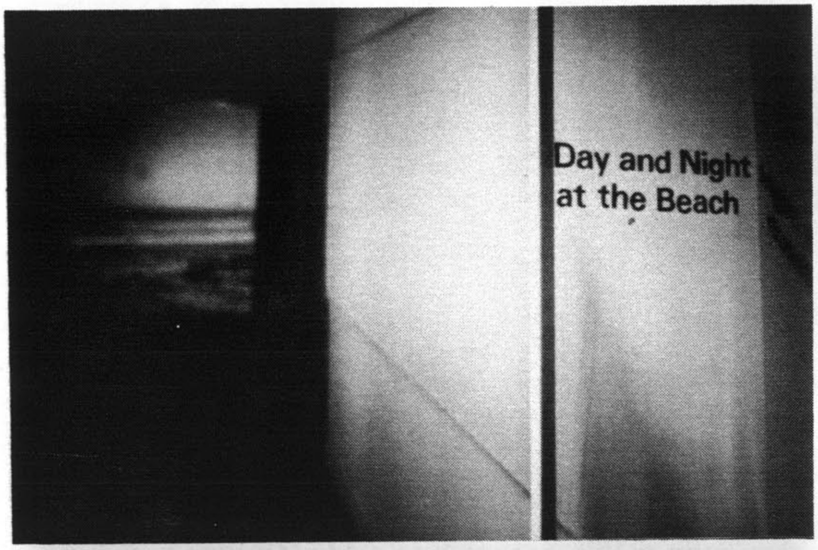


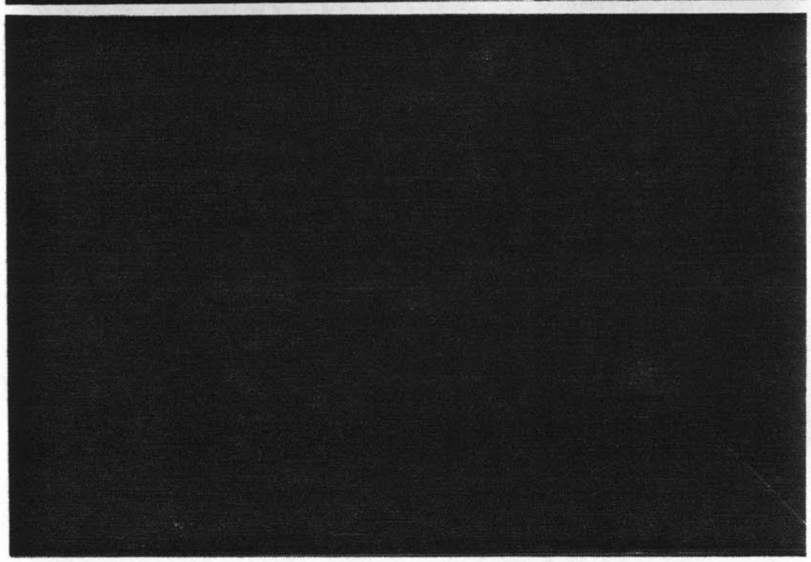
The foot-candle

Such rudimentary essays at measuring light developed into a science -- photometry -- at the turn of this century, at the time when an unprecedented availability of light posed for the first time the question of what to do with it. The "candle-power" (or candela), was defined as the intensity of light from a given light source; the "foot-candle", as the amount of light reflected on a surface at one foot from this source. The "foot-lambert" was the amount of light reflected or "luminance" from a one square foot surface. A "lux", like the foot-candle, was the amount of reflected light from any point of a surface, but at one meter from a candle made of sperm whale fat (2). These measures are still in use today. However, the last 10 to 15 years have seen a shift in the understanding of environmental lighting that is challenging the ways by which we measure light.

(2) The sperm whale supplied the fatty material used in candle-making before large amounts of mineral oils were extracted from Pensylvanian wells (beginning in the 1860s). The epic era of whalers hunting sperm whales in particular, to satisfy the huge demand for fat in the candle-making industry inspired Melville's great novel: "In merchantmen, oil for the sailor is more scarce than the milk of queens. To dress in the dark, and eat in the dark, and stumble in darkness to his pallet, this is his usual lot. But the whaleman, as he seeks the food of light, so he lives in light. He makes his berth an Aladdin's lamp, and lays him down in it; so that in the pitchiest night the ship's black hull still houses an illumination."(3)

(3) Herman Melville, Moby-Dick (London and New York: The Penguin English Library, 1972), p.536





Luc Courchesne. Day and Night at the Beach -- an installation at the Center for Advanced Visual Studies that used a time-laps study of the 24 hour light cycle, as a lighting device. 1983

The use of natural light

To the prehistoric human eye, the sun, among the major natural phenomena, must have been the most visible. It regularly appeared, disappeared, reappeared -- and, with it, the world around. Its light, from early on, has not only been an object of worship and a measure (by its use to mark the passage of time) (1) but has also been used to define space in the built environment. Its role in defining built space will be elaborated below.

(1) Days, years, and the "path of the ecliptic" were measured by the layout of a landscaping that "remembered" the position of the sun or other celestial bodies in a horizon-based astronomy.

Cavedwellers must already have had some notion of the advantages of a controlled light environment: They could choose to go inward -- for shade, to seek the protection of the dark or to meet with their gods -- or outward, toward the visible world. They could negotiate that visible world because it provided them with a clear sense of the space and time in which they found themselves. From the cavern described in the 5th chapter of Plato's <u>Republic</u> as a theater of light offering a point of view on the outside, to Le Corbusier's "machine a habiter," which numbered the window as an essential constituent feature (2), the built environment has provided throughout history various conditions for the use of natural light.

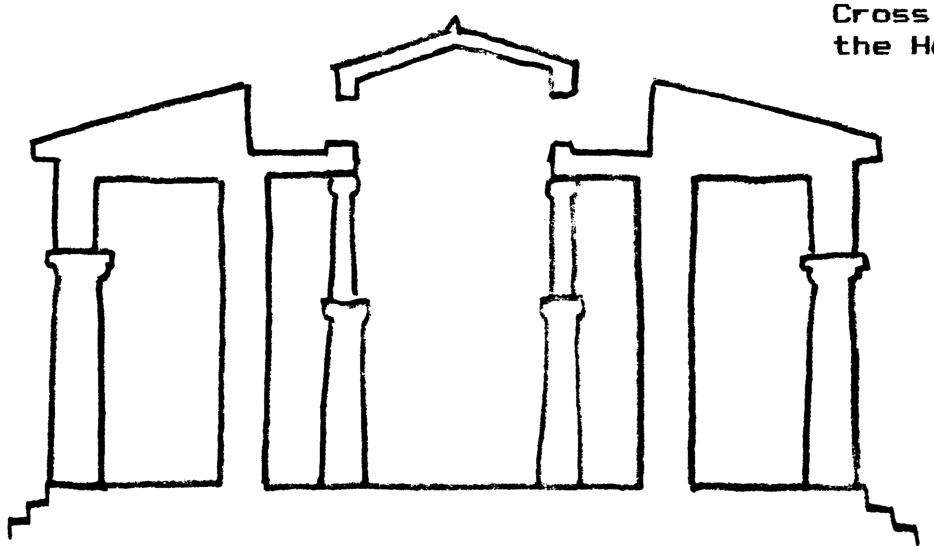
(2) Plato, The Republic (New York: Basic Books, 1968)

The Indian temple of Karle is thought to be a later example of what must have been a common formula in early architecture (3). The principle of using the doorway as the only source of natural light appears to be a direct heritage from cave architecture. Karle's altar at the dark end, faces the entrance, reflecting light as the visitor enters. Ionic temples also used the doorway as the only source of natural light. However, the argument that this was due to yet unresolved technical problems involved in creating windows overlooks the possibility that the architects might have favored the darker space thus created, and/or wished to accentuate the experience of passage between two distinct light environments.

(3) The fact that the temple remains remarkably well preserved offers a good opportunity to experience one of the oldest form of architectural lighting.

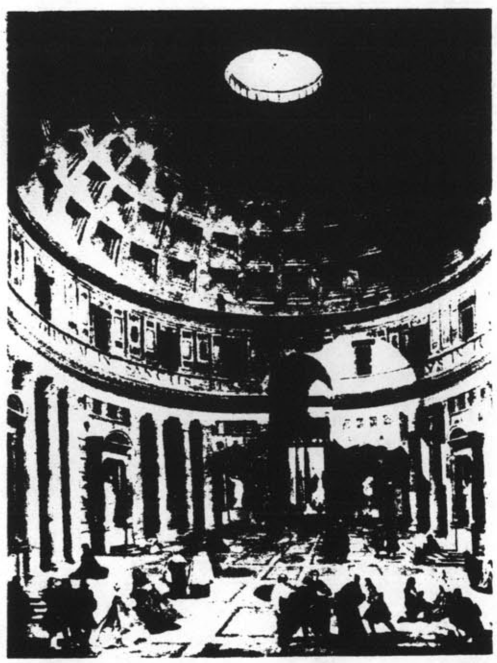
The Egyptian temple of Karnak offered a striking contrast to the bright light of the Nile valley as it admitted a visitor into a darker interior with myriad rows of columns covered with hieroglyphs. These were illuminated by raking sunlight pouring from "opaions" (small openings) on top. A brighter central alley, lit by an open-ended recess on the roof above, led to an increasingly dimmer environment as a visitor walked away from this central axis. The lavishness of the inside of most Egyptian temples contrasted with the sobriety of their exteriors. It is interesting to note that the Greek architects of the Doric period, inspired though they were by Egyptian architecture, sought nevertheless to turn the Egyptian temple inside out: The exterior alignment of columns characteristic of Doric temples -- and the ever-changing patterns of light and shadows they offered to view -- contrasted singularly with the simpler inner chamber which they housed. The high visibility of Greek sacred cities suggested that their gods were out in the world, conducting affairs not too remote from those of mortal beings.

Seeking to house their gods properly, the Greeks developed a mode of lighting their temples which used side openings (or "metopes") between the roof and wall. Later, as in the Parthenon, metopes embedded in the roof were used as more layers of columns were incorporated into temple designs. This provided enough light to keep the entrance doors closed when necessary. Permanent staircases leading to those metopes shows that frequent and easy access was made necessary by the need to adjust the changing natural lighting conditions by means of blinds or screens. It is remarkable that the interiors of Greek -- and later, Roman -- temples became increasingly brighter as their architectural vocabulary developed.



Cross section of the Heraion. Olympia

The introduction of glass in the architecture of the Roman villa points to the Romans' taste for natural light. They opened the interiors of their buildings to the outside, unifying the two previously segregated spaces. The interior reflected onto the garden which in turn reflected back inside, introducing a sense of transparency. Inasmuch as the conditions provided for the use of natural light in Roman architectural practice seem to have undergone major revisions, it is interesting to consider the Pantheon. This unique building was lit by a single circular roof opening, an oculus that strangely reminds one of the iris in what could be a giant model of an eye.(4)



The Pantheon. Rome
(from Janson, p.135)

(4) Remember the mechanisms of vision were unknown at the time. Not until the early Renaissance was the idea of the eye as a "camera obscura" developed by Leonardo da Vinci, Kepler, and others.

Fear of persecution drove the early Christians to seek the protection of the night, and of the underground byways of Rome. Their early churches were dark and ceremonies were held by preference, when possible, at night. Not until the erection of St. Sophia -- and the Byzantine dome with windows at its base -- was any significant amount of natural light again admitted into temples or churches. By then, however, the use of stained glass had transformed the function of the window; the admission of light became a secondary function. Natural light could thus be used to substantiate the interior space by coloration and call to mind the mysteries underlying the faith. It helped transform the cult into a more diurnal practice. The specificity of the sacred space had been preserved, and with Chartres and Gothic

Stained-glass.
Bourges, France.
(from Janson, p.265)

architecture, the rich volumes and characteristic qualities of light of the interiors had partly replaced the evocative powers of the much darker settings used in earlier times.

With more people seeking the protection of their walls, the growing fortified cities eventually became overbuilt, with the result that very little natural light reached the living spaces. Although image-preserving (transparent) glass became available from the 13th century on, the tax on windows inhibited the development of a more open architecture.

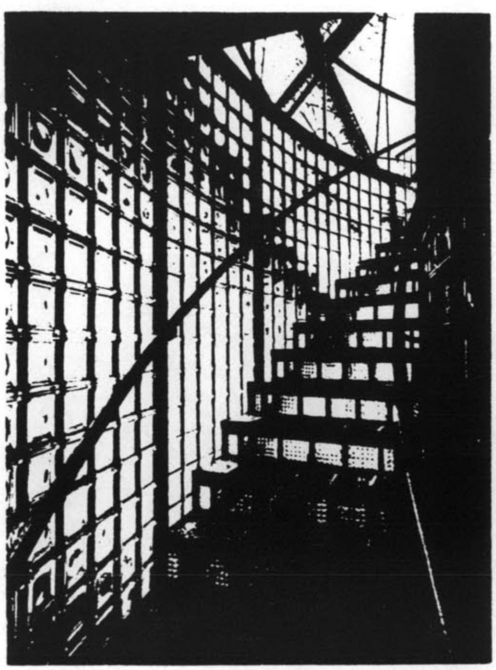
The political and religious turmoil of the Middle Ages, with epidemics, vandalism, and persecutions, subsided with the rise of new wealth resulting from the emergence of the new colonial powers. With the availability of larger sheets of image-preserving glass, Versailles could open its interiors on a garden that itself tried to open the landscape with alignments channeling vision, and reflecting planes breaking up the horizon. But before this new taste for natural light could reach the citizen, it took the miseries and resources of the industrial revolution and the ingenuity and aspirations of a society striving for health.

The 19th century saw in light the index of a new society. At just the time when Chadwick was campaigning for better "sanitary conditions [for] the laboring population of Great Britain" (5), and just after a cholera epidemic hit London, the Crystal Palace was built in London for the world's first International Exhibition. Commenting on this structure with its 1,000,000 square feet of glass a humorist wrote: "We shall be disapointed if the next generation of London children are not brought up like cucumbers under glass."(6)

Paxton. The Chrystal Palace. London, 1851 (from Janson, p.553)

Already, as plans were being formulated to legislate on health conditions, industrial architecture for which light was essential was developing its open-roof aesthetic. By 1900, Paris was a giant construction site:

Avenues were broadened and building construction regulated to provide every living space with sufficient daylight. It nevertheless took the development of reinforced concrete and a new generation of architects before the programmatic use of natural light could be seen in the built environment. Observing the "horror of being poor and cold in a world of brick and masonry,"(7) Scheerbart wrote his visionary Glassarchitektur in 1914. Le Corbusier's Pavillon de l'esprit nouveau in 1925, Walter Gropius's Bauhaus in 1926, and Duyker's sanatorium in 1929 are early examples of the modern movement that provided inspiration for much 20th-century architecture.



Taut. The Glass House. 1914 (from Janson, p.562)

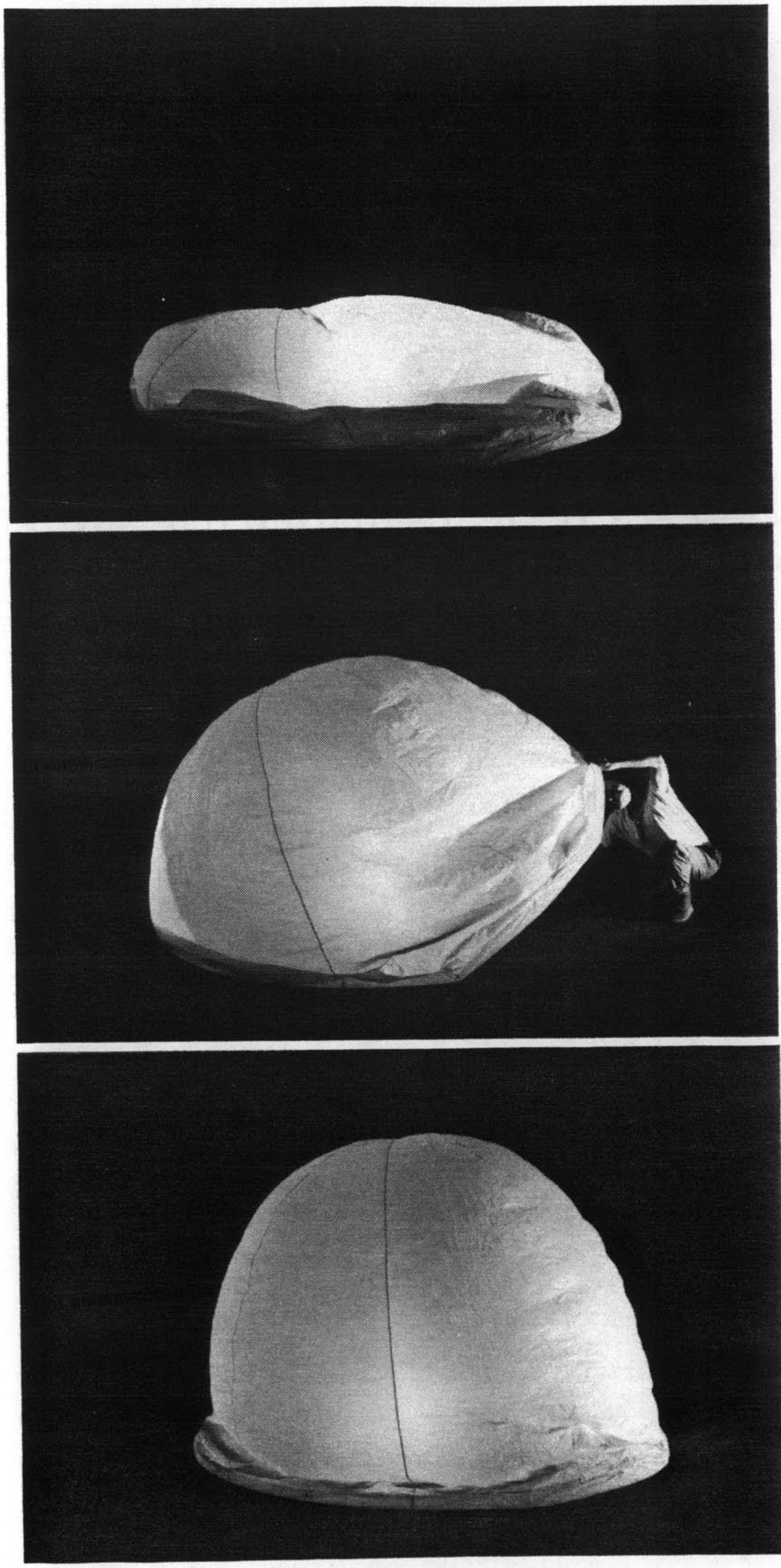
(5) <u>The Age of Progress</u> (Alexandria, Virginia: Time-Life Books, 1966), p.36

(6) <u>The Age of Progress</u>, p.17

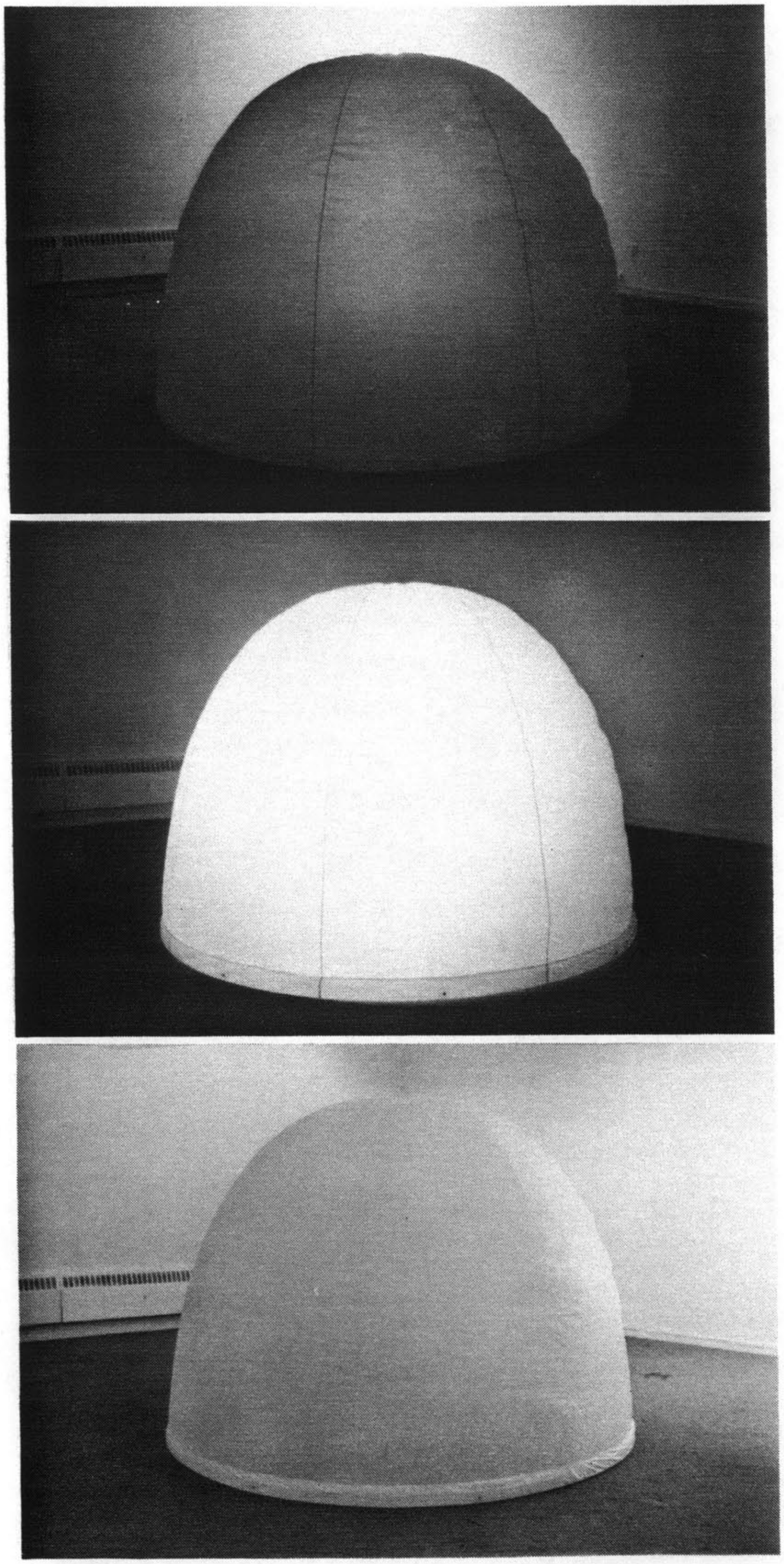
(7) Reyner Banham, <u>The Architecture of the Well-Tempered Environment</u> (London: The Arhitectural Press, 1969), p.125

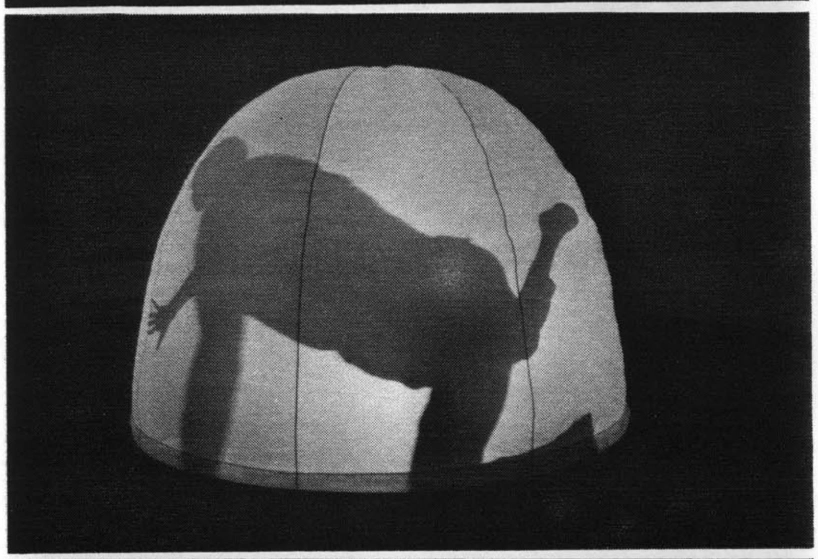
"To bring in the sun, that is the new -- and the most imperative -- duty of the architect." ("Introduire le soleil, c'est le nouveau et le plus imperatif devoir de l'architecte") (8). Written ten years after the Congress of Modern International Architecture met in Athens (1933), this sentence today rings even truer as, after the oil embargo in the 1970s, houses must be designed to not only let in natural light, but also store its energy. After becoming visually transparent the house had to become energy transparent.

