Color, Facture, Art and Design*

Iona Singh

> The *forming* of the five senses is a labor of the entire history of the world down to the present.
>
> —Karl Marx

> Painting was not figurative but represented nothing realistic: it was a pictorial presence created by a painter who knew how to specialize a surface to make it into a sort of highly sensitive photographic plate destined not to photograph like a machine but be present witness of the pictorial poetic moment; inspiration, state of communication and enlightenment of the artist, in the presence of all.
>
> —Yves Klein

In Northern Europe, since the late 19th century, synthetic colors have been used profusely in the designed and built environment. The majority of clothes, furnishings, cosmetics, and pharmaceuticals as well as many foods are dyed with hues that have emerged from industrial production. In the modern industrial era, a great variety of color seems to abound, and the choice for the consumer has never been wider. This is in sharp contrast to the period before Perkins invented aniline purple, when color was difficult and expensive to extract, and the luxury of coloring every synthetic object did not exist. Items either remained uncolored or were gently dyed with relatively sparse natural colorants. Natural dyes often originated from Asia, where for centuries they had been extracted from diverse sources such as the cochineal insect, madder root, and lapis lazuli before being imported into Europe for use by artists, ceramicists, weavers and furniture makers. Once synthetic colors were introduced by Western industry, profound changes ensued. Comparing modern day color production to that of the past, Delamare and Giuneau say:

> …the very abundance of colors in the modern world seems to dilute our relationship with them. We are losing our intimate connection with the materiality of color, the attributes of color that excite all the senses, not just sight. Just as saffron yellow seems to have a certain scent and clay white to be soft and powdery to the touch, all colors can be perceived according to their nature.

This essay will argue that humans have an intimate connection with the materiality of color and that this is alienated under the circumstances of modern production. This relationship becomes a major factor in the control and restriction of subjectivity at the level of the senses as it underpins dominant ideology. The latter idea originates from Marx's notion of the "sensuous," which is touched on in his first Thesis on Feuerbach:

> The chief defect of all hitherto existing materialism (that of Feuerbach included) is that the thing, reality, sensuousness, is conceived only in the form of the *object* or of *contemplation*, but not as *sensuous human activity, practice*, not subjectively. Hence, in contradistinction to materialism, the *active* side was developed abstractly by idealism—which, of course, does not know real, sensuous activity as such.

This notion had been explored in more depth by Marx in the *Economic and Philosophical Manuscripts of 1844*. The humanist/anti-humanist debate still rages around the 1844 Manuscripts, based on its alleged connection to the transcendental legacy of European philosophy. The fact that the text pivots on a notion of human sensuousness in relation to the forces of production is often interpreted as the positing of the Absolute Spirit as a residue of western bourgeois idealism. However, this has been disputed by Gary Tedman, who denies a division between the early "humanist" and late "scientific" Marx, partly on the grounds that the term "sensuousness" should be translated from Marx's original German text of the Manuscripts as "sensual" and refer to the sensual bodily feeling of the species. Tedman also argues that Marx's own use of the term "species-being" in this work alludes to a concept of sensuality that is not essential though still subject to change according to the physical environment though the much slower change of evolution. In this essay I utilize the concept of a materialist sensuality to analyze the affective aspect of color that is created by the industrial forces of production and used in the designed and built environment.

In my view, the application of color within the fine-art tradition is a highly advanced instance of production for our "intimate sense," in contrast with the modern industrial order of synthetic color. This conclusion is based on research that has been incorporated in an art-historical study of the methods and techniques of a number of painters, including Vermeer, El Greco, Rubens, Poussin, Turner, Uccello and Van Eyck. These disparate artists have in common an in-depth approach to the fabrication and usage of their materials. With the exception of Turner, they were all educated within the rigors of a guild system that entailed at least seven years familiarization with the vast body of knowledge comprising art materials and techniques. As a result, each of these artists was able to evolve specific methods and techniques and construct unique combinations of materials. These materials were manipulated to serve their meticulous aims to create a distinctive affect, feel and texture. The sources and utilization of the materials used in these works reflect the evolution of the "intimate senses," an evolved sphere of perception manifest as the ability to respond with discernment to a wide range of texture, shape and color.