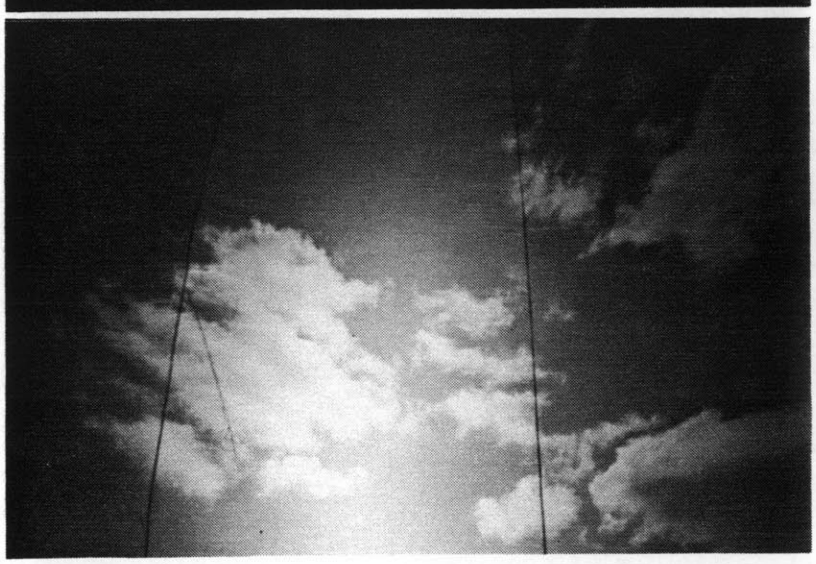
(8) Le Corbusier, <u>La charte d'Athenes</u> (Paris: Editions de Minuit, 1957), p.51



Luc Courchesne.
Light Dome -- an inflated translucid structure for experimenting with space, as defined by light patterns and intensities. 1984

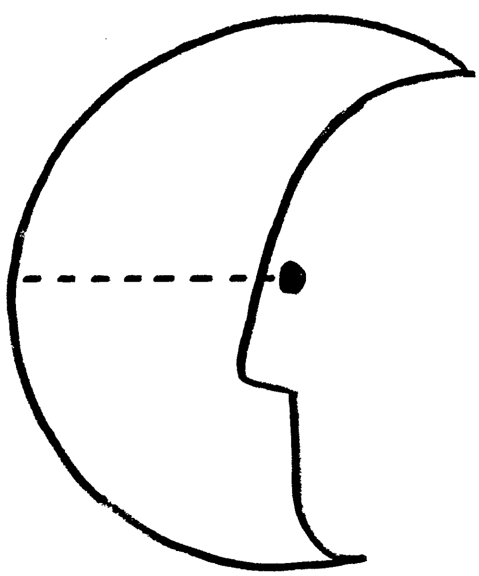






The horizons of the unaided eye

The visual sensation is triggered by a combination of properties of the external reality. These include the amount of available light, the size and distance of an object, contrast between object and background, relative position, the movement and speed of objects in the visual field (the eye cannot register movements faster than a certain threshold). All these factors supply useful cues, and, in their extremes, impose potential limits on the experience of vision.



The unaided eye adapts remarkably well to very low levels of light provided it is given enough time to adjust. After 30 minutes or more, the scotopic (dark-adapted) eye will be sensitive to a star of the sixth magnitude, a candle at a distance of 1.8 miles, or the reflected light from white paper illuminated by 25 candles at a distance of 300 yards. According to physiological psychology, a minimum of six photons entering the eye -- of which one is likely to reach a retinal receptor -- is the ultimate threshold of the visual sensation of an external phenomenon. This corresponds approximately to the conditions provided by a cloudless sky on a moonless night (Southal, 1937). For the photopic (light-adapted) eye after just seconds of adaptation, the maximum bearable luminosity corresponds to the luminosity of a hazy sky near the sun at its mid-summer zenith, or the reflected light from white paper illuminated by 43750 candles at a distance of one foot (Luckiesh, 1942). The adaptation capabilities of the human eye are remarkable; capable, according to Southal, of bridging extremes of 1,000,000 fold magnitude. The eye, moreover, is perfectly adapted to respond to the conditions found in nature, not only to varying degrees of brightness, but also in that the eye's color sensitivity models almost perfectly the spectral curve of sunlight. (Ott, 1973).

The maximum sensitivity of the <u>dark</u>-adapted eye, (which is then most sensitive to <u>brightness</u>), corresponds to a wave length of about 510 $m\mu$, in the bluish-green (at the eak of the sun's radiation), and stretches between 620 $m\mu$ and 360 $m\mu$ toward the blue end; sensitivity goes down in the reds. The *light*-adapted eye (most sensitive to *color*), peaks around 570 $m\mu$ in the greenish-yellow. The spectral range to which the eye is sensitive is shifted slightly toward the reds, stretching from 720 $m\mu$ to 360 $m\mu$; the eye is less sensitive toward the blue end.

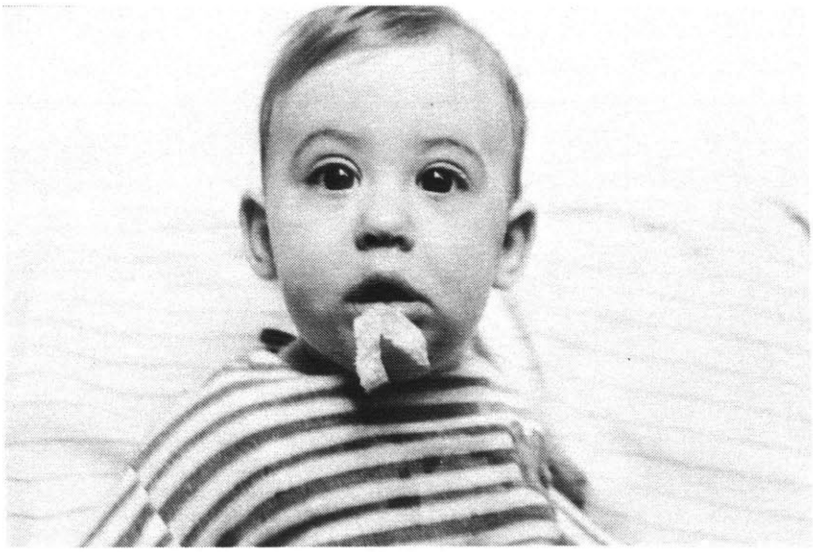
The adult human eye can focus anywhere from six inches from the cornea to infinity; the "rest position" (dark focus) is an arm's length away from the eye (Owens, Leibowitz). Any object or detail within this range can enjoy the foveal or macular (that is, "involving the central part of the retina") attention of the light-adapted eye if it is not smaller than 30 seconds of arc (or 1/100 of an inch at 12 inches), and not exceeding the visual angle of 3 degrees on the vertical plane and 12 to 15 degrees on the horizontal plane (Hall). Up to and beyond 120 degrees on the vertical plane and 180 degrees on the horizontal plane, the light-adapted retina's rod cells perform a blurry and colorless rendition of the object of visual attention. Anything larger will not be perceived in its entirety unless eye movements are performed.

To distinguish an object from its background or otherwise extract information from a visual field, contrast is necessary. Contrast is usually a result of the combination of surface reflection and luminosity. Absolute contrast, as in a light-emitting surface juxtaposed to a low-reflectance opaque surface, will fatigue the eye. Minimal contrast, on the other hand, will tend to blend the visual field, and requires more attention and the use of other strategies for visual discrimination.

For depth perception through stereopsis, objects must be no further than 16 feet away from the eye. But a more comprehensive perception of three-dimentional space will be achieved by either movements of the observer or movements of objects within the visual field. A sense of depth depends on those respective potentials for movements, and movement is essential to any visual sensation at all: A perfectly still eye and an absolutely static -- an ideal theoretical visible field abstraction -- would result in nothing but a sensation of greyness. Eye movements are thus essential, but the 50 milliseconds it takes for the visual system to register anything creates a time-based horizon to the visual experience. It makes it impossible for a supersonic pilot, for example, to see things before bumping into them, or for a moviegoer to perceive the succession of still frames that comprise a film.

Time is responsible for another horizon of the naked eye as well: The further we look, the more ancient a perceived event. At 186,000 miles per second, light travels 5,865,696,000,000 miles in a year, or one lightyear. The furthest and most ancient visible object we can see is the galaxy of Andromeda, 2 million lightyears away. In a sense, everything we see belongs to the past, if we consider the time it takes light to travel from an object to the eye, and then the time it takes for the visual system to register. This thesis as you read it is close to being experienced in the present, but anything further away ages proportionally. Toward the future, we see nothing: No light has yet reached it.

Finally, within this range of luminosities, sizes, distances, contrasts, geometries, speeds, and times, what ends up being visible depends very much on what is interesting to the mind



Blanche at six months.

The eye as a light sense

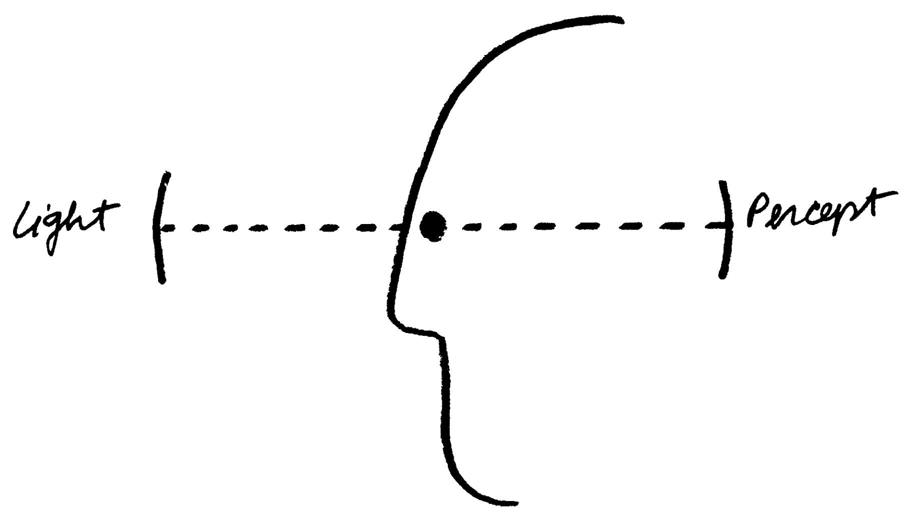
The horizon of the unaided eye is a product of evolution. It is now assumed that evolution has been a process wherein "chance mutations sporadically produce variability in the DNA structure, acting as a motor of evolution and enabling organisms to strive for the best available niche." (1) From the first synthesis of amino acids to processes like photosynthesis and the image-forming accomplished by the visual systems, the universal availability of light-radiating energy has certainly been a dominant factor in species diversification. Jennings offered an interesting perspective around 75 years ago, when he sketched a hierarchy of the evolution of organisms' reactions to light. (A paraphrased outline is given below):

1. At the bacterial level, light intensity as a factor of aggregation. 2. At the level of unicellular organisms like the amoeba, changes of light intensities result in contraction and orientation in some cases. 3. At the bacterial level, sudden changes in light intensity result in inhibition or aggregation. 4. Same as 3, but for circumscribed parts of larger organisms; producing orientation and movement of the organism toward or away

from a light source. 5. First instance of reaction to a sign and of choice whether to respond to or ignore a light change. 6. Reaction to a sign, wherein change in intensity (shadow) represents an object with qualities and behavioral implications (beneficial, injurious, food, enemy). 7. Reaction to a sign where the light condition or configuration, which causes the response, represents objects, not by means of shadows cast by them but by means of the light reflected from them, expressing size, form, or color -- in animals with image-forming eyes.(2)

(1) Eric J. Chaisson, "The Scenario of Cosmic Evolution," in Harvard Magazine (Cambridge, Mass.: Harvard University, Nov./Dec. 1977), p.30

(2) O. S. Mast, Light and the Behavior of Organisms (New York: John Willey & Sons, 1911), p.263



The human brain, "the most complex clump of universal matter known to exist" (1) is, with its eyes as a window on the outside, a genuine light sense. Moreover, "binocular vision and dexterous hands undoubtedly contributed to an increase in cranial capacity." (1) What sensitivity the human light sense failed to develop -- compared to that of other species with far more competent eyes, capable of seeing in the dark or focusing on smaller objects at greater distances -- it gained in cerebral capabilities. As a result, the rather average human retinal sense ends up being capable of generating an exceptionnal sense of reality.

If you "see" what I "mean," it is that the human visual and cognitive systems are so intimately connected that it is impossible to tell where one ends and the other starts. Plato thought that visual models were necessary to understand the dance of the gods (3); and Aristotle writes in the first sentence of the Metaphysics: "Of all the senses, trust only the sense of sight." (4) In civil and criminal trials, where legitimate reality is at stake, testimony from eye witnesses is preferable and visual evidence unsurpassable -- for seeing, it is proverbially held, is believing.

(3) Philip Morisson, et al., Powers of Ten (New York: Scientific American Books, 1982), p.1

(4) Edmund Carpenter, Oh, What a Blow That Phantom Gave Me! (New York: Holt, Rinehart and Winston, 1973), p.38

Though the horizon of the unaided eye seems unacceptably limited, humanity has found ways and means: It can work at optics assisting the eye in seeing smaller, faster, and further; it can try transposing its expanding conceptual reality within its visual range; and finally, it can work at getting more insights with less visual evidence.

The horizon of the aided eye

The development of optics brought about a whole new picture of reality. Early Greek philosophers already knew that what they called "visual rays" had properties; Euclid that they traveled in straight lines; Aristotle that they inverted themselves as he observed on the ground the upside-down image of a solar eclipse; and Ptolemy that different materials had different reflectance properties. Only centuries later, when Al Hazen (965-1039) and Roger Bacon (1214-1294) reopened the quest for the properties of light, did instruments specifically designed to use light came to exist. Darkrooms, parabolic mirrors, and lenses were objects of amazement if not cult, and many faced prison and death for heretically playing with nature and truth by such means. Bacon in his Opus Magnus had foreseen how "pictures could be projected in the space, into air, where they could become visible to the multitude". (1)

(1) E. M. Feher, Toward a Theater of Light (Toronto: Ontario College of Art, date unknown), p.19

The first genuine contribution of this new science to the resolving power of the eye was the development of magnifying glasses, to be used for deciphering manuscripts. By the middle of the 14th century, there flourished in Venice and Antwerp a new industry making eye glasses, which had been "recently invented for old men whose eyesight had begun to fail." (2,3)

(2) James P. C. Southal, Physiological Optics (New York: Dover Publications Inc., 1937), p.90

(3) It may not be mere coincidence that the establishment of the first candle-making guilds, the production of spectacles, and the new art of printing occurred around the same time (in the 14th century), and between Venice, Paris, and Antwerp (along the most intensely traveled commercial route, and just as the discovery of new continents was about to happen.

Another giant step was made when the camera obscura and lenses were coupled. Porta's (1533-1615) achievement was to popularize an old idea and find a practical application. That portable device for framing the world and making it more manageable (Rosinsky, 1984), of great help to artists and scientists of that time, in fact created a new one, in which has evolved television, the dominant frame of reference of our day.

The phenomenon created by a room made dark, where a reversed image of what lies outside is projected on a wall opposite a small hole, in other words, a camera obscura, was known to Al Hazen, who experimented with it around the year 1000 A.D. The addition of a lens (around the time of Bacon in the 13th century) and the interception of the image, as suggested by Leonardo da Vinci, with a translucent material (near the end of the 15th century) made it possible to shrink the camera obscura to a manageable size. Soon after Porta, Kircher (1601-1680) described in his Ars Magna Lucis et Umbrae (1646) the "laterna magica," a device evolved -- as its name betrays -- from the lantern and the camera obscura, and the ancestor of all later projections devices. Meanwhile, the combination of lenses and black boxes yelded the microscope (first described by Hooke in 1665), and the telescope: the astronomical telescope by Kepler; the Galilean telescope; the Newtonian telescope; and the Gregorian telescope. By the end of the 17th century, a quite novel picture of the world appeared -- as observed through a camera obscura; as projected from a laterna magica; as enlarged by a microscope; or as brought closer by a telescope. (4)

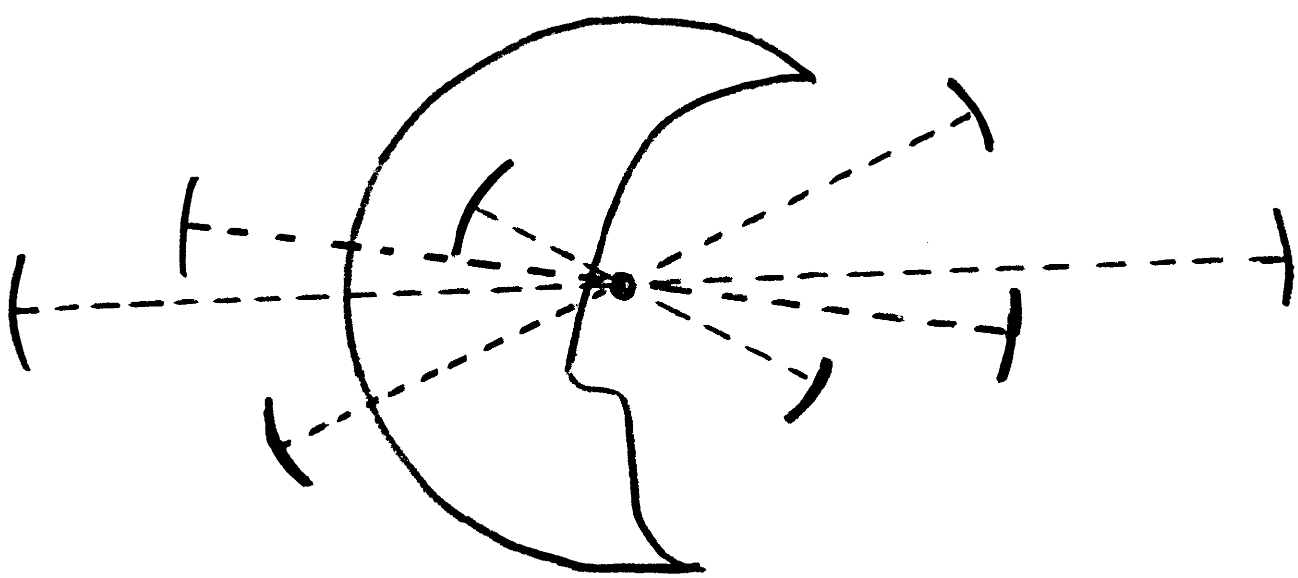
(4) Again, it is not likely mere coincidence that the development of the portable camera obscura, the laterna magica, the microscope, and the telescope came in the lifetime of Descartes, Newton, and the foundations of modern science. The period saw as well as the first periodicals, the Age of "Enlightment," and...the first permanent public lighting in Paris.

From the camera obscura and the laterna magica to photography, cinematography, and cineprojections, memory has been added. In one instance it produces a new insight on the ephemeral and instantaneous, and in the other, it records duration and expresses time and transformation. The transformation from camera obscura to photographic camera is credited to Daguerre and the Lumiere brothers among other 19th-century inventors.(5)

(5) The 19th century was obsessed with light and its "philosophy" (or rational application). It saw with the invention of the electric light bulb the turning point of humanity's combat with darkness. It also saw the development of the rotary printing press, photoengraving, the linotype and cheap paper; the telegraph, and the telephone. The 1900 first edition of a London paper could proudly headline: "No event can occur in the most remote corner of the earth without The Daily Express being placed in immediate possession of its fullest details." (6) But it also saw the emergence of the unconscious; had the first insights into quantum mechanics and the uncertainty principle; and saw the explosion of pictorial representation with impressionism, followed by the cubism and abstraction that ushered in the next century.