In this essay, I concentrate on the visual apparatus—conceived as a biophysical faculty that interacts with and informs all the senses as an integral part of perception—and contemplate some recent developments in psychology and physiology. The profound effect/affect of artistic color production is then compared with color produced in a modern industrial setting, with the focus on the chemical components of the two largest synthetic color groups that dominate our environment today, the azo pigments and the pthalocyanine pigments. The omnipresence of these in the human environment are the result of economic pressures from the large chemical cartels that produce the chemicals compounded into these colors. These chemicals are the byproducts of other areas of the cartel's business—usually oil or coal—and the promotion and marketing of them increases the profitability of these companies. I conclude the historical study of artistic technology by moving to the modern industrial period to examine an artist who used 20th century technology to develop his artistic production specifically in contrast to the synthetic industrial color produced under the economic constraints of the oil-coal cartels. Yves Klein, working with the chemist Edouard Adam, used modern industrial processes to create synthetic colors and resin binders outside the direct economic pressures of cartel production and as a result achieved sharply contrasting perceptual and aesthetic outcomes.

1. Art and Design: Color Production and Art

What, therefore, are the possibilities of an "intimate connection" with color, as Guineau and Delamare say? Within the visual arts, painting in particular, a number of professionals have to some degree rejected the ordinary world in order to create their own environments. Their artworks are characterized by the huge amount of time and effort invested in learning how to arrange substances to affect the viewer. They developed and experimented specifically within the visual field on a daily basis to arrange matter as they would like it to be. The matter they arrange is the artist's materials. Some artists take this approach to an extreme and have distinct and even peculiar ways of organizing their materials according to their discoveries. This can be ascertained through observation of their working methods. Turner, for example, spent many years developing his late technique of thick white ground overlaid by thin paint layers containing a variety of media, wax, resin and oils. Poussin, Vermeer and El Greco also developed unique techniques for paint and ground. By using and developing various materials, each of these painters created works that interact with the visual capacities of the viewer to make a *specific sensory environment.* A number of materials—pigments, binders, fillers and mixers, a variety of oils, resins, and waxes derived from numerous sources in nature—are available to artists for this purpose.

In order to understand the artist's relationship with materials, it is necessary to comprehend the range of sources at their disposal. The following, taken from Doerner's book, *The Materials of the Artist*, is a schematic list of substances that can be used to make paint, ground, and varnish: cologne glue, bone glues, Russian glue, rabbit glue, gelatin and chalks such as marble white, Paris white, whiting, gypsum, kaolin, heavy spar, marble dust, pumice, stone powder, soapstone, zinc white, titanium white, lithopare, and cremnitz white. A number of oils can also be utilized: cold-pressed linseed oil, hot-pressed linseed oil, sun-thickened oil, stand oil, oxidized oils, Siccatif de Haarlem, Siccatif de Courtai, malbutter, nut oil, poppy oil, hemp oil, sunflower oil, soybean oil, cottonseed oil, oil of turpentine, and many more.

Natural color, too, yields many sources for artists. The earth's crust contains numerous iron oxides, ochres and rubefied earths, such as iron oxide rock. This is initially black, but depending on the size of the pulverized grams, it yields shades ranging from violet-purple (0.5 microns) to red (0.1 microns) to orange (0.05 microns). Ochres also have many hues from yellow to red, depending on the mixture of their composition of quartz sand, clay (kaolin), and iron oxide. Limonite, composed of goethite and poorly crystallized gels, produces a variety of yellows, as do plants such as Buckthorn berries and saffron. Mulberry juice yields red and purple, and a variety of reds have also been derived from the herb, alkanet. The red and purple pigments—for example, indigo, kermers, and cochineal red— come from a type of beetle and also from ardil, a red-producing lichen originally used by Egyptian dyers. Further sources of red are aragonite, malachite, and realgar. Green pigments tend to come from rocks rich in green clay, such as glauconite, celadonites, and chlorite. Greens are also made from copper salts. Chalk is used in the fabrication of some of the most widely used artists' white pigments, including, unfortunately, the poisonous white lead. This list of the possibilities regarding pigments is partial and could be much longer.