(6) The Age of Progress (Alexandria, Virginia: Time-Life Books, 1966), p.38

Twentieth-century-technology is further expanding the visible domain. The development of more sensitive films, brought X-rays, infra-red, and ultra-violet radiant energies inaccessible to the naked eye into the eye's range of sensitivity. Brighter and faster light pulses reduce the very notion of what an instant means: Strobe lights can show us a bullet going through an apple (or even a light bulb) freezing the action to show us what really happens; fantastically short light pulses, only a picosecond long, used in optic-fiber communications, by which complex information (including finely detailed images) can travel at the speed of light from a generator to a displayer. Transmission electron microscopes can display single atoms -- and space telescopes, we are promised, will observe the universe 16 billion light years away, showing objects like the quasar PKS 2000-330, the most distant object known, which "exists" at a time somewhere near the Big Bang. Unmanned space probes can take color pictures at the edge of our solar system as if we visited there ourselves. Radars, sonars, and ultra-sound scanners bring audio frequencies within the visual range. Nuclear-magnetic resonators (NMR), used in medical imaging, are sensing variations in atomic structure to get clear pictures of hidden features within living organisms.



The phenomenal distribution of cathode-ray tubes establishes television as the main referential frame. Housholds the world over can access through broadcasting and satellite transmission real-time events from anywhere. It is an elaborate ongoing display of moving images of reality, ranging from the viewer's own (home videos) to packaged news and soap operas. In addition, with home computers, users can access networks of data banks, and enjoy their set's increased visualizing capabilities. Television can present any visual experiences, and it has become therefore a universal window on reality. We have reached the point where what cannot be seen on a TV screen can hardly claim to be a legitimate part of reality.

If we add to the horizon of the aided eye everything that is in the range of the unaided eye -- the experience of territory (distances, and geometries); of points of views (from moving cars, planes, space ships); the vicarious experience of the myriad facets of human expression found in every new medium that has been piling up since humans are humans; the resulting accumulated wealth of visual evidence on past times, and the unsurpassed means to produce still more of it -- we end up knitted with visual information. We have become as Edmund Carpenter says, "angels": "spirits freed from flesh, capable of instant transportation anywhere" (5)

(5) Carpenter, p.3

An evening at the Center for Advanced Visual Studies

And yet we are back to where we were 60 thousand years ago; we watch TV as we used to watch a fire. TV doesn't look the same as fire, but today's world doesn't look the same as it did either. The same old eye going for its light.

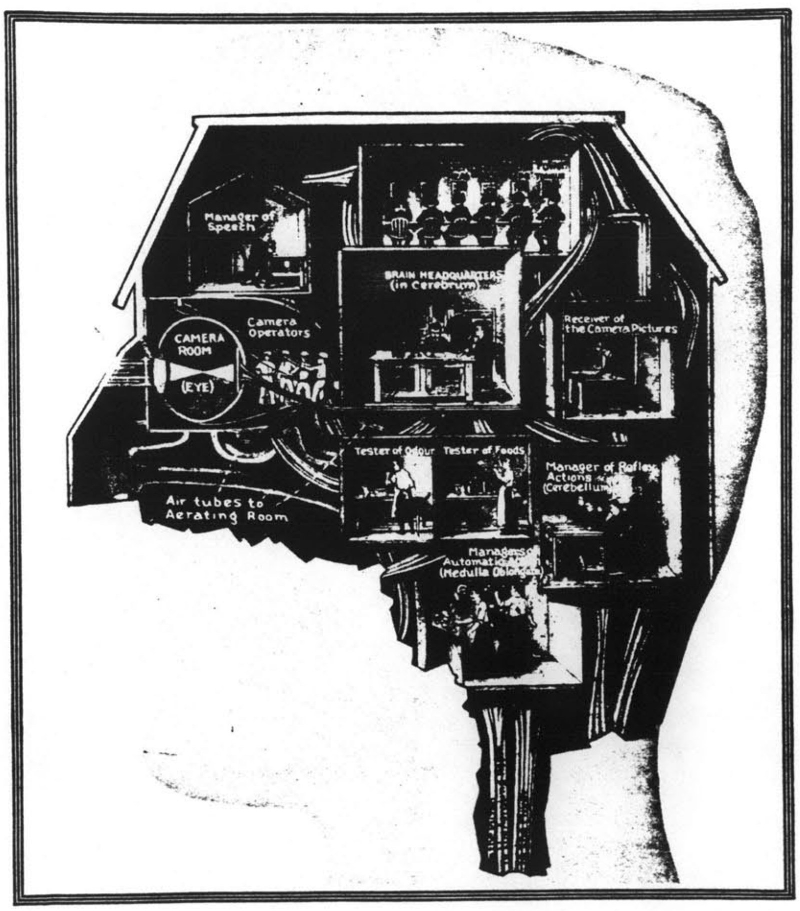
There is yet another way to enlarge the scope of visual experience, beside all the possible developments of what is already accessible to the eye, with or without aid: That would be to stimulate the visual cortex directly.

The nervous system

"The famous town of Mansoul...was advantageously situated in the spacious continent of the Universe and at the same time protected from outside assault by a well-nigh impregnable wall completely surrounding it. Access to this stronghold was practically... impossible except through one of the five gates of the city which were known far and wide as ear-gate, eye-gate, mouth-gate, nose-gate, and feel-gate. Accordingly, whenever the curious inhabitants of Mansoul desired to know what was going on in the great world around them, they would repair to these gateways and converse with travelers from afar who chanced to pass that way, and above all they congregated most at eye-gate and ear-gate because the principal highways led up to these two gates and here, therefore, gossip and rumor were rifest." (1)

(1) From an allegory by John Bunyan (1628-1688) as told by James P. C. Southal in his Introduction to Physiological Optics (New York: Dover Publications Inc., 1961), p.1.

When one attempts to understand what it is to experience reality, and to understand the mechanisms by which consciousness occurs, one easily succumbs to metaphors and allegories. Plato's description of the head, the seat of the soul, as a miniature model of the cosmos; Bunyan's fortified city of Mansoul; Sherrington's "enchanted loom weaving a dissolving pattern" (1940); or Crick's slow and messy computer (1983) are among the many models found along the path of the search for what it is to be conscious of our consciousness. Evocative as they are, they are simply reductive accounts of an otherwise unresolved mystery.

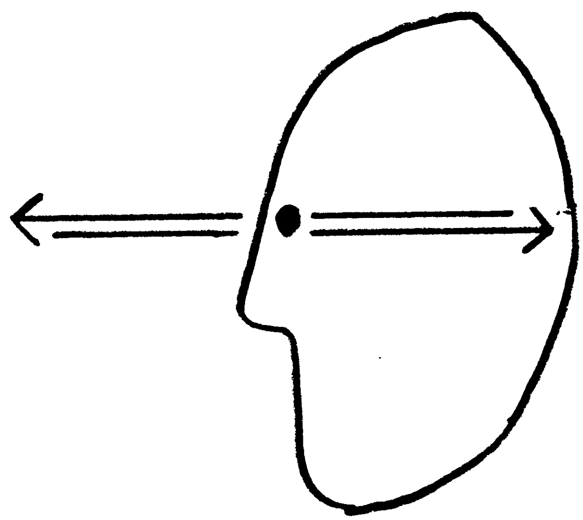


Rose, p.31

The discovery by Galvani (1737-1798) that signals were carried along nerves in the form of electric impulses and by Brown-Sequard (1817-1894) of the chemical nature of the electrical release have been milestones in the current view of the nervous system. With electro-encephalograms and single-cells recordings, a new picture of the brain is being formulated, wherein it is now possible to point at things like mind and consciousness.

The typical mammalian nervous system consists of sensory and motor nerves in the periphery, connecting at the center, and through the brain stem to the cerebral cortex. This network, capable of transmitting electric impulses along its circuits with the help of chemical releases, works in two directions: from the periphery to the center, sensing events; and from the center to the periphery, creating events. This is obviously an over-simplified view of an extremely complex system; more than a mere switchboard connecting a stimulus to a response, the nervous system is capable of being aware of itself.

A royal road to understanding its operation is provided by the visual system. The visual system not only constitutes the major channel of information by which the brain connects with the environment -- visual discrimination being the cornerstone of our idea of reality -- but it also demonstrates, via tell-tale eye movements, what the mind is interested in, moment by moment and second to second.

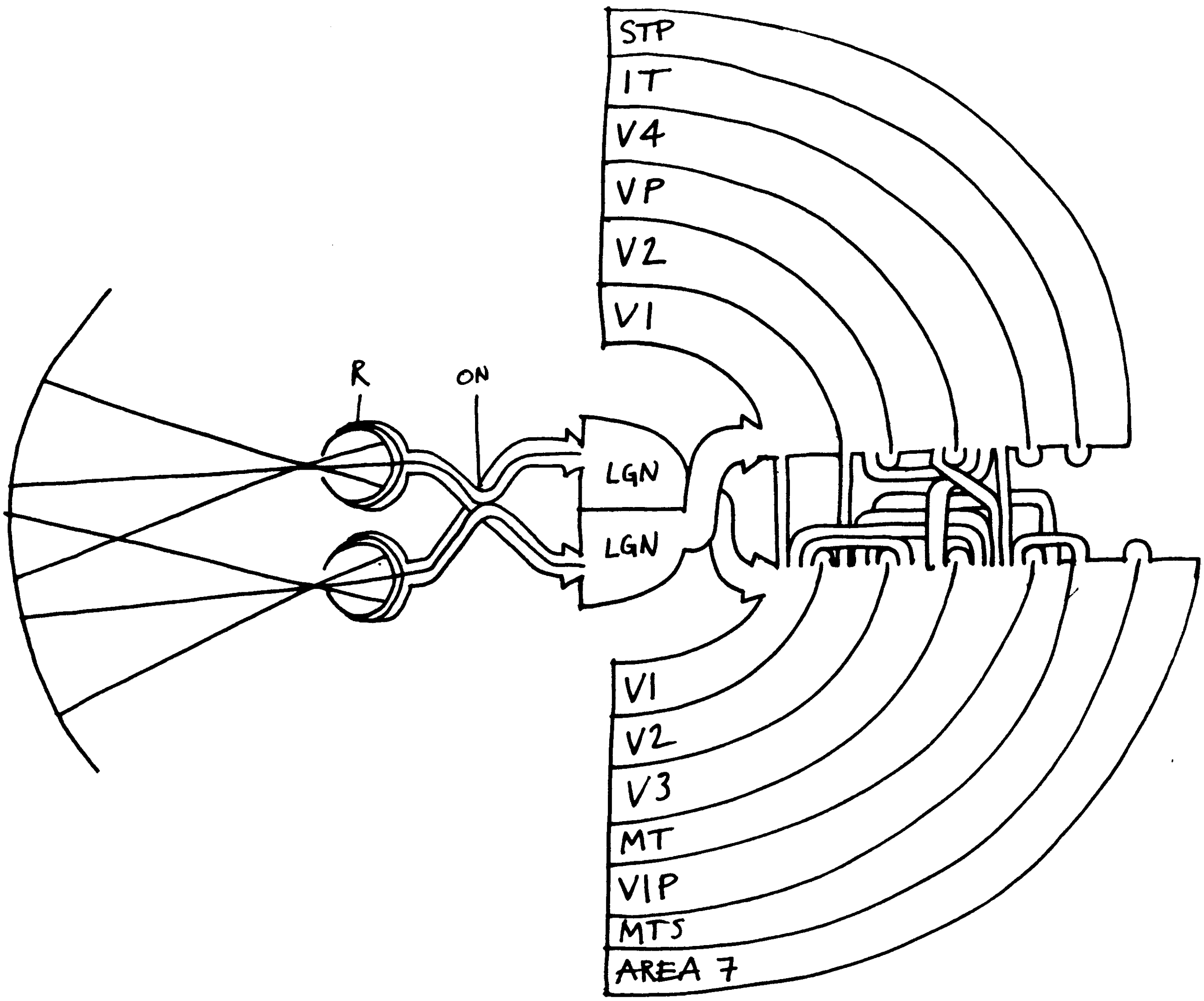


The visual system

The visual process starts when at least one photon, oscillating (1) between 380 mμ and 760 mμ, enters the eye and impacts on the retina, producing an electrical impulse by triggering chemical reactions in the receptor cells (rods and cones). This signal then travels through several synaptic junctions at each of which it is analysed further: Brightness is extracted at the retinal level; contrast, at the optic-nerve and lateral-geniculate levels; edge discrimination and angular rotation, in the primary visual cortex (area 17); stereopsis and movement detection, in the secondary visual cortex (area 18); and so on until the formation of a meaningful sensation at the highest levels of cortical activity.

(1) Light is either a wave or a particle depending on how we look at it.

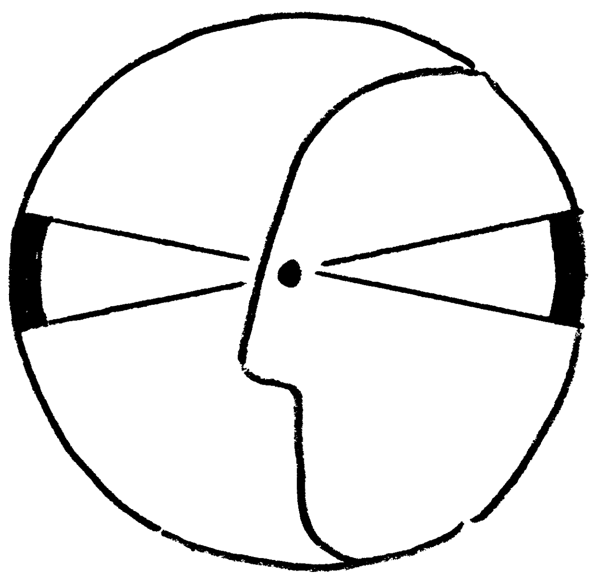
An interesting fact recently uncovered about visual processing is that successive mapping occurs from the original patterns on the retina and, from there, far into the higher cortical areas, while acquiring ever greater substance because more and more cells and electrochemical events become involved in representing and conveying the information on its way to the highest cortical levels.



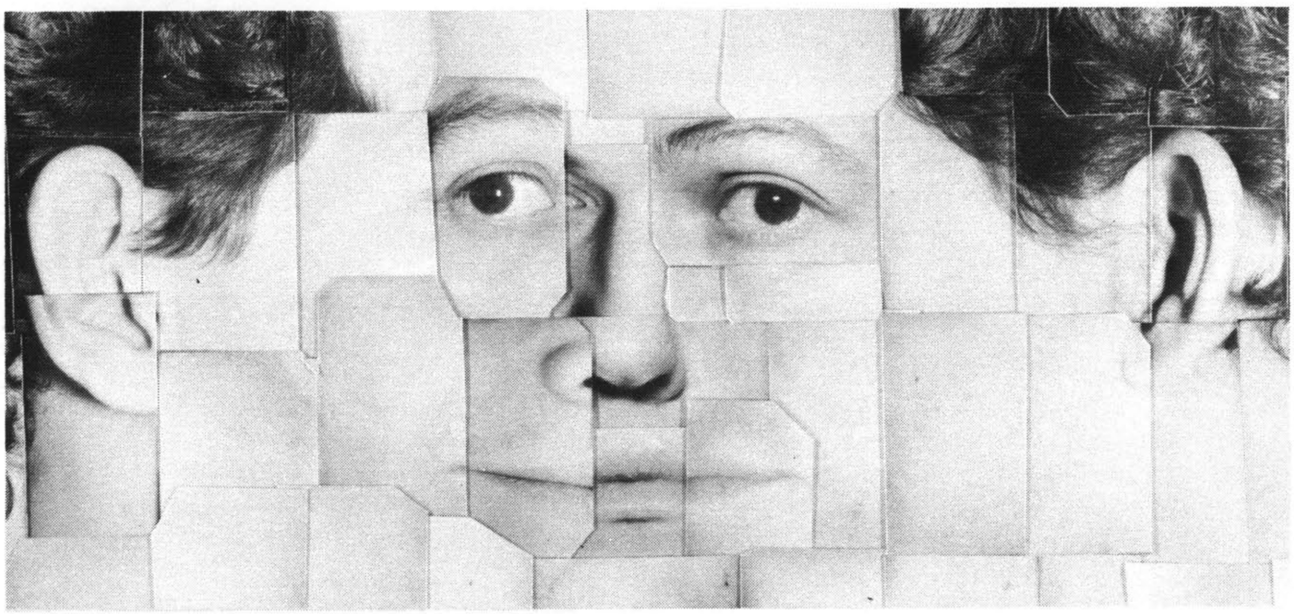
This finding is the result of an investigative method based on single-cell recording, wherein a stimulus presented to the eye is associated with the firing of a cell in the brain. Some cells will only respond to brightness; others to edges and specific angles; and some even have been found to respond only to monkey hands. In view of that it would appear that at higher levels can be found maps of potential reality ready to be excited or brought to consciousness if triggered by the proper external or internal condition.

(2) More than 50 percent of all cortical functions are thought to be directly involved in visual processing and traces of visual stimulations are found in the highest cerebral centers.

The apparent corresponding geometry between the external reality and the brain's internal reconstruction of it inspires my somewhat poetic model, described below. It presents the external and the internal as two polarities and the experience of consciousness as a reverberation resulting from transfers between the two. Here the whole cortex is seen as a screen on which the environment is projected, and the environment as a screen on which the cortex is projected -- or the interface of the the two as the locus of a freely floating consciousness.



It is interesting at this point, as the recycling of the mind by the environment and the environment by the mind proceeds, to consider both mind and environment as the artifact of the other. Furthermore, one can now argue about what constitutes the boundary between the two. The boundary exists. It is a product of the discovery of the self (3), but it appears to move inwards and outwards depending on either mental or environmental conditions. The inside adjusts itself to the outside and vice versa. The inside or the self may appear to inflate in darkness and retract in daylight and in that sense, the skin is a constantly shifting boundary. Someone's car in a traffic jam, or clothes in a crowd, or skin in a sauna, or even someone's inhibitions on the sofa of a psychiatrist are felt like alternating tangibles limits between the self and the environment.



Luc Courchesne. Mapping of body. 1984

(3) Children born blind, observed psychologists Fraiberg and Adelson, only begin to refer to themselves as 'I' or 'me' after they have learned to play with dolls." (4) The acquisition of personal pronouns is closely linked with the capacity for symbolic representation of the self, and vision normally plays a central facilitating role in these achievements.

(4) Young, J. Z., Programs of the Brain (New York: Oxford University Press, 1979), p.39

Inasmuch as vision is the instrument by which the self is established, self-consciousness is best expressed by practices that make it possible to hide oneself from being seen. The night constitutes a remarkably effective visual cover but there are other means by which unwieldy selves can venture in broad daylight, and among them, screening the eyes is by far the most economical.

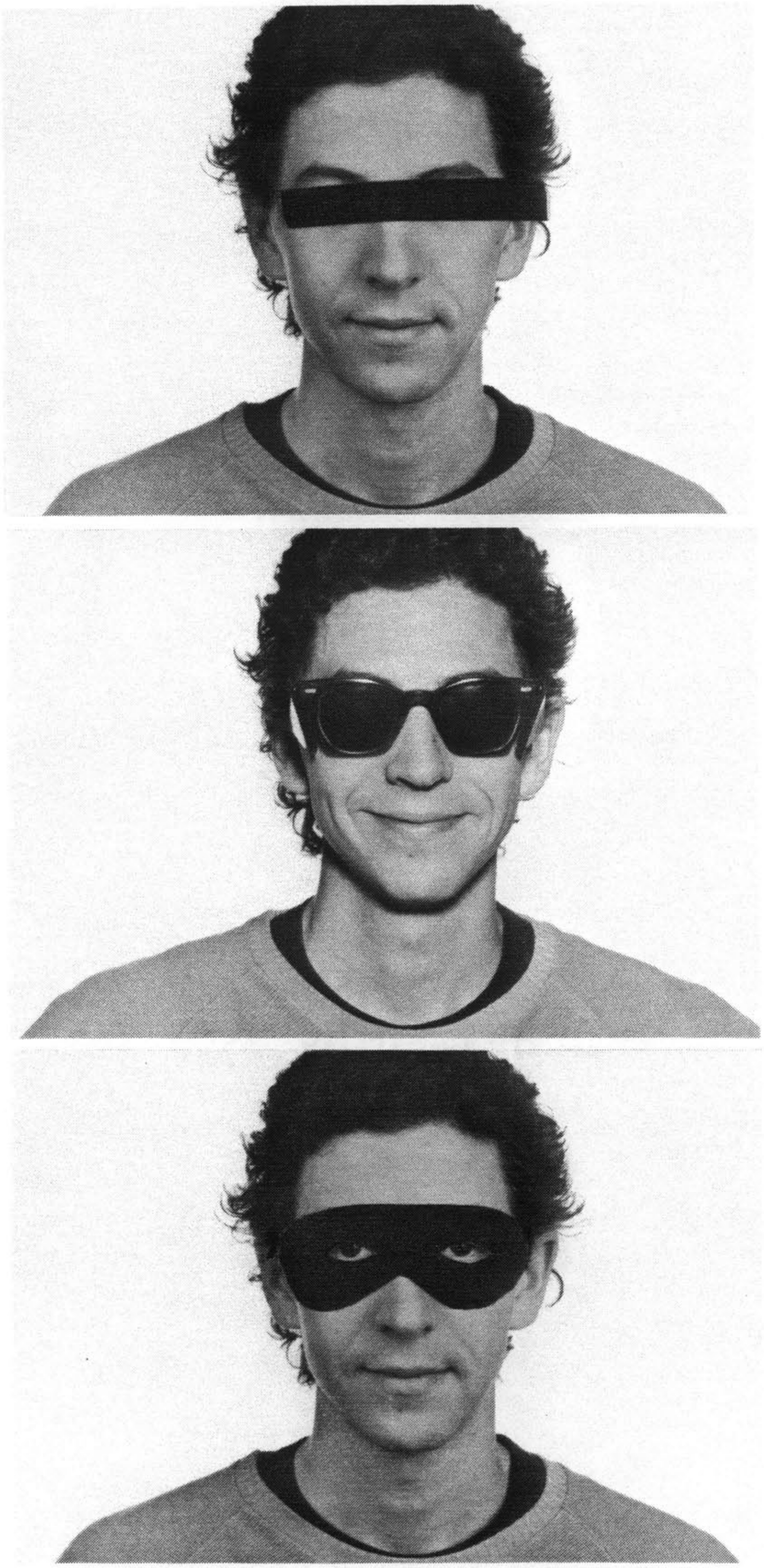


Photo Yves Binette

Retinal sensitivity

Loeb attempted to show in 1887 that "animals go toward a source of light neither because it is useful for them to do so nor because they enjoy light or can see, but because they are positively heliotropic." (1) This view, which attempted to place all light-sensitive organisms -- micro-organisms and plants and animals -- under the same general behavioral principle, met wide criticism because it precluded establishing grounds for the study of more specific aspects of the light-related behavior of animals with image-forming eyes. There was however general consensus that "animals with image-forming eyes no doubt orient and go toward a source of light much as they go toward any other object of interest to them" and also that "all organisms that respond to light at all, respond to changes of intensity." (2)

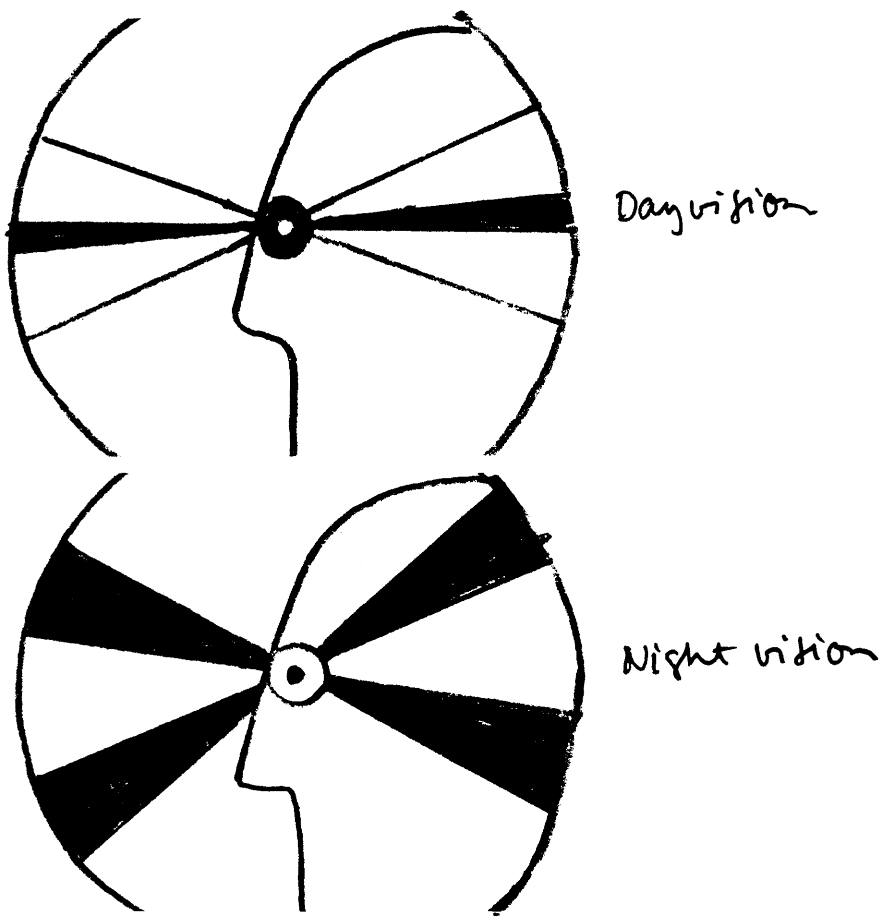
(1) S. O. Mast, Light and the Behavior of Organisms (New York: John Wiley & Sons, 1911), p.53

(2) Mast, pp.233-234

In the visual system, brightness is the first light condition to engage the visual process. Its components are immediately extracted at the retinal level by the combined action of the receptors, the bipolar cells, and the horizontal cells. They are responsible, by an interplay of excitatory and inhibitory impulses, for the adaptability of the eye to a wide range of luminosities and degrees of brightness contrast.

"At night, all cats are grey" -- because the retina operates under two distinct modes: daylight and twilight vision. In the daylight mode, the fovea (a small circular area in the center of the retina, the size of a pinhead with 25 thousand closely packed color-sensitive cones), and the neighboring macula -- a not quite as tightly packed arrangement of cones -- mostly provide a focused and colorful visual sensation, provided there is sufficient light to surpass a high sensitivity threshold. The twilight mode, on the other hand, depends for its operation on the loosely arranged rods that fill the periphery of the retina. Rods are very sensitive to low levels of luminosity but not at all to color -- the resulting sensation yields a rather wide and blurry visual field without color. One reason is that the neurons in rods are arranged differently than those in cones. Two hundred rods send signals to a single neuron, resulting in more sensitivity in low levels of illumination and little finesse, while each cone connects to one neuron, thus generating more information but also requiring more light to trigger a visual sensation. (3)

(3) The fovea is a more recent development of the retina. It is believed to have evolved becuse the species required better focusing capacity and more spatial resolution, because its members lived in trees, plucking dinner, in the form of berries, from the end of branches.



The light-adapted eye is sensitive to colors and, compared with the dark-adapted eye, has a narrower field of vision and good visual acuity. It operates under a focused mode, with high threshold sensitivity (that is, it is less sensitive to light). The dark-adapted eye, in comparison, has a wider field of vision, poor visual acuity, and is totally blind to color. It operates under an unfocused mode, sensing in periphery, with a low treshold of sensitivity (that is, it is more sensitive to light). The visual experience hardly transpires in one absolute mode or the other, but rather in an ever-varying combination of the two as the retina adapts to changing environmental conditions.

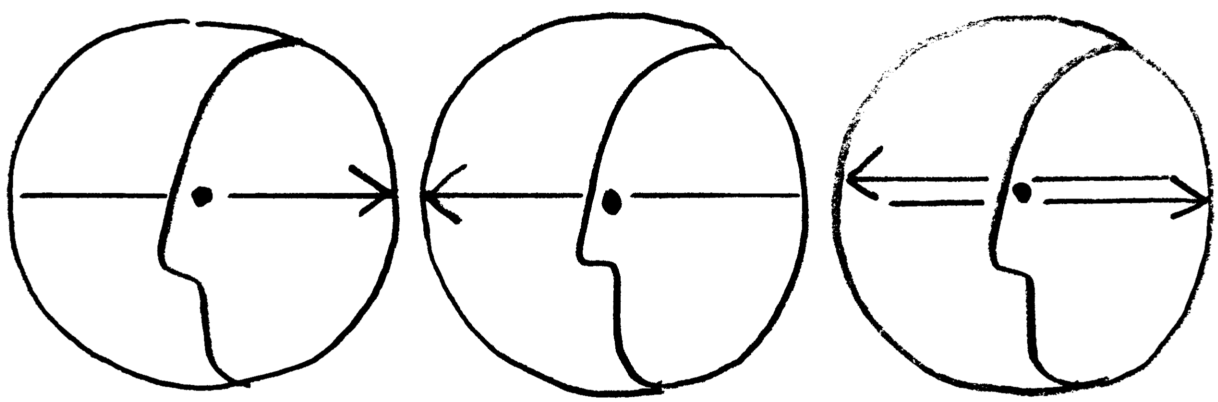
For the eye to adapt to light takes just a few seconds, but full adaptation to the dark can take 30 minutes or more. In dark adaptation, the dilation of the pupil takes one minute; the adaptation of the fovea, ten minutes; and the rods, 30 minutes or more. After one minute of dark adaptation 5 percent of the optimal potential is reached; after ten, 20 percent and after 30, 80 percent. The spectral sensitivity of the dark-adapted eye stretches from 640 mμ to 360 mμ toward the blue end of the spectrum, and it peaks around 510 m , in the blue-green. The light-adapted eye stretches between 720 mμ and 360 mμ toward the red end of the spectrum, and peaks around 570 mμ in the yellow-green.

The different formatting of reality provided by daylight vision versus twilight vision is no doubt a critical factor in light-related behavior. Daytime activities in humans are tied to the light-adapted eye's ability to focus on details and activate the central region of the cortical maps related to the visual experience -- which results in an objectification of reality. Nighttime activities are linked to the dark-adapted eye's peripheral sensitivity and the corresponding peripheral-vision-related cortical maps, where lack of details makes the perception of objects more difficult and facilitates spatial synthesis: Reality is subjectified when night holds sway.

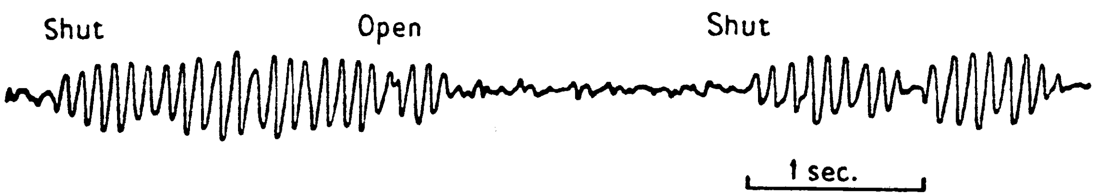
The reticular formation

A debate similar to the modern one surrounding the wave/particle nature of light was carried on among the Greek philosophers, who, attempting to understand vision, argued about whether the "visual fire" emanated from the object seen or from the eye itself. It was the point of view of Pythagoras (530 BC), Euclid (300 BC), and Hipparcus (150 BC), that visual rays darted from the eye to "feel" external objects. Aristotle (384-322 BC) rejected this hypothesis, arguing that if the eye emits the visual rays, why are objects invisible at night? He instead supported the idea, with Leucippus of Miletus that objects emitted miniatures of themselves, some of which would enter the eye and develop within it. An even more interesting idea was supported by Empedocles and Plato: They held that the experience of vision was a result of the adaptation of these two "fires" between themselves. Black would be a result of a visual fire much stronger than an external fire; white, the opposite; and color a result of an equilibrium between the two.

That later theory announces nicely what we are now just beginning to understand about the nervous system: Not only do we now recognize two distinct realities, the objective external one (which we can associate with the Greek's "external fire") and the subjective internal one (which we can associate with the "visual rays"), but we also recognize that an experience is the result of an adaptation between (external) availability of stimulus and (internal) intentions or other mental dispositions. Furthermore, the analogy can be stretched to cover the dynamics of the system, where stronger internal dispositions will allow less external stimulation (black), while darkness will facilitate strong internal dispositions; and inversely, that strong external stimulation will weaken internal intentions (white).



The invention by Berger in 1929 of the electro-encephalogram (EEG), gave new insight into the mechanisms of the brain. This method for recording changes in the brain's electrical activity has shown that the brain is constantly active despite the fact that "consciousness and mind come and go." (1) The changes in brain waves during sleep and wakefulness observed with its help provided evidence for the existence of several pathways and of a central mechanism programed to regulate and channel the energy flow between different centers of the nervous system. Brain wave changes helped show how the nervous system adapts to biorhythm cycles as well as changing conditions in the environment -- or the brain's <u>idea</u> of it.



EEG by Adrian and Matthews, 1934 (from Blackemore, p.51)

More recently it was found that the ascending reticular activating system (ARAS) (also called "reticular formation") -- a tissue that occupies the central core of the brain and connects the peripheral receptors of the nervous system to the cerebral cortex -- plays the role delineated by the brain-wave studies: "Presumably, the reticular formation contains some mechanisms which analyze the sensory inputs, and, should they contain information which may be potentially worthy of consideration, its neurons fire. Signals from the reticular formation neurons thus arrive at the cortex concurrently with the incoming sensory information, alerting the cortex 'to take note of' the sensory information." (2)

(1) Steven Rose, <u>The Conscious Brain</u> (New York: Alfred A. Knopf, 1975), p.205

(2) Rose, p.240

Another segment of the reticular system "functions in such a way that the level of neural activity in the cortex and in the reticular formation serves to regulate the amount of sensory input in the ARAS by blocking incoming impulses from the receptor systems." (3) Inasmuch as it connects to many areas of the cortex and can spread signals to large portions of it, and the fact that it features as well both ascending and descending pathways, the reticular formation possibly is a modulator of sensory input and cortical output and maybe responsible for dispositions such as sleep and wakefulness; attention; arousal; and boredom. To borrow from Julesz (4), the reticular formation would be like some cyclopean eye of the human organism, the point at which the inside and the outside meet. This could be why, despite the fact that we dwell in two worlds -- an external one that exists independently of us and an inner one that we all make for ourselves -- we are generally aware of one single reality which is, following Plato's view, an intercourse of inner and outer realities. (5)

(3) John F. Corso, The Experimental Psychologyof Sensory Behavior (New York: Holt, Rinehart and Winston, 1967), p.588

(4) Bela Julesz, Foundations of the Cyclopean Perception (Chicago: The University of Chicago Press, 1971)

The importance of uncertainty

In his collected papers of 1915, Freud posited the following about the unconscious: "We now assert on the findings of psycho-analysis that a mental act commonly goes through two phases, between which is interposed a kind of testing process (censorship). In the first phase, the mental act is unconscious and belongs to the system Ucs; if upon the scrutiny of the censorship it is rejected, it is not allowed to pass into the second phase; it is then said to be repressed and must remain unconscious. If, however, it passes this scrutiny, it enters upon the second phase and thenceforth belongs to the second system, which we will call Cs. But the fact that it so belongs does not unequivocally determine its relation to consciousness. It is not yet conscious, but it is certainly capable of entering consciousness... In consideration of this capacity to become conscious, we also call the system Cs the preconscious (Pcs)." (1)

(1) Sigmund Freud, "The Unconscious" in <u>The Major Works of Sigmund Freud</u> (Chicago: William Benton, 1952), p.431

The lucidity of Freud's presentation of his revolutionary ideas ensured that they -- and psychoanalysis -- would enjoy a wide influence. However, the last several decades seen a questioning of Freud's ideas, as the notion that crucial mental activities could take place unconsciously came under challenge: "Through the 1950s, these experimental psychologists largely ignored any such entity as 'the mind,' focusing instead on observable behavior. Even in the 1960s when the resurgence of cognitive psychology legitimized the study of how the mind registers information, the unconscious was still slighted outside psychoanalytic circles." (2) More recently, however, as neurobiologists map brain functions of the highest order (Eccles, Popper (1)), something like Freud's notion of the unconscious has been rehabilitated to some extent, in the form of what is now called the "nonconscious." The assumed fact that "figuratively speaking, [the portion of nonconscious cognitive activity] could be 99 percent" (2) -- far more than Freud himself envisioned -- generates a real concern among experimental psychologists, most of whom now tend to take the unconscious seriously. The studies on the subject are showing that the nonconscious mind "may understand and respond to meaning, form emotional responses, and guide most actions, largely independent of conscious awareness." (2)

(1) John C. Eccles, The Understanding of the Brain (New York:

Mc Graw-Hill, 1977), p.193

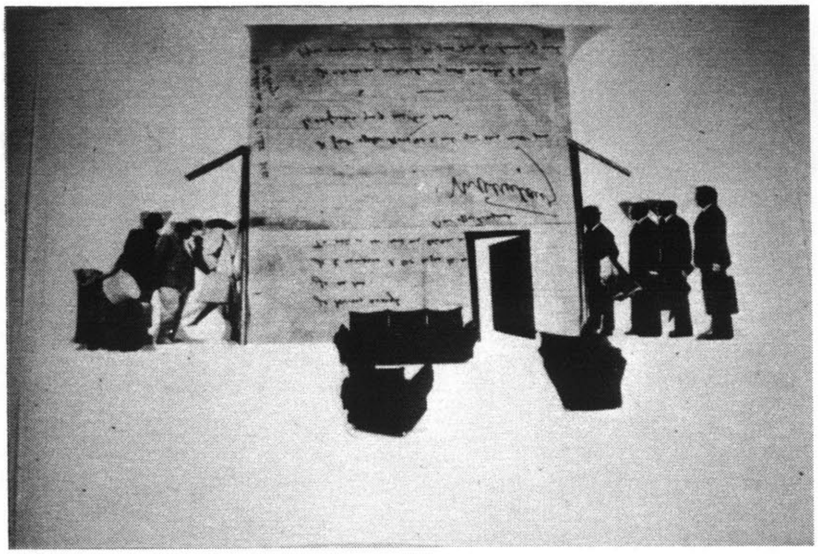
(2) Daniel Goleman, "New Views of Mind Gives Unconscious An Expanded Role" in The New York Times (Feb. 7, 1984), p. C1.

Cow, version 2, by C.F. Nodine.

What interests us here is how a "mental act" or "experience" (in our own terms), passes from the preconscious -- or nonconscious, if that indeed is a better term -- to the conscious: Our view is that it happens because of the level of uncertainty attached to the mental act or experience itself. If we had to consciously experience everything that we need to perform in order to maintain our system "alive and well," we could not breathe and read at the same time (which means, given the necessity of choosing one or the other, that very few of us would read). The truth is we are conscious of very little of what we actually experience even though we may be conscious most of the time. Neils Bohr is reported to have said that the only way the sea eel can find its way back to the same Norwegian fjord after traveling oversea for several months is that it doesn't know how it does it.

Conscious experience, we suggest, is made of what remains unresolved in the experience of wakefulness. The most usual gestures, and even the simpler learning operations, will happen without our necessary being aware of it. A parallel can be drawn with sleep: According to Braunschweig and Fain, the dream remembered in the morning is a sign of the failure of the process by which mental acts are supposed to resolve themselves within the unconscious during sleep (3). If the idea can be extended states of wakefulness, the conscious experience is a sign of the failure of the nonconscious to resolve a situation. The conscious is then a problem solver, one of many brain functions with a particular talent for handling novel situations.

(3) D. Braunschweig, M. Fain, La nuit, le jour (Paris: Presses Universitaires de France, 1975)



Luc Courchesne.
Collage. 1972

Uncertainty, by the necessary choice between alternatives it implies, can be considered as the cutting edge of consciousness. As such, it represent a condition by which the passage from the nonconscious into the conscious is triggered. An unusual situation, once attended to and learned from, is likely to be remembered, and automatically resolved when it reoccurs. The conscious experience of reality, then, has to do with finding information that will reduce uncertainty. In mathematics, information theory proposes that uncertainty and information are measures of each other: "The amount of information is determined by the amount by which the uncertainty is reduced." (4) "Maximum uncertainty," then, "...exist[s] when two alternatives have the same probability of occurence." (5) In this context, maximum uncertainty is likely to correspond also to maximum consciousness, since this is when all the attention that the brain is capable of generating and maintaining will be used. An overwhelming level of uncertainty, however, might require too much of an effort for the resolving power of a given organism at a given time. The notion of inhibition is therefore very important to understanding consciousness.

There is a range between familiarity and unfamiliarity where the conscious experience occurs. The most "comfortable" conscious experience is where discrimination is difficult enough to generate interest but simple enough to be manageable. Therefore, "average uncertainty is an important parameter in learning" (6) and learning capabilities are altered when an experience departs from that average.(7)

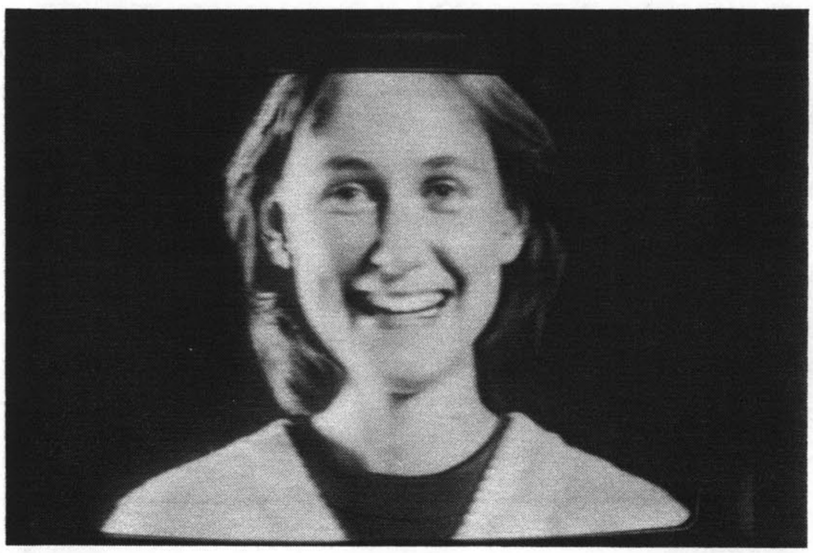
(4) John F. Corso, <u>The Experimental Psychology of Sensory Behavior</u> (New York: Holt, Rinehart and Wilson, 1967), p.466

(5) Corso, p.467

(6) Corso, p.488

(7) The most striking image for humans, from infancy to

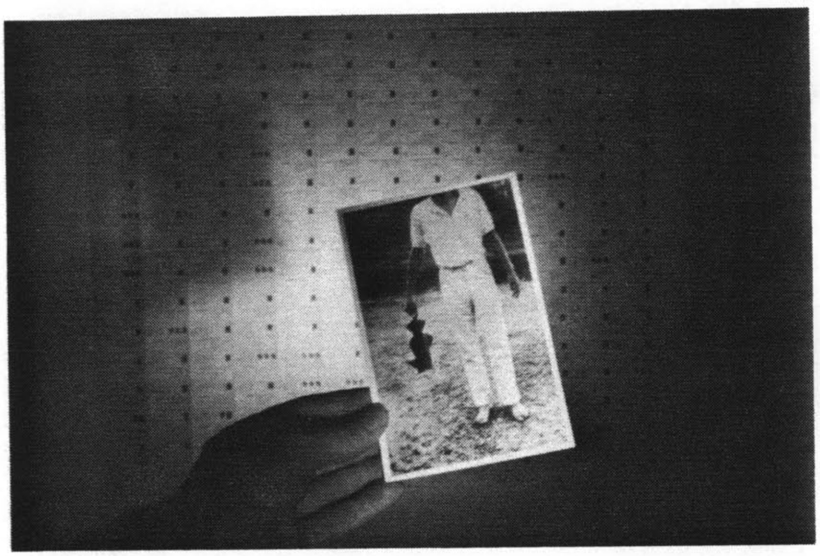
adulthood, is that of a face made in some way ambiguous; the more ambiguous, the more arresting. We are most engaged by a face if we are not sure it represents some thing (human or animal, friend or foe, male or female, happy or sad). Cognitive psychology has told us that we are hard-wired to respond to a human face or face-like configurations. The human face is, then, the source of a wide range of experiences since it always offer enough ambiguity to make us consciously register most of its forms, but at the same time, it is never such a challenge that we can't absolutely make sense of it. Such a situation brings out the necessary components of the dynamics by which a person draws on internal resources until he or she can solve a puzzle and move on to the next thing. (8)



Luc Courchesne. Excerpt from "Twelve of Us", a five minute video tape. 1983

(8) The general topic of this thesis can now be used as another illustration of the dynamics of uncertainty. Since those moments when I first experienced darkness as a remarkable condition of the environment with the power to trigger vivid imagery, the questions it raised kept reappearing under different forms as if, at different steps of maturation, they were needed to trigger necessary growth processes. Such pools of uncertainty may very well remain, in their totality, unresolved; while they assume ever-changing shapes, they are, I maintain, the main spurs to growth in consciousness

In other words, it is proposed here that what makes us conscious of something is the amount of uncertainty attached to it -- and, according to the resolving power of each individual, there is an average level of uncertainty that is optimal for engendering consciousness.

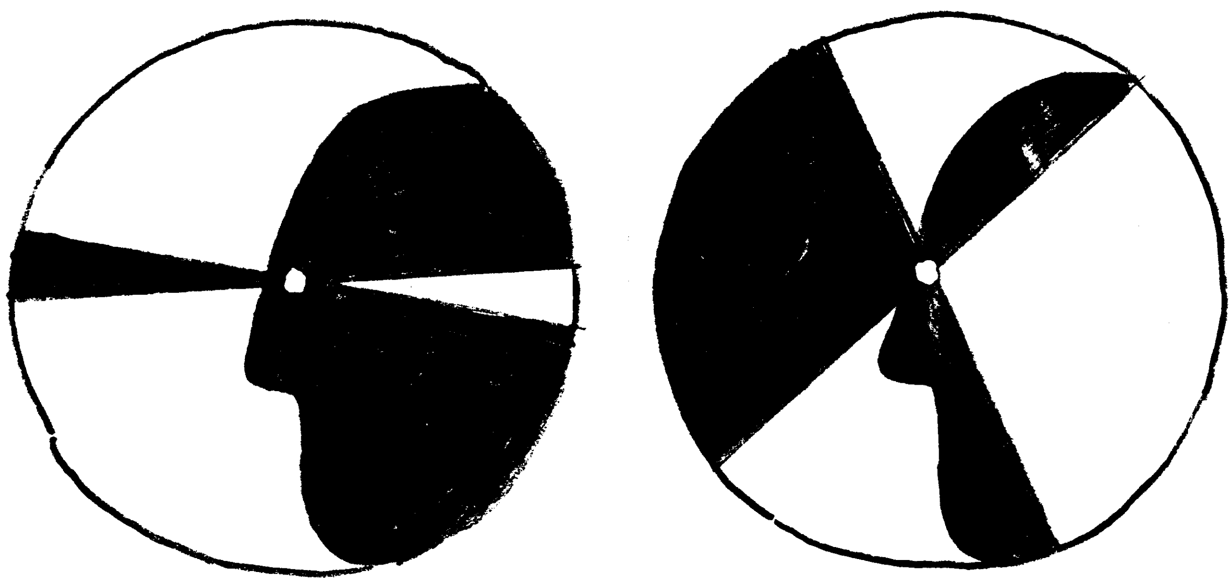


Luc Courchesne. Post card to commemorate my 30th birthday. 1982

For visually specialized organisms like humans, the visual system is a major source of uncertainty. Visual uncertainty originates from two sources: unfamiliar visual stimulation and absence of visual stimulation. Their outflow, however, is not equal. Unfamiliar visual sensation, although omnipresent, is nevertheless easier to resolve because the range of visual experience is limited to a set of given possibilities at the source of visual sensation: The visible domain has a horizon, and visual uncertainty will therefore happen, more than otherwise, within the limits set by the threshold of inhibition. And, in instances of exceptional unfamiliarity, an ambiguous visual experience can always be accounted for by the brain as a physical sensation resulting from light. On the other hand, the absence of visual stimulation due to the lack of light -- that is darkness -- is, for the human cognitive system based on visual evidence, the ultimate wellspring of uncertainty.

Experiments in sensory deprivation, which sparked a lot of interest among scientists in the 1950s and 1960s, revealed that under these environmental conditions, the subjects consistently reported "some form of imaging, usually visual in quality, which ranged from shifts from light to dark, dot of light, and simple geometric patterns to complex visual experience." (9) The findings that, in the absence of a "meaningful environment," the nervous system was creating "daydreaming," "fantasies," "illusions," "hallucinations," "analogies," and "pseudosomatic delusions," -- which revealed a great deal about the subjects' personalities -- implied an independent activity of the cerebral cortex and the action of a mechanism regulating the balance between the cerebral output and the sensory input. This serves as an introduction to the idea that, even in the absolute absence of visual stimulation, the brain, provided it is not overwhelmed by fear, is capable of generating consciousness of some kind. We hope for our part that the exercise of consciousness in such boundless territory as provided by darkness will extend the list of the earlier defined states of the mind.

(9) Corso, p.575



The visible domain is an icon: an image of reality too often mistaken for reality itself. The more that forms are recognized, contours emphasized, and names applied, the more frozen reality becomes, and the less relevant to reality any object so represented becomes. I feel that with the accumulation of things taken for certain, reality has become unpenetrable. "We are full to the gorge with our own names for misery" says the character Nora in Djuna Barnes's Nightwood (12). It then seems necessary, to follow Thomas Browne's example and consider that "all the data of science are visible symbols of an invisible reality", that it exists as a "stenography." (13)

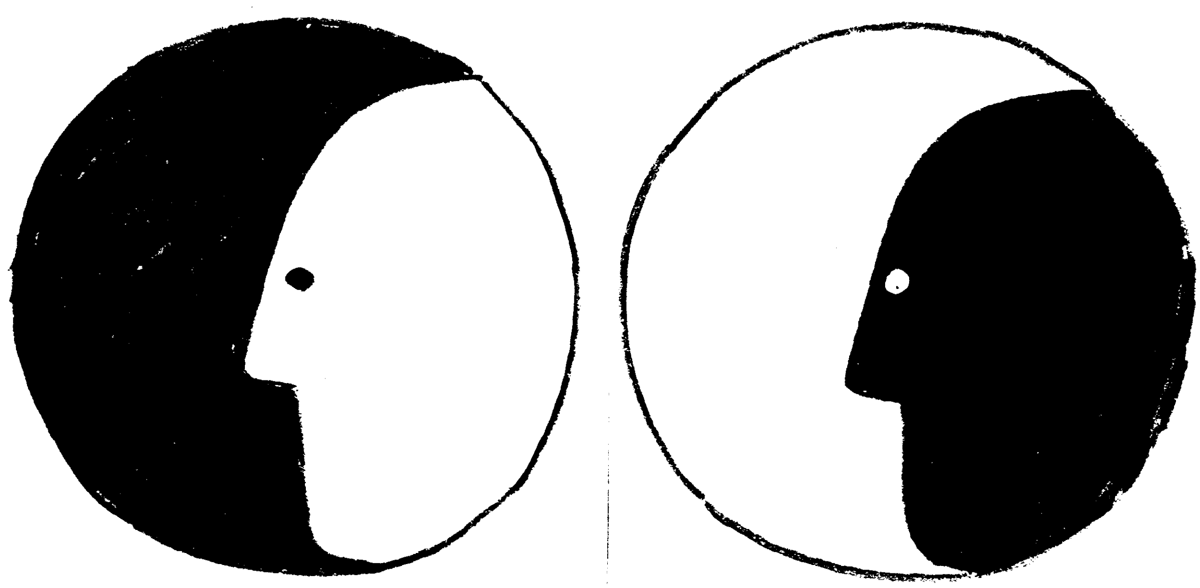
(12) Barnes, p.83

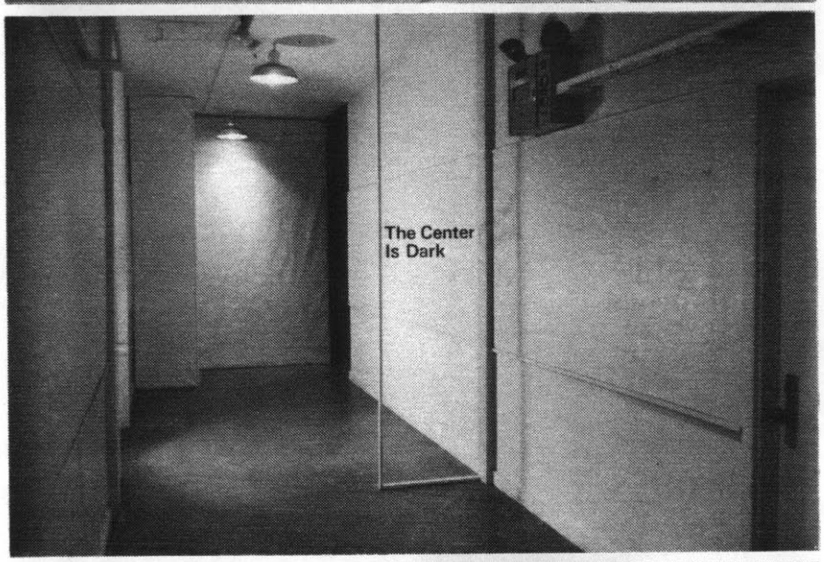
(13) Egon Stephen Merton, Science and Imagination in Sir Thomas Browne (New York: King Crown Press, 1949), p.61

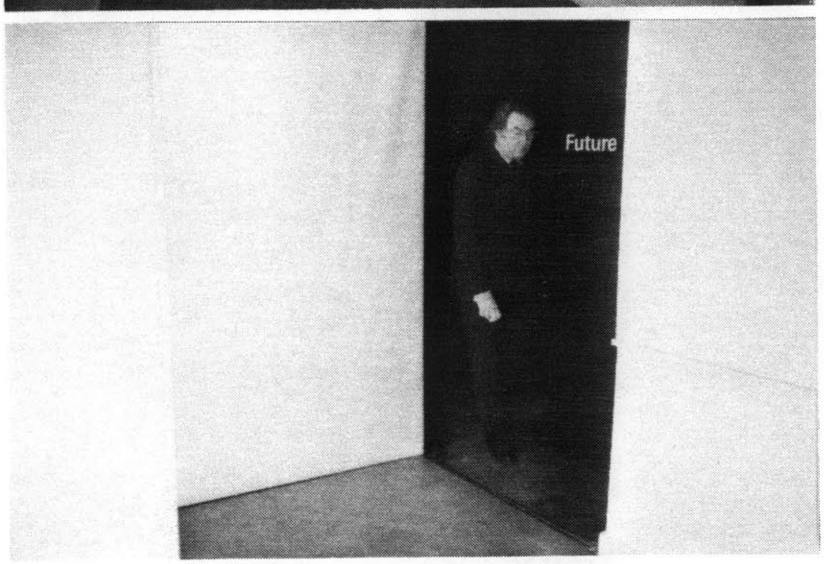
The night is a remarkable environment in that it reduces the impact of the iconographic visible domain, leaving more space for creative thinking. If we now go back to what we proposed earlier -- that the conscious experience can be stretched by uncertainty, and that darkness provides visually discriminatory brains with large supplies of it -- we add that the most important factor in the evaluation of the quality of a given environment is the extent to which what holds its meaning is visible. Furthermore, and by implication, the balance of light and darkness is the first and most effective environmental definer. (15)

(15) Each object is separated from the light and shadow around it because we have learned its significance as an object. But if what concerned us were not its significance but the degree of certainty or of rigidity of reality, then the amounts and dispositions of light and darkness themselves would be the materials in which the conscious experience would take root and grow. It seems important to establish this distincton between what is seen, and how much of it is visible: It is essential to the formulation of a principle by which, if some aspect of reality has to be analyzed, the particular balance of light/darkness or certainty/uncertainty related to it will have to be first established. This distinction is necessary because an object does not retain its meaningful properties as it travels across varying light/darkness equilibria. What happens there is comparable to what happens of an object as we compare two and three dimentional renderings of it: the object is the same but its properties are different. The topological problem of the effects of light and darkness on a given object would itself be a thesis of its own.

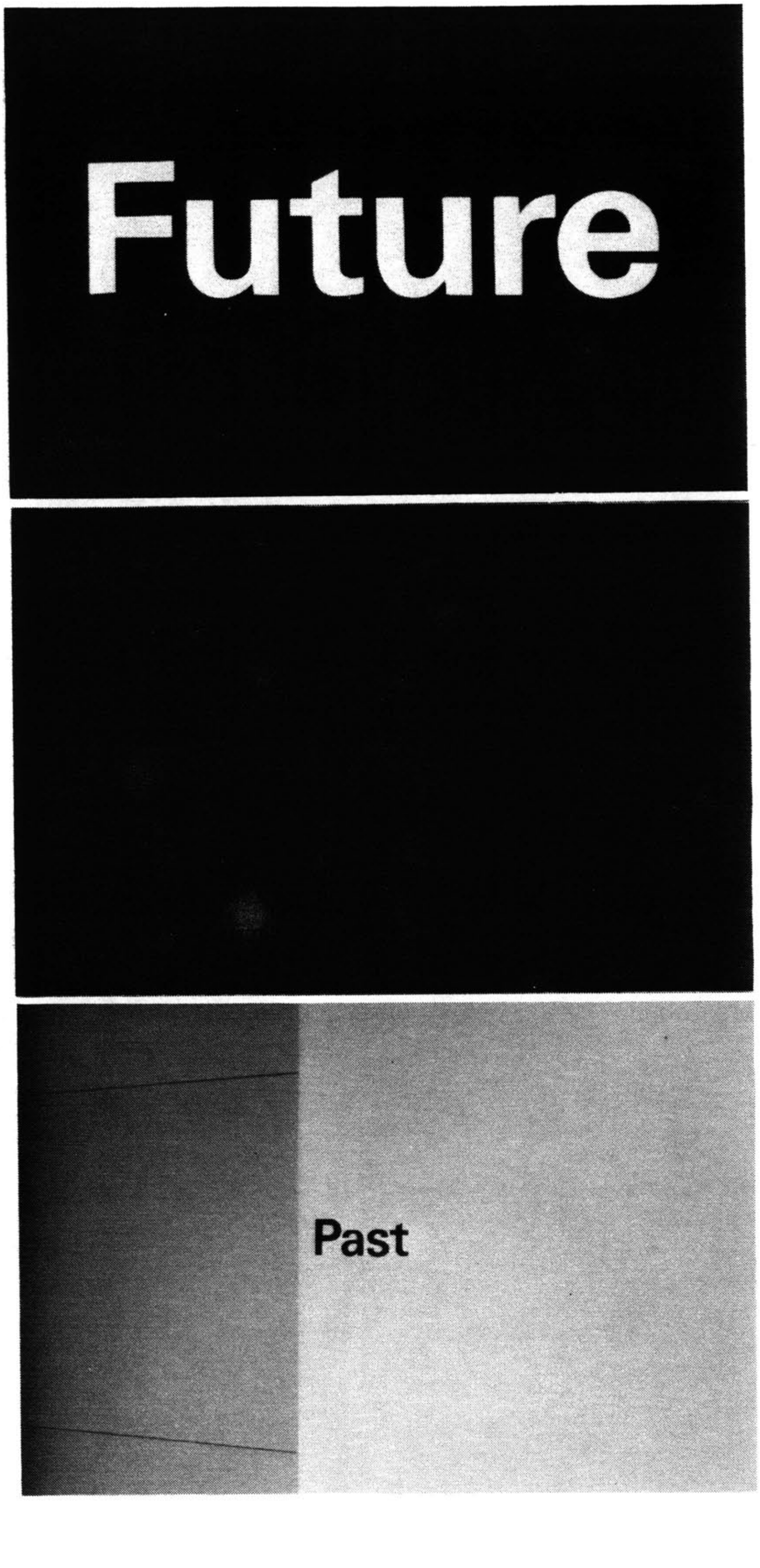
Finally, if we consider that darkness creates uncertainty, which in turn triggers imaginative speculation and revery, and also that light brings out the space in which we are physically active (mostly betwen sunrise and sunset), we could summarise by saying that light stimulates the body and darkness, the mind.





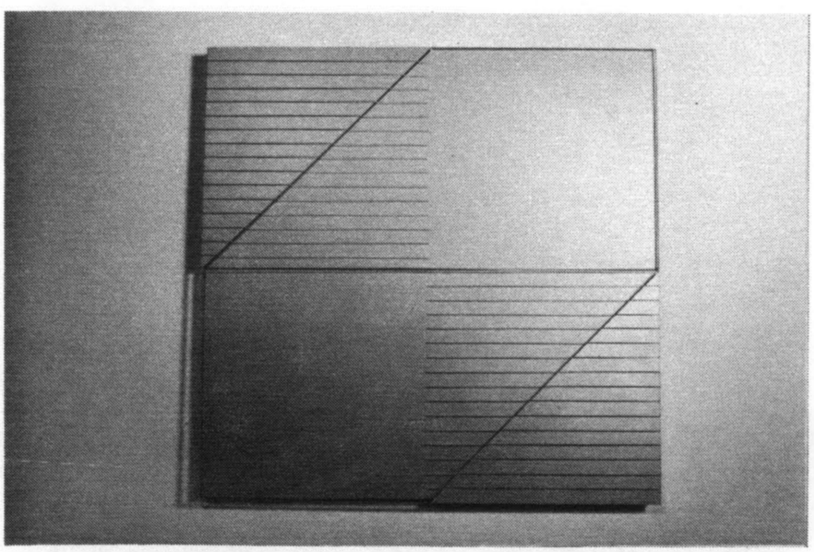


Luc Courchesne. The Center is Dark -- An installation at the Center for Advanced Visual Studies that divided the building into two areas: a totally dark one, and a well lit one; The entrance of the dark was marked with the word "Future", and the entrance of the lit area, with the word "Past". 1982


Future
Past

The dynamics of uncertainty

Uncertainty -- like darkness -- can be interpreted as an environmental condition and therefore, considered in a set of those, it plays a part, and has dynamics of its own. The model presented here is a translation of the previously discussed idea that the external availability of stimuli and the internal modes of the brain activity are interconnected, and their balance, as controlled by the reticular formation of the lower brain stem, constantly adapts to changing internal and external conditions.



Luc Courchesne. The Uncertainty Model -- painted acrylic. 1984

The model attempts to correlate the action of external mechanisms (such as different levels of light intensities and visual stimulations), with internal mechanisms such as wakefulness, attention, arousal, and sleep -- those modes in which the imaginary may occur. It proceeds from the assumption that the most important factor in vision is not the specificity of the thing seen, but the extent to which it is visible. Further, the model reiterates the notion that light stimulates the body; darkness, the mind.

In the "uncertainty model", the grey tone represents experience that is not conscious -- the nonconscious, preconscious, or unconscious, and grey is seen as the tendency of white and black to cancel each other out. White and black are the two poles of conscious experience; they can be associated with functions such as visual potential and mental states, or light (the given) versus darkness (the imaginary), or any other set of opposite values related to visually triggered uncertainty (1). Each of these values is assigned a scale: left for white-corresponding values and right for black-corresponding values.

The scaling is not to suggest that those values absolutely need to be quantified, but rather that they can give a sense of proportions as the manipulation of scalers modify the relations among the different elements of the model. Each scaler is adjusted independently according to the values assigned to it. The space thus defined represents the potential for a given person to experience consciousness, that is identifies an instant between the moment when consciousness is triggered -- by a minimal internal or external condition -- and the moment where it is inhibited -- by an unmanageable set of internal or external conditions. Finally, the model's sliding horizontal marker is also independently set, according to internal or external measurable conditions; it represents a given moment of conscious experience, a particular slice of the overal potential.

(1) In the Pythagorean circle, around the 6th century B.C., "every thinker wrestled with the problem of opposites and how they functioned. It was obvious that in our universe... pairs of contraries were ranged either in balance with one another, or in hostile opposition with one another, or as following one another in cyclical succession... Our universe being a living one, its life was conceived as characterized by change, but change after an order or pattern in which contrary forces by their interaction produced all the variety of the visible world....They were thought of [the identified forces] as attracting their likes and interacting with their opposites." (2) The Pythagoreans established ten pairs of opposites which accounted, they believed, for everything they could observe:

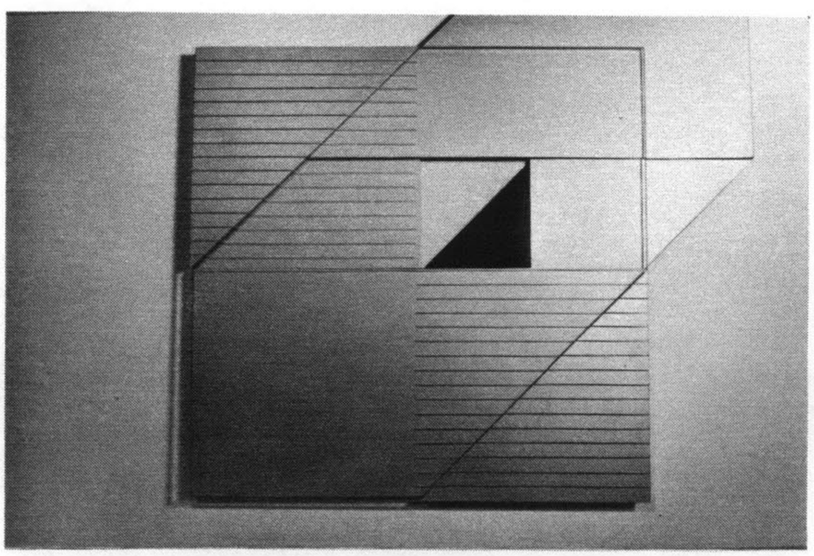
Light	Darkness
Limited	Unlimited
Odd	Even
Unity	Plurality
Right	Left
Male	Female
At rest	In motion

Straight	Curved
Good	Evil
Square	Oblong

Another perspective, developed much later in Masonic theosophical circles, saw an "inevitable duality which finds concrete expression in countless pairs of opposites, such as day and night, fire and water, man and woman." (3) They couched the idea of trinity in terms that identified it as a byproduct of a play of opposites: "In every duality, a third is latent;...for each sex so to speak is in process of becomming the other, and this alternation engenders and is accomplished by means of a third term or neuter, which is like neither of the original two but partakes in the nature of them both." (3) Twilight comes between day and night; and color, between light and darkness.

(2) J. A. Philip, Pythagoras and Early Pythagoreanism (Toronto: University of Toronto Press, 1966) p. 45

(3) Claude Bragdon, The Beautiful Necessity (New York: Alfred A. Knopf, 1922) p.43



Enlarging the potential to see.

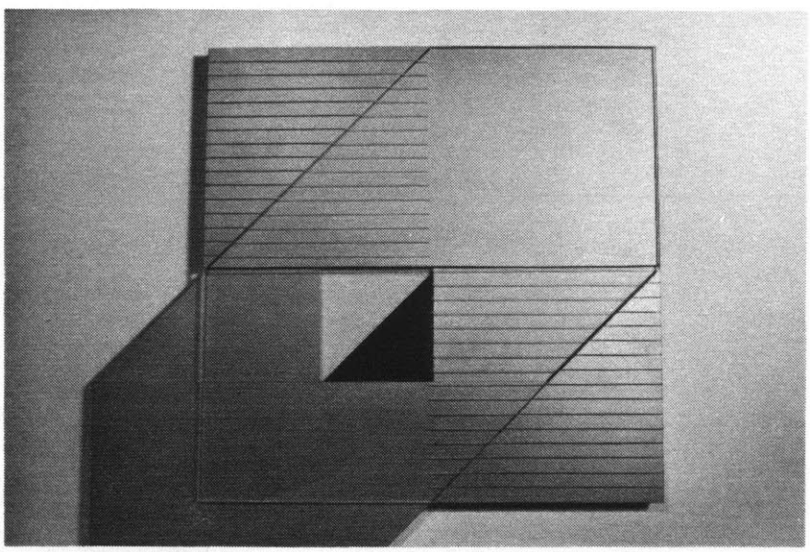
Six months after birth, a child's visual system is already as capable as it will ever be. (4) It will nevertheless take much longer for someone to learn what to make of this source of information about the external reality; in some ways, learning to see is the project of a lifetime.

The visual specialization of the human organism has so far implied, at least in the case of most occidental societies, a privileging of the visual mode in the development of a field of consciousness. Although ultimately limited in its capabilities to appreciate reality, the visual sense has not only become the essential channel by which the brain accesses the environment, it has also assumed a hegemonic hold on every thing that the brain is thought to be capable of conceiving.

In order to provide visual evidence, modern societies have developed increasingly sophisticated visualizing tools to the point where progress and the capacity to produce yet ever newer kinds of images seem inextricably linked. An example is the television set, which has already become our pervasive window on reality, and will only come increasingly to dominate our views of the world, to the point where perhaps it will choke any competing views. It seems as if what cannot fit in its unblinking lighted stare will not exist.

(4) Tracing the steps by which a signal is processed as it travels through the visual and cognitive system, we can observe a growing order of complexity of the image presented to the eye:

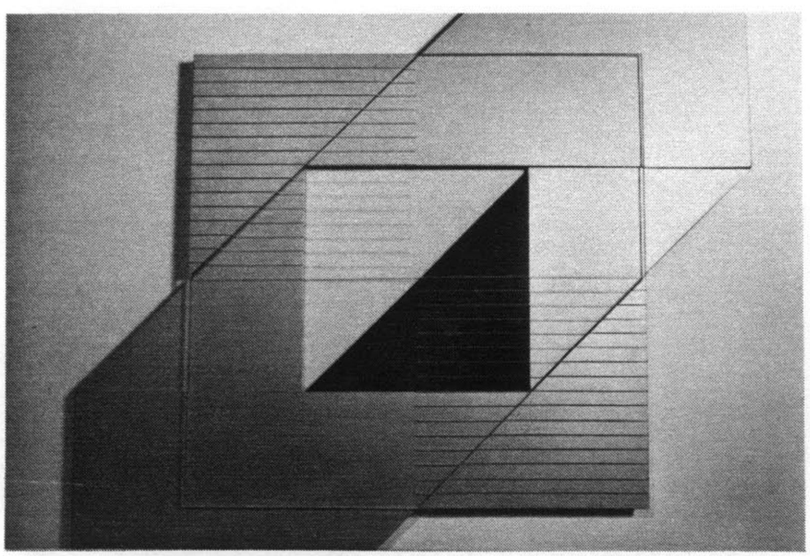
1. Light (brightness)
2. Texture (contrast)
3. Object (edge)
4. Space (stereopsis)
5. Ensemble (higher cortical analysis)
6. Dynamics (memory)



Enlarging the potential to imagine

The development of humanity appears to rest on the development of consciousness. If it proves true that the source of enhanced consciousness in the world we see is drying out, we still have the world we can imagine from which to draw material on which our consciousness can work.

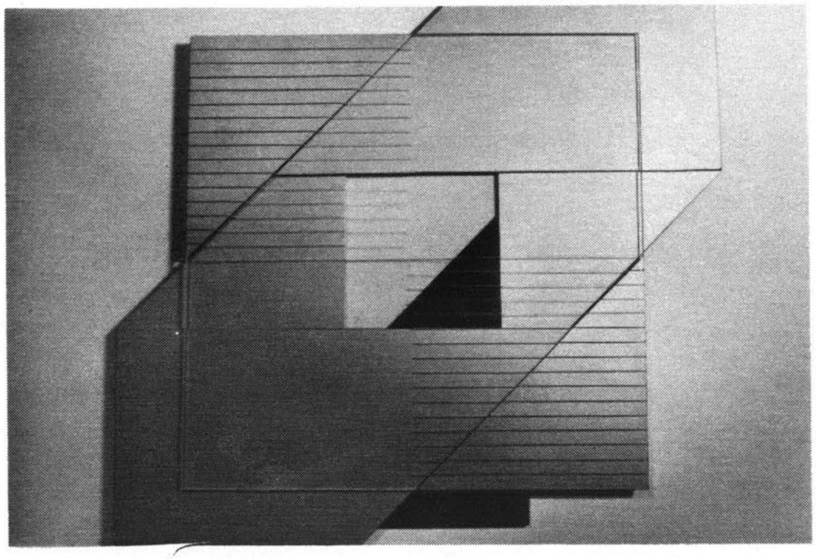
This world differs from the visible world in that it originates from the inside. In one instance we seek, perceive, and grow accustomed to increasingly complex sensory stimulation, pushing further our limits of perceptual inhibition; in the other, we become accustomed to registering internal impulses until, at the edge of boredom, wakefulness is dissolved. Needless to say, in the context of our society, the threshold for boredom is rather low, and the option of darkness and silence as sources of conscious experiences have therefore largely been disregarded.



Nesting fields of consciousness.

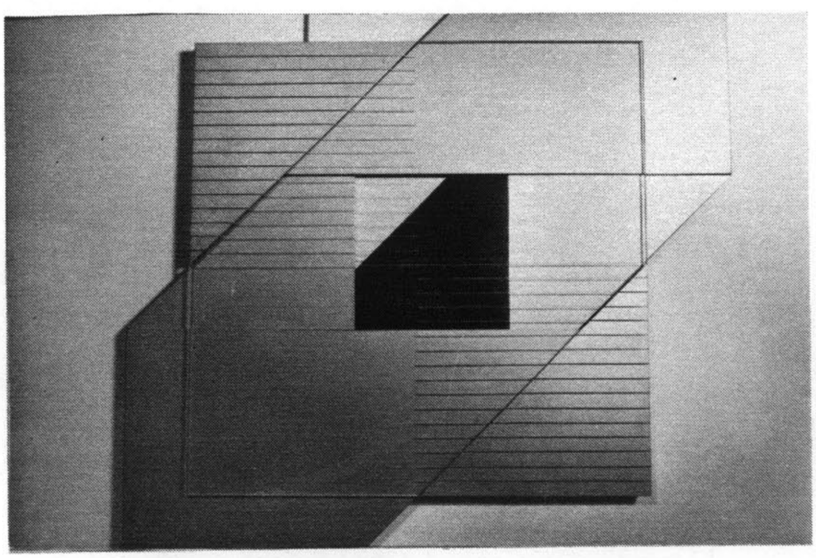
Let us consider the theoretical case of two individuals.

One has developed in a context that favored introspection, and the other, has consistently experienced situations favoring extraspection. The introspective individual sees the environment as external evidence for his or her internal dispositions, therefore conforming the outside to the inside -- or, put another way, projecting the inside outside. The extraverted individual, in contrast, tends to recognize evidence originating primarily outside, and therefore conforms the inside on the outside -- or, to put it in another way, hosts external re ality within. This illustrates the possible tendencies at the origin of the nesting of fields of consciousness for given individuals or groups. A consequence of that is different individual react differently to identical environmental conditions. The threshold of sensory inhibition, for example, will be lower for the introspective type and higher for the extraverted. In one case an expanding inner world will clash with an imposing environment, and in the other, an absorbent inner world will collapse in the absence of exterior determinisms. We should remember however that in reality, fields of sensitivity are dynamic values, and that, in the best of cases, their path will oscillate between these extremes.

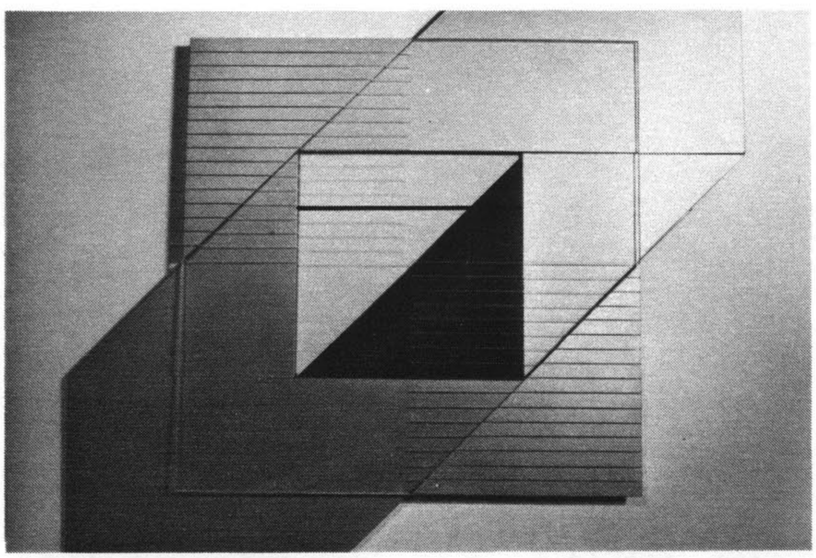


Adjusting to changing contextual conditions

A good reason to try to develop the largest field of consciousness possible is to prevent the destabilizing effects of sudden shifts of the general background in which any experience occurs: The wider the field, the fewer unsettling effects will be felt.

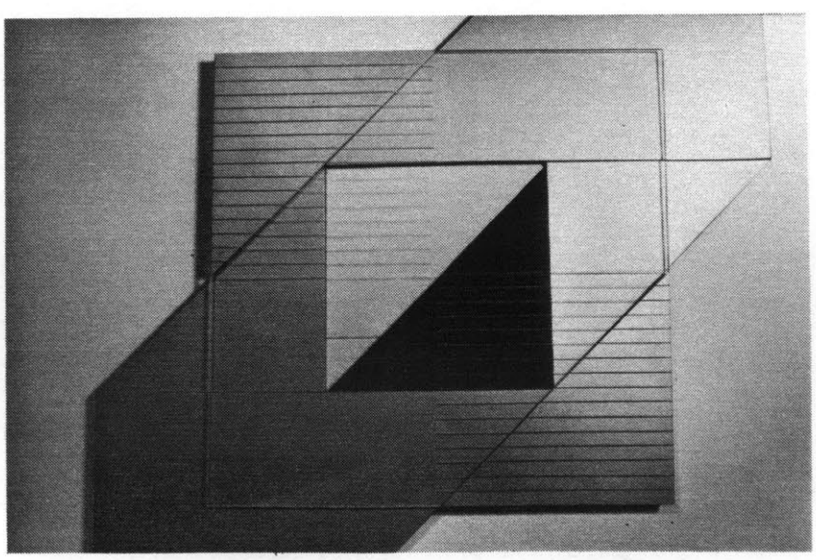


This accounts for the constant effort to adjust that living organisms must make in order to survive. A shift of the general background toward the white (over-exposure) can be corrected by removing oneself from excessive stimulation; and an imbalance toward the black (under-exposure); by opening oneself further. In the course of a day, adjustments of that sort are made constantly and automatically. The eye itself is a little machine for making such adjustments.



Moments of consciousness.

The field of consciousness described serves as a context for moments of consciousness, to which we will now turn our attention. A field of consciousness exists as a range of possibilities within which a conscious experience can occur, provided that the proper conditions prevail. For example, if white represents light and the given, and black represents darkness and the imaginary, the conditions at the top of the scale would favor a conscious experience based on great receptivity to the outside, and little sensitivity toward the inside; at the bottom of the scale, we will have the opposite: little external sensitivity and great insight. This is to suggest that the external and internal contributions to the experience of consciousness are inversely proportional. If light -- or its absence -- is the most powerful environmental definer, while the imaginary, is the most significant result of the experience of consciousness, then imaginary activity is inversely proportional to the amount of light. Furthermore, if uncertainty is what triggers the experience of consciousness, the lower end of the scale will be the privileged domain of imagination.

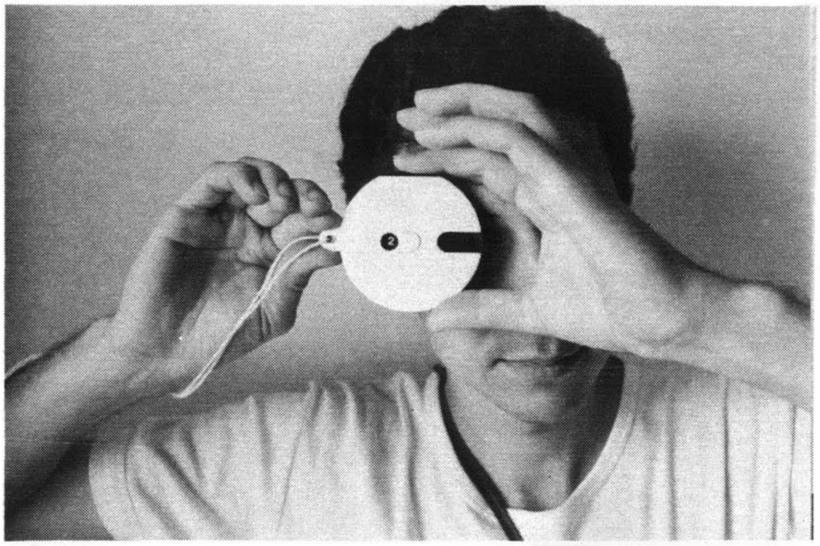


The measure of uncertainty

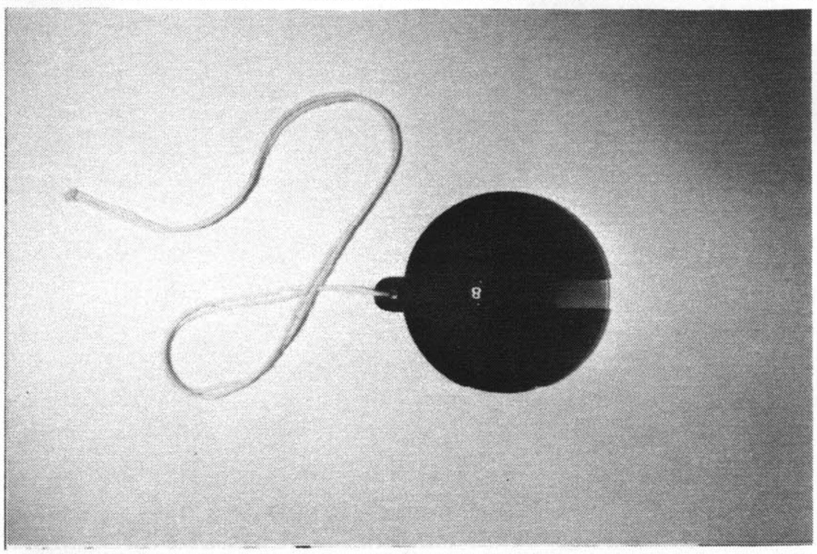
In a chapter titled "Meaning and Visibility" in his 1944 book Light, Vision and Seeing, Matthew Luckiesh presents the "Visibility Meter" he developed with Frank Moss. As he writes, "all things that are visible are not equally visible," and "defining visibility using brightness-contrast as the primary variable" proves useful to find the proper level of illumination for specific tasks that the "human seeing machine" must perform (1). Luckiesh's mechanistic views seem rather obsolete today; nevertheless, his visibility meter is of considerable interest to us.

(1) Matthew Luckiesh, Light, Vision and Seeing (New York: D. Van Nostrand Co., 1944) p.177

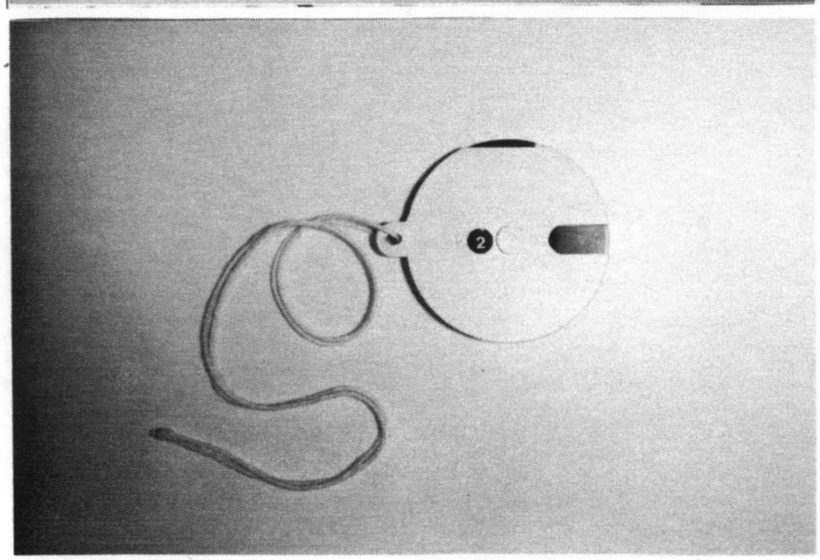
The "Uncertainty Meter" presented here is an adaptation of the Luckiesh-Moss idea. Like the Visibility Meter, it establishes the visual treshold of a given environment -- but differs in that it derives a measure for uncertainty from it. Put another way, it determines the moment when it is no longer possible to resolve visually what needs to be intelligible. The Uncertainty Meter will prove practical in field-work for instant evaluation of a given



Luc Courchesne. The Uncertainty Meter -- painted acrylic. 1984



Side one: uncertainty dial



Side two: certainty dial

environment, extracting the percentage of uncertainty from which the proportional afferent/efferent activity (perception/expression) is established. This instrument complements the model presented earlier inasmuch as it provides the measure from which the horizontal marker (defining the moment of consciousness) can be set and further analysis conducted.

Using it is simple: Look in the Uncertainty Meter and adjust the filter by turning just until what you are looking at fades from view. The meter has two faces, each of which displays numbers from one to nine (which can be read as ten to ninety percent.) Read on the black scale the percentage of uncertainty, or on the white scale, the percentage of certainty; they should add up to 100 percent.

The art of darkening

The science of photometry arose with the invention and deployment of electric lighting from the late 19th century onward: The unprecedented availability of artificial light called for some rationale in its use. By the second half of the 19th century, a "fear of dark space, of a screen of obscurity obstructing the clear visibility of things, of people and of truth" (1) was prevalent and photometry would consequently profess that light should be everywhere and that there can hardly be too much of it. In the "Edison Era," photometry was the reserved domain of of engineers and lighting manufacturers, committed by and large to raising the required illumination level as cheaper and brighter light sources were developed.

The incandescent light bulb, especially after its decisive improvement around 1910 -- dramatically redefined the universal interior lighting standard. The mercury-vapor lamp in 1932 succeeded gaslight as the new standard for exterior lighting; it furthermore established that floodlighting buildings at night would come to be considered a near necessity. The invention of fluorescent light in 1940 provoked daringly high new levels of illumination as it provided interiors with much more light at much lower cost.

(1) Michel Foucault, Discipline and Punish (New York: Pantheon Books, 1978)

The "post-Edison Era" arrived along with the realization that there might be a point where increasing light intensity will no longer boost productivity and that higher levels of light might prove to be uncomfortable. In the 1950s, architects and interior designers began to think that one should evaluate a lighting design by looking at the results, rather than "going by the book" for the proper levels of illumination. "The exuberance of the quantitative approach" in the design of the luminous environment "has come to be tempered by an increasing interest in the ways in which the expert deployment of lighting can genuinely enhance a building" (2). These were the first signs of a dramatic turnabout in the field of lighting design, whereby value judgments and a humanistic approach were opposed to the prevailing mechanistic approach. Nevertheless, it took until the late 60s, and the Skidmore Conference on the Luminous Environment (3) -- and later the oil embargo in 1973 which caused a shift in emphasis to saving energy-- (5) for the general recall of official guidelines concerning lighting design. The new rules required engineers to save energy and architects to take responsibility for "quality."

(2) Peter Jay, "Seeing Light" in The Architectural Journal (Information Library, 4 January, 1967)

(3) Conference at Skidmore College, titled "The Luminous Environment," Saratoga Springs, N.Y., July 1967. Participants deemphasized quantitative measures like foot-candles, brightness ratios, scisor curves, and other mechanistic measurements, in favor of factors related to humanistically based elements of perception. "Everyone [including architects] agreed that in current practice, the architect does not become sufficiently involved with decisions on lighting design. The consensus of the conference was that the architect has the right general background for this responsibility and that [s]he must become more involved." (4)

(4) Massachusetts Institute of Technology, An Approach to the Design of the Luminous Environment (Albany, N.Y.: State University Construction Fund, 1967) p.126

(5) Federal Energy Administration, Lighting and Thermal Operations (Washington, D.C.: U.S. Government Printing Office, 1974)

Following the Skidmore conference, those interested in changing the rules in lighting design tried to establish that lower levels of illumination did not affect visual performance. According to a visibility chart (6) that scaled light from 0 to 10,000 foot-lamberts, 82 percent of the maximum possible visibility is obtained at 10 foot-lamberts, implying that from 0 to 10, visibility increases by 82 percent, and that from 10 to 10,000, it increases by 18 percent. It was further suggested that anywhere along the scale, increments in size and contrast will do more to enhance visibility than would significantly increasing light. For example, reducing the viewing distance by 1/4 will equal multiplying light by 100. It will even be more fruitful to increase contrast. Therefore, "above very minimum illumination levels, the geometry of light sources and objects viewed is far more important than light quantity. To increase visibility by brute strength (foot-candles) rather than skill (geometry) is wasteful and likely to produce bad [a] bad side effect in the form of glare." (7)

(6) Massachusetts Institute of Technology, p.42

(7) Massachusetts Institute of Technology, p.53

Yet another dimension, psychological this time, is being added to the process of defining a new approach to lighting. In one of the rare studies on the subject my research turned up, it is suggested that "some lighting [arrangements] convey meaning such as interrogation, task performance, meditation, reverence, and mysticism" (8). Such results are unexpected, coming from experiments conducted at General Electric. This shows how some of the most conservative groups have become sensitive to the issues around the definition of a new photometry. The findings quoted however, from the point of view expressed in the present thesis, represent an understatement: We have argued that cognition in humans is highly dependent on the visual process and maintained that any variation in light deeply affects physical as well as mental behavior. Lighting is, therefore, the most important factor in any environmental design and the one to which all others should be subordinate.

(8) Martyniuk, Flynn, Spencer, and Hendrick, "Effects of Environmental Lighting on Impression and Behavior" in Architectural Psychology, Proceedings of the Lund Conference (Lund: Student Litteratur ab, 1973)

Further, we would suggest that the recent humanistic approach to lighting design that has sprung up along with the growing idea that lighting does affect behavior remain s inadequate until it takes up the question of the role of darkness as a significant part of the environmental vocabulary. Indeed, visibility should not be the sole lighting strategy, but rather designers should aim at an appropriate balance between what is visible and what is present but not visible. As someone once remarked, a very large proportion of all the lighting design is the work of non professionals: those who have to live with it. We should then be edified to note that the "dimmer" is an increasingly popular item in hardware stores: This shows that there is a growing concern in the general public for the control of light levels and a new sensitivity for how things look. It might be the recognition of this that has led some supermarket managers to reconsider their store's lighting strategies. As recently noted in a radio report (9), lighting designers from Hollywood were asked by a major supermarket chain to participate in the design of upgraded stores. As a result, a much darker environment with highly directional lighting on the offered goods was implemented. On testing, it was concluded, the reporter said, that the shadow sells.

(9) WBUR, Boston, one Saturday morning in May 1984.

The notion that light is a language is fortified when the direct relationship between environmental conditions and mental states is recognized. Darkness, too, is a language and its vocabulary and syntax should be known and used more competently by those involved in design problems related to visibility.

D is for darkness

The gaze we cast on reality is not "naive or innocent" says Wartowsky, a philosopher interested in the history of human vision, which he considers an artifact: "Every visual system is an interpreter of nature to the organism which evolved it." (1) Vision, then, is highly interested -- and the study of what is looked at would reveal much about the mind. The mind, it seems, is paddling through the light that bathes the visible world, in search of the best opportunities to evolve. Science now generally assumes that the acquisition of binocular vision at one moment in the evolution of our species "undoubtedly contributed to the increasing of cranial capacity -- culminating in Homo Sapien's brain." (2) This further affirms the link between the capacity -- the resolving power -- of the mind and what it is looking at.

If we dared to predict what might be the basis of the next evolutionary leap, we might speculate that the mind will try to look beyond the visible -- or that its attention might be snag by the invisible -- thus freeing itself from the visual framework for its operations. Furthermore, the attenuation of the fear of darkness (or of the unknown), might transform our current notion of light and darkness into an obsolete relic of a fossilized mode of consciousness. Perhaps our accustomed conception of light and darkness will eventually give way, as has the formerly held notion of ether: The existence of ether was a necessary support for most models of reality until Einstein proposed that, inasmuch as it had eluded all attempts at detection, it may simply not exist. Ether -- ever since Aristotle postulated its existence -- had been the medium in which, it was believed, reality was suspended. In a similar way, perhaps, light is the necessary milieu for the models of reality as conceived by post-Promethean mortals, whose heirs we are.

(1) Marx W. Wartowsky, "Sight, Symbol and Society, Toward a History of Visual Perception," in Annual Proceedings of the Center for Philosophic Exchange (Summer 1981, Vol.3, No.2) p.36

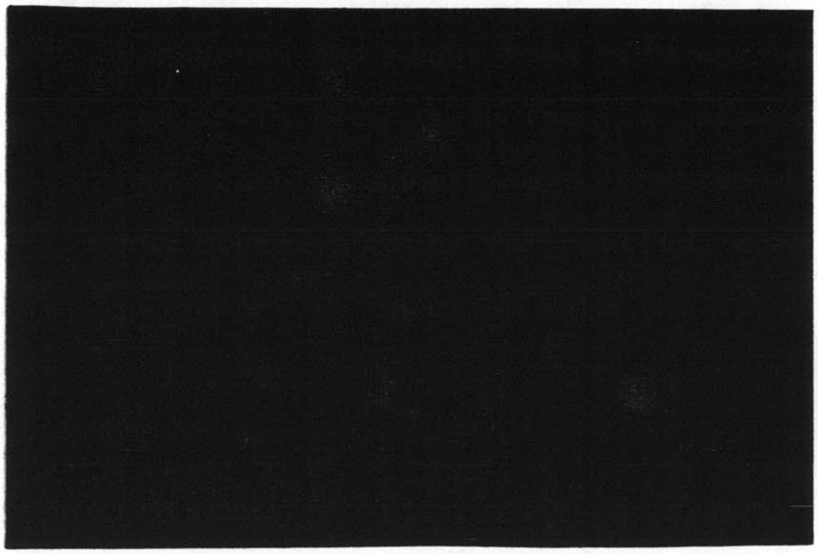
(2) Chaisson, p.30

In Greek mythology, Prometheus is severely chastised for helping the human race by making available to mortals the fire he had stolen from the gods: "For I am he who sought the stolen fount of fire, stored in a stalk, which proved to be the teacher of all kind of crafts to mortals and their great resources." (3) More recently, the founders of modern science took a Promethean stand in what is remembered as the Age of Enlightment. Thomas Browne, a contemporary of Thomas Hobbes, (associated with the philosophy of materialism), Rene Descartes (dualism), and the Cambridge Platonists (idealism) have all foreseen the danger of the iconization of reality, at a time when visual evidence was getting stronger, and suggested that (as paraphrased by Egan Merton) "all data of science are visible symbols of an invisible reality." Of Browne, Merton continues, "the great impulse animating all his scientific research is the desire to interpret this 'stenography' of the world." (4) Associating knowledge with both light and darkness, Browne states beautifully the need to look in the shadow of science for the essence of reality, and formulates an updated hermeticism -- for which truth lay in whatever remains hidden.

There now appears to be a converging of disciplines toward an interest similar to Browne's: Science has learned to recognize that it cannot look at something without transforming it, thereby finding "uses" for uncertainty; cognitive psychology finds in ambiguity a motor for learning; and in the arts where some -- like James Turrell or Marguerite Duras -- have come to model darkness, we begin to learn the value of the invisible.

(3) "Prometheus Bound" as told by Aeschylus, from Grant, p.200

(4) Merton, p.61



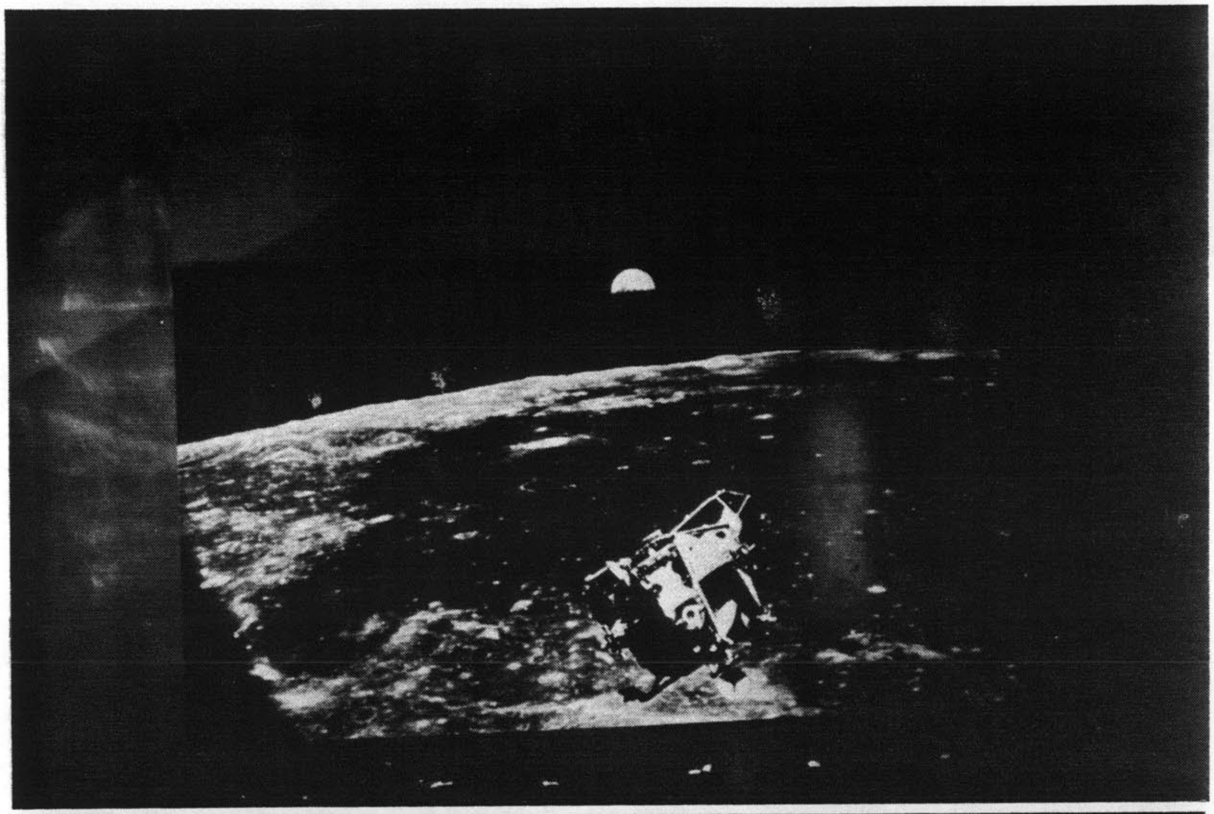
D is for darkness

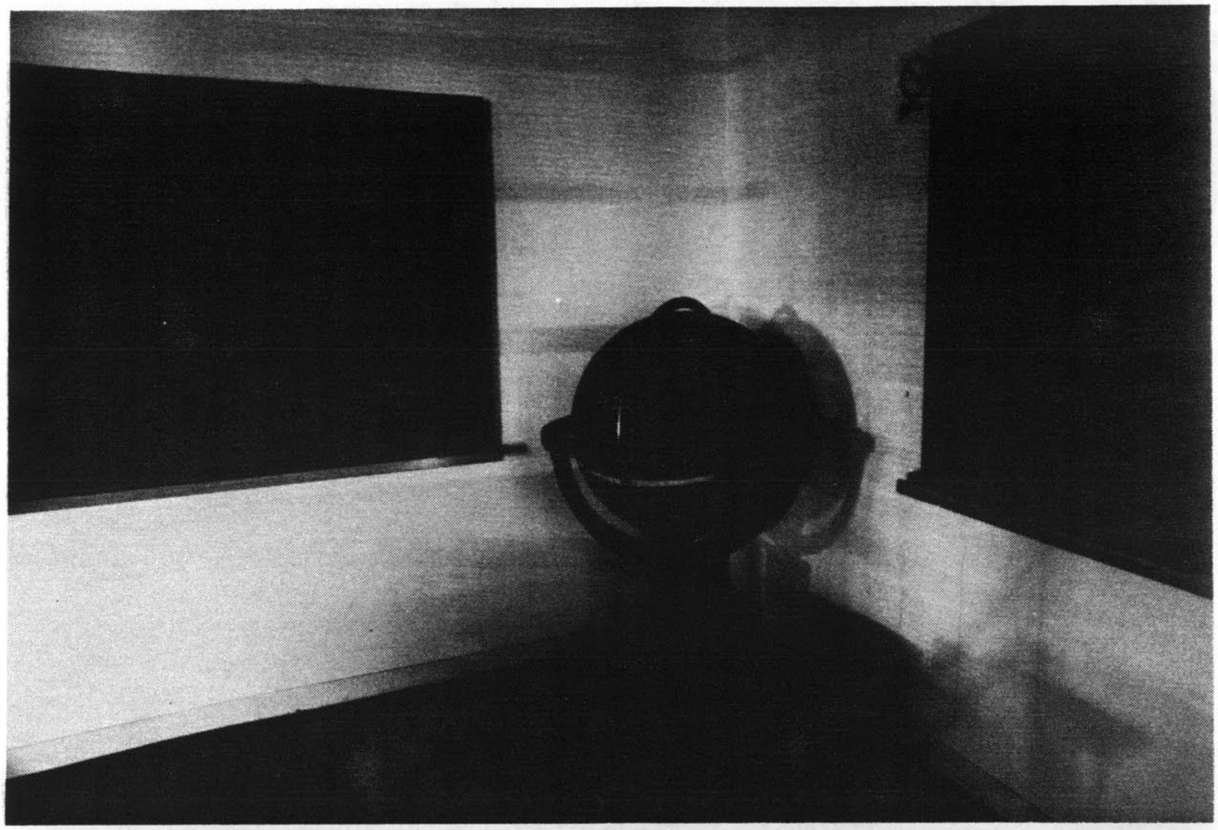
It now seems to us that there are only two general perspectives on reality: the past and the future. The past is light -- everything we see -- and the future is darkness -- what is not yet visible. We have seen how light-biased we tend to be, how we only have eyes for light. We suggest it is now time to develop an "eye" for darkness. The night is a rich and beautifull source of the invisible. It is fragile because of its inherent uncertainty; something to challenge a visible world which has become an icon for reality; something that challenges us to pry it open and make the future possible. Overnight anything will happen.

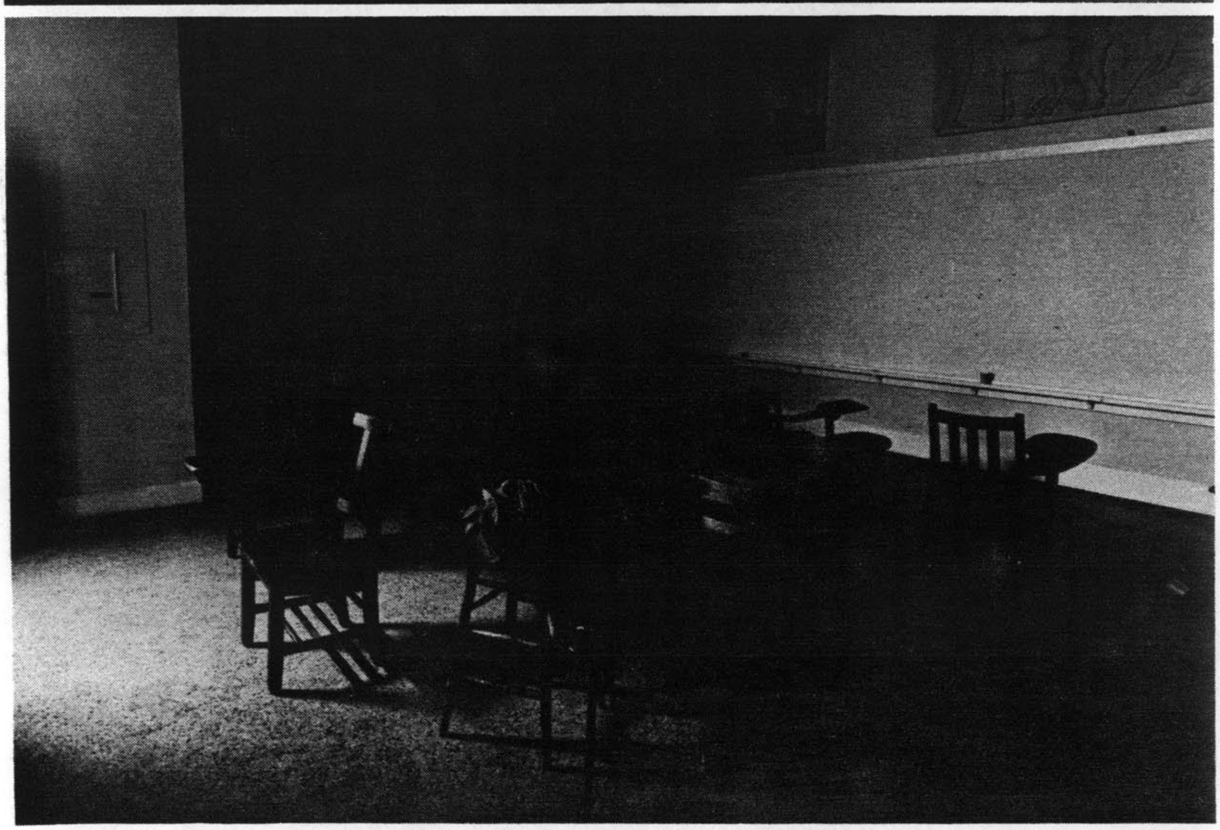
As impassable as once appeared the oceans of an earth believed to be flat, the dark void beyond the doctor's "dark door" in Djuna Barnes's <u>Nightwood</u> (5) seems to us today. There we stand, "at the edge of the Copernican world" (6) waiting for the invention of a rudder that can steer through darkness.

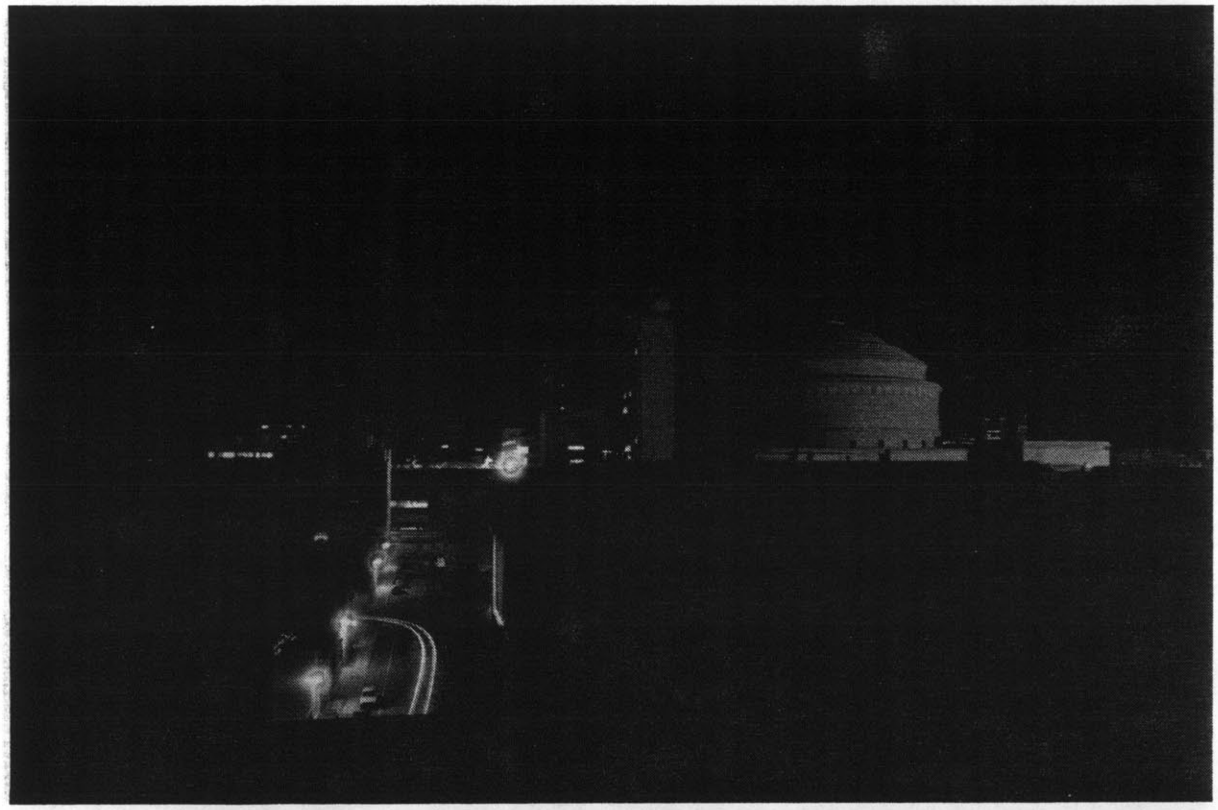
(6) Barnes, p.--

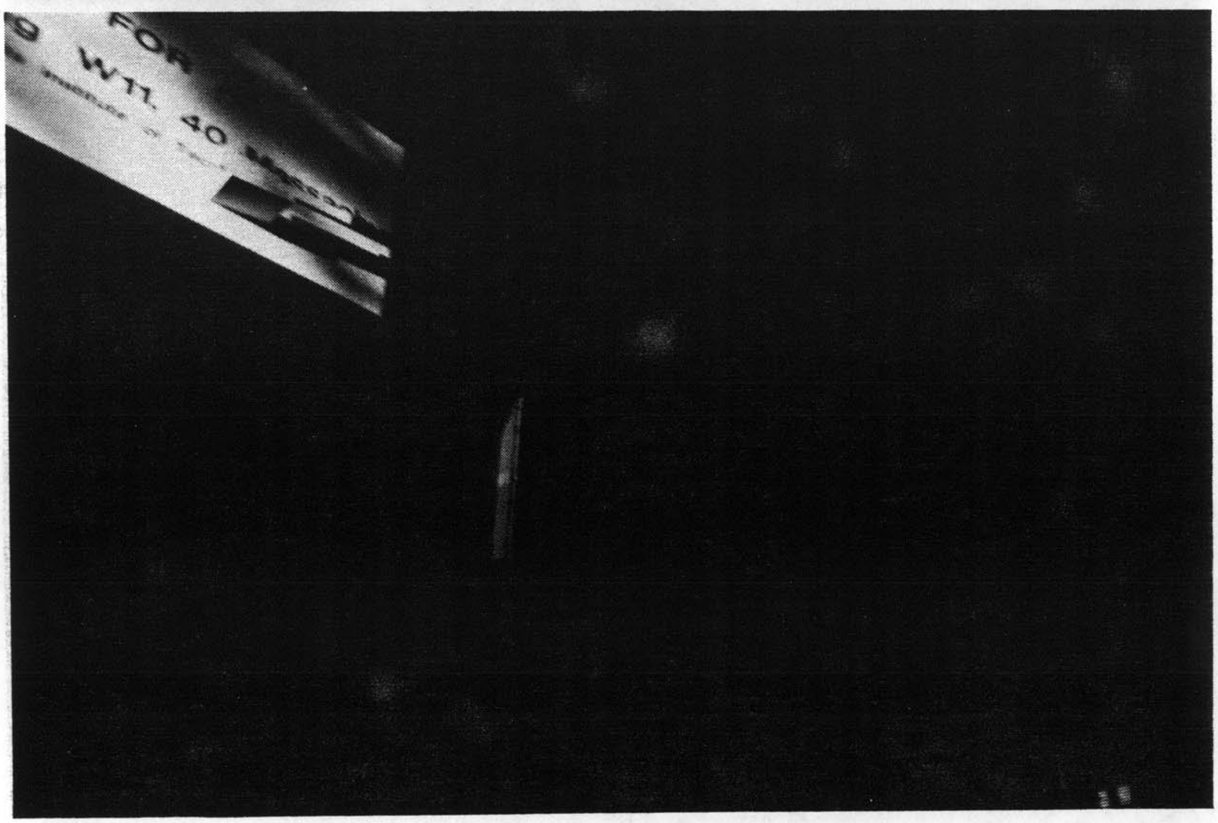
(7) This is how Philip Morisson, in a talk he gave recently at M.I.T., described the position of science, as new matter is being discovered.










FOR
W11, 40

Luc Courchesne.
M.I.T. Is Dark
-- a picture essay
on the Massachusetts
Institute of
Technology at night.
1984

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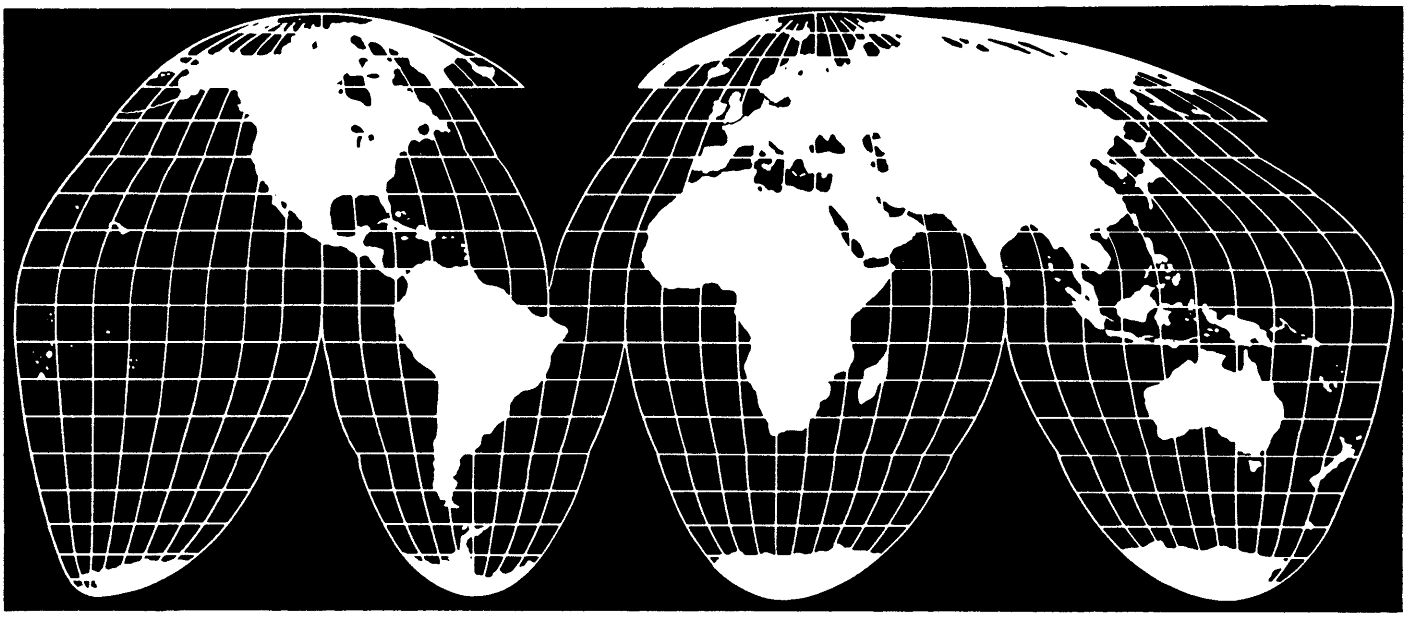
Appendix A

Hours of darkness on the
21st day of each month between
latitude 0 and 60 (1)

	Jan	Feb	Mar	Apr	May	Jun
Latitude 60	16:52	14:16	11:42	08:55	06:25	05:07
Latitude 50	15:12	13:32	11:47	09:53	08:20	07:37
Latitude 40	14:11	13:02	11:49	10:30	09:26	08:59
Latitude 30	13:27	12:42	11:51	10:56	10:13	09:55
Latitude 20	12:53	12:24	11:53	11:18	10:51	10:39
Latitude 10	12:21	12:18	11:53	11:36	11:23	11:17
Latitude 0	11:53	11:53	11:53	11:53	11:53	11:53
Latitude 10	12:21	12:18	11:53	11:36	11:23	11:17
Latitude 20	12:53	12:24	11:53	11:18	10:51	10:39
Latitude 30	13:27	12:42	11:51	10:56	10:13	09:55
Latitude 40	14:11	13:02	11:49	10:30	09:26	08:59
Latitude 50	15:12	13:32	11:47	09:53	08:20	07:37
Latitude 60	16:52	14:16	11:42	08:55	06:25	05:07

(1) Derived from the Smithsonian Meteorological Tables (Washington, D.C.: Smithsonian Institution, 1951), pp. 507-515.

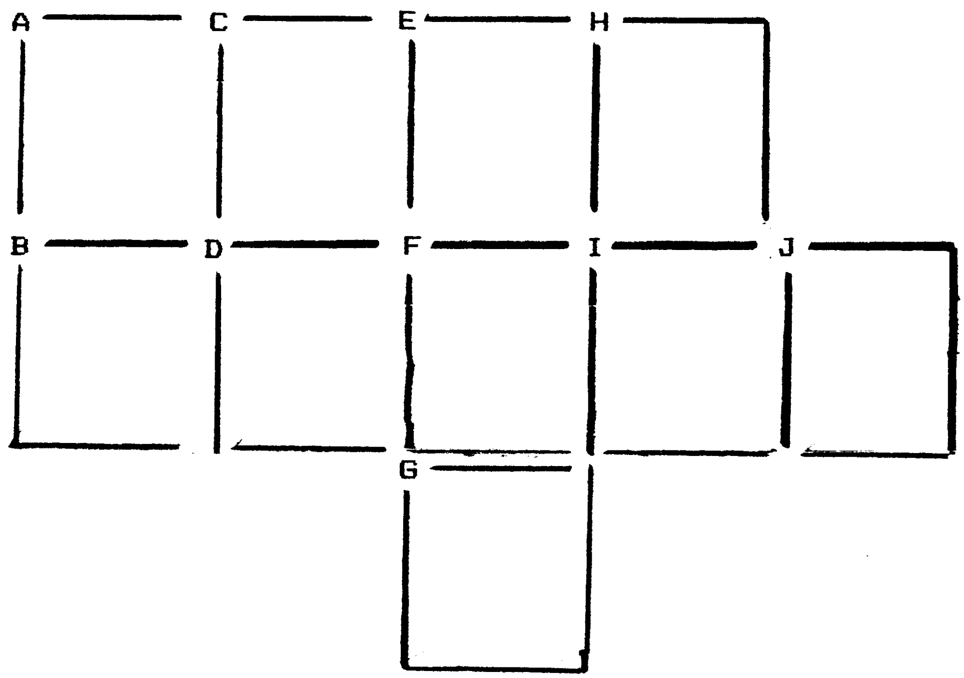


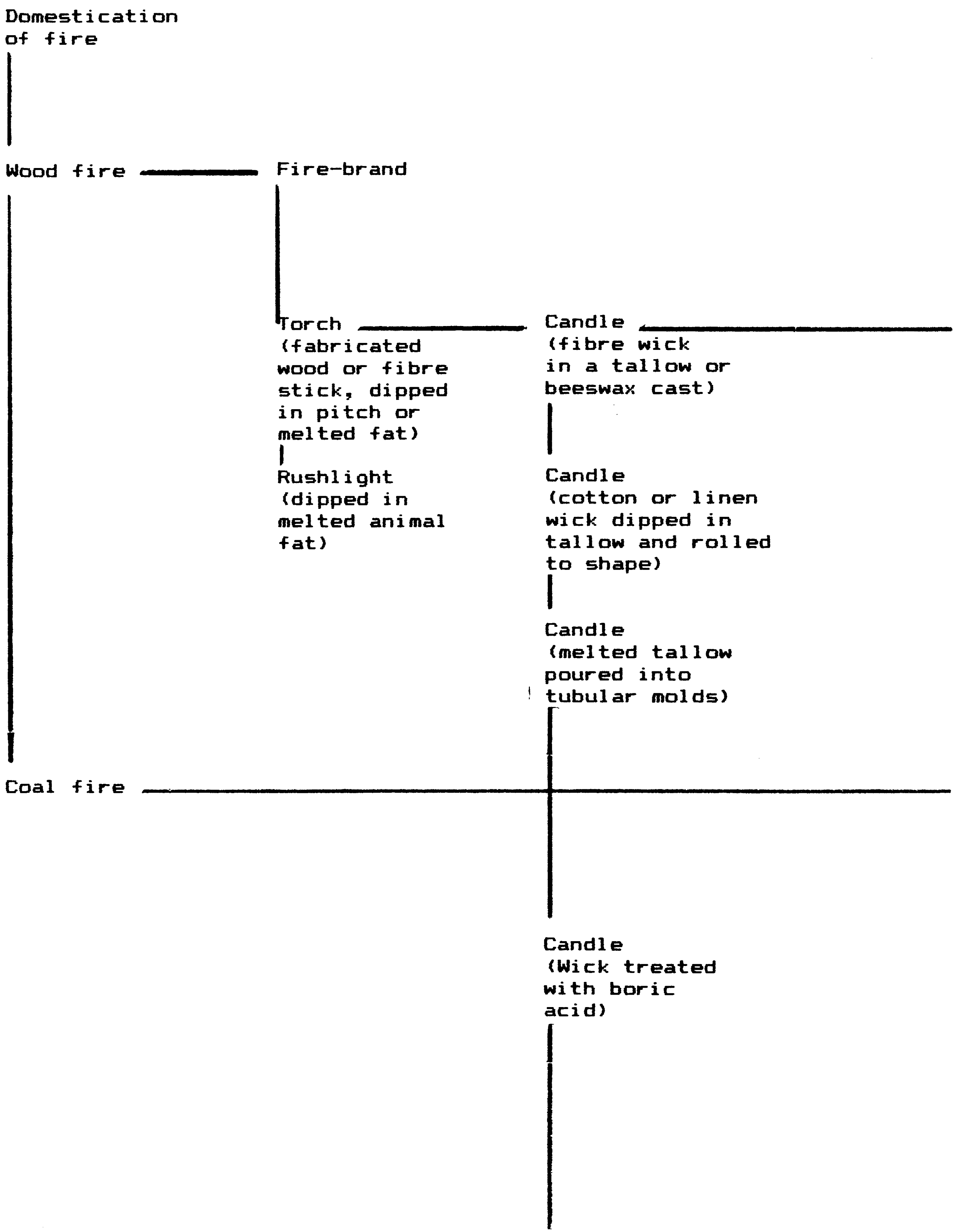
Jul	Aug	Sep	Oct	Nov	Dec	
06:19	08:51	11:37	14:19	16:53	18:08	Latitude 60
08:16	09:51	11:43	13:34	15:13	15:52	Latitude 50
09:24	10:28	11:47	13:05	14:12	14:40	Latitude 40
10:12	10:56	11:50	12:43	13:28	13:48	Latitude 30
10:50	11:18	11:52	12:25	12:53	13:05	Latitude 20
11:23	11:36	11:52	12:09	12:22	12:28	Latitude 10
11:53	11:54	11:54	11:53	11:53	11:53	Latitude 0
11:23	11:36	11:52	12:09	12:22	12:28	Latitude 10
10:50	11:18	11:52	12:25	12:53	13:05	Latitude 20
10:12	10:56	11:50	12:43	13:28	13:48	Latitude 30
09:24	10:28	11:47	13:05	14:12	14:40	Latitude 40
08:16	09:51	11:43	13:34	15:13	15:52	Latitude 50
06:19	08:51	11:37	14:19	16:53	18:08	Latitude 60

Appendix B

Development of artificial light sources

Key to chart:




Domestication of fire
Wood fire
Fire-brand
Torch (fabricated wood or fibre stick, dipped in pitch or melted fat)
Rushlight (dipped in melted animal fat)
Candle (fibre wick in a tallow or beeswax cast)
Candle (cotton or linen wick dipped in tallow and rolled to shape)
Candle (melted tallow poured into tubular molds)
Coal fire
Candle (Wick treated with boric acid)

Candle
(stearine)

Candle
(spermaceti)

Candle
(whitened
paraffin wax)

Candle
(triple strand
wick)

Grease lamp
(twing of fiber
in animal grease,
in found cresset)

Oil lamp
(cotton or
linen wick in
vegetable oil,
in fabricated
open cresset)

Oil lamp
(closed cresset)

Oil lamp
(floating wick)

Oil lamp
(tubular wick)

Oil lamp
(constant level
oil reservoir
-- Heron type)

Pyrotechnic
(combustion
of powder)

Pyrotechnic
(canon, cracker,
rocket)

Pyrotechnic
(Combustion of
mineral salts
and metals for
color effects)

Gaslight
(gas produced
from distilled
coal, distributed
through a pipe
system)

Gaslight
(gas
purification)

Oil lamp
(pressurized
oil reservoir
-- Cardan type)

Oil lamp
(double air-
stream chimney
-- Argand type)

Oil lamp
(mineral oil)

Oil lamp
(flat wick
with metal
flame spreader)

Acetylene lamps
(water distilled
carbide)

Gaslight
(Flame shaping
burner)

Gaslight
(intensive
cold double
air-stream
burner)

Gaslight
(pilot
igniter)

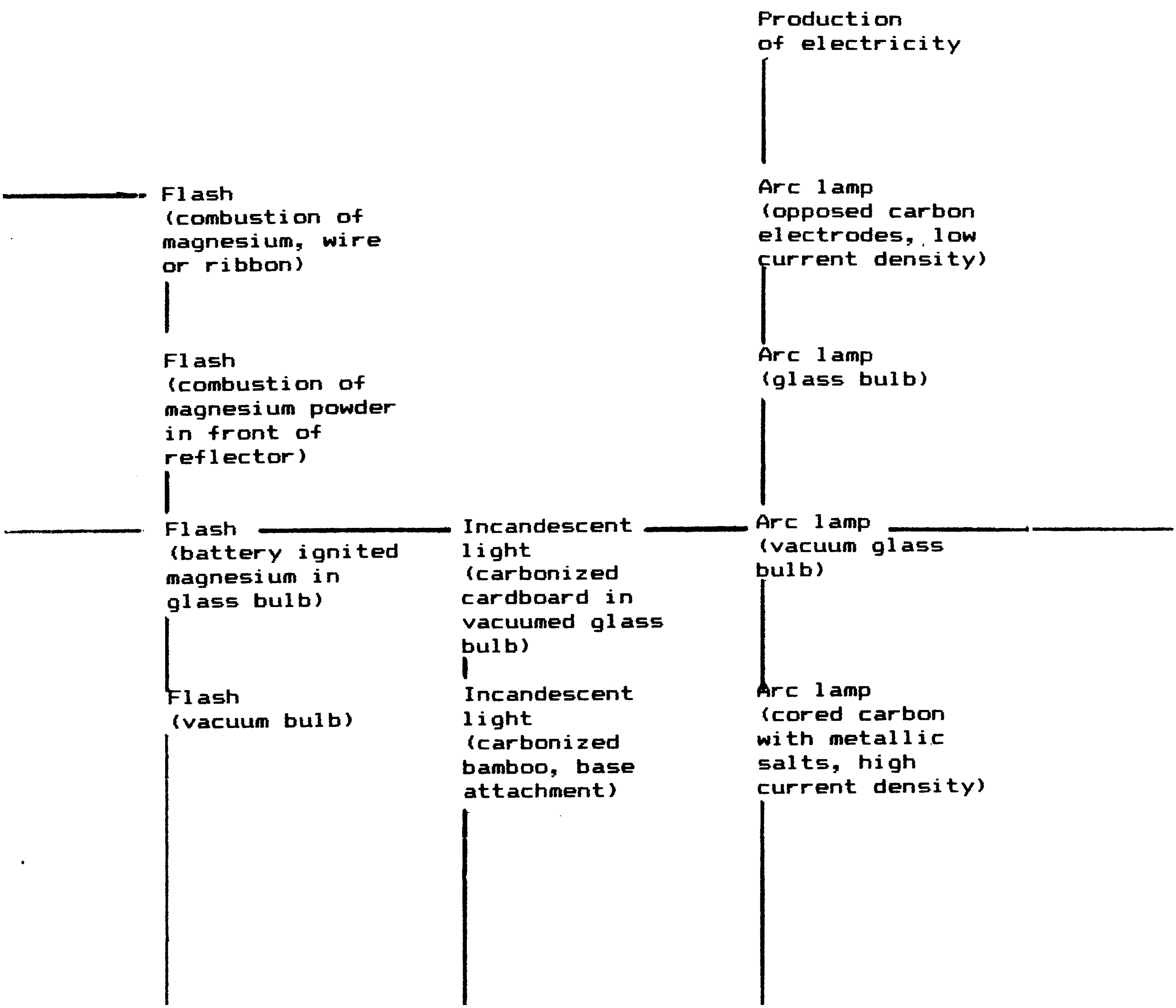
Gaslight
(pressure
regulator)

Gaslight
(intensive
hot air stream
burner)

Gaslight
(incandescent
mantle)

Gaslight
(compressed gas
in portable
container)

Gaslight
(oxy-hydrogen mix
-limelight)


Production of electricity
Arc lamp (opposed carbon electrodes, low current density)
Arc lamp (glass bulb)
Arc lamp (vacuum glass bulb)
Arc lamp (cored carbon with metallic salts, high current density)
Flash (combustion of magnesium, wire or ribbon)
Flash (combustion of magnesium powder in front of reflector)
Flash (battery ignited magnesium in glass bulb)
Flash (vacuum bulb)
Incandescent light (carbonized cardboard in vacuumed glass bulb)
Incandescent light (carbonized bamboo, base attachment)

Flash
(aluminium
wire or ribbon
in oxygen filled
bulb)

Incandescent
light
(flashed
cellulose)

Incandescent
light
(nernst)

Incandescent
light
(stretched
carbon in
vacuum)

Incandescent
light
(osmium
filament)

Incandescent
light
(tantale
filament)

Incandescent
light
(tungsten
filament)

Incandescent
light
(ductile
tungsten
filament)

Arc lamp
(glass bulb
with mercury
vapor)

Arc lamp
(argon filled
bulb, molten
zirconium coating
on one electrode)

Strobe light
(xenon filled bulb
high intensity
discharge)

Fluorescent
discharge and
incandescent
lamp
(tungsten, hydrogen
and luminescent
coating)

F

Incandescent
light
(coiled tungsten
in nitrogen)

Incandescent
light
(double coil
tungsten)

Incandescent
light
(quartz allogen)

Discharge
lamp
(high tension/
frequency power,
mercury vapor)

Discharge
lamp
(low pressure
nitrogen or
carbon monoxyde
-- Moore type)

Fluorescent
tubes
(luminescent metal
in discharge tube)

Fluorescent
tube
(rare gas and
luminescent
material)

Discharge lamp (improved mercury vapor -- Cooper Hewitt type)

Discharge lamp (quartz or silicium tube -- ultra-violet)

Discharge lamp (neon)

Discharge lamp (neon and sodium vapor)

Discharge lamp (mercury vapor and varadium coating)

Fluorescent tube (low pressure mercury vapor and zinc silicate)

Fluorescent tube (better fluorescent material -- whiter light)

Fluorescent tube (reduction of tube diameter)

Fluorescent tube (electronic discharge)

Cathode ray tube (electron beam reflected by mirrors onto phosphorous surface in rare gas)

Luminescent paint (ionized phosphorous material)

Laser

Light emitting diodes