This considerable number of pigments can be combined with various resins, waxes, oils, and so forth, in innumerable ways, thereby creating the possibility of a huge number of grounds, pigments, and varnishes, each with their own particular visual and tactile characteristics. Depending on the substances chosen, the amount of each substance, and how they are blended, they can yield numerous—in fact, countless—surfaces, tones, and textures. The combination of materials used generatively to convey color and the affect they have on the canvas is known by the term *facture.*

2. Chemistry: Vision and the Physical

What reference do artistic methods and use of materials have to visual perception? Vision is usually meant as light-mediated information conveyed to the brain from the outside world. The conventional understanding, however, tends to ignore the link between the visual sense and the rest of the organism. Recent developments in neurophysiology have established that the nervous system is so astutely integrated that the visual apparatus can inform the whole organism, on psychological as well as somatic levels. These effects are intricate, subtle, and function unconsciously. It is now recognized that the optic nerve splits into many streams as it approaches the visual cortex. Some of these streams go to different parts of the brain and actually bypass visual consciousness to provide unconscious information to cognitive facilities other than vision. This, in turn, helps to guide behavior. This ability has been observed in blind subjects where it has been labeled with the term, blindsight. A study of conventionally blind subjects (whose primary visual cortex had been damaged or destroyed) revealed, for example, the ability to discriminate the position and even shape of light stimuli with near perfect accuracy. These patients insisted they could not "see" or "feel" anything and that they were merely "guessing" where the light source was, thereby implying that visual neurological pathways still actively "perceiving" the light do not return to the visual cortex but to other parts of the body. These were possibly providing unconscious information or "intuition" as to the location of the light source. It was also discovered that a number of sighted subjects were correctly able to detect minute changes in computer images flashed at them without being able to define "rationally" what the changes were; they just "sensed" that the images were different. It was concluded that the visual system sent the relevant information to various parts of the body to produce a "gut feeling," and subjects could sense something had changed even though they did not know "mentally" what that change was.

The interrelationship between the senses of touch and vision was demonstrated when normal-sighted subjects were blindfolded for several days and taught Braille. At first, brain scans revealed total inactivity of the visual cortex, but after a few days, the cortex began to be activated again. The conclusion was that the cortex was being recruited by the brain to aid the subjects' touch sensation, not their visual sensation, for the purpose of learning Braille. What astounded scientists was how quickly the brain seemed able to utilize the visual cortex for this. As the response was far too swift to be the result of the formation of completely new connections, the investigators concluded that "tactile and auditory input into the 'visual cortex' is present in all of us and can be unmasked if behaviorally desirable." The Applied Vision Research Centre states that recent studies show that contrary to previous supposition, the pupil constricts in a systematic manner to stimuli such as spatial structure, color, and movement, even when there is no change in the light flux. These stimuli are associated with the electrophysiological activity of neurons that do not return to the visual center of the brain but radiate to other centers. The possibility arises that vision comprises but one sentient tentacle feeding information and feelings to the whole, while the body adjusts itself to accommodate this in a much more mutable, economical and pragmatic sense than has previously been conceptualized. The senses can be seen to meld into each other with the distinction between one and the other—and the whole of cognition—not separate, but to some extent interchangeable, indeed, almost topological.

Sarnat and Netsky's book on the evolution of the nervous system is based on Darwin's theory of evolution, tracing its development from an anatomical perspective. As they imply, the development and interaction of the hand has aided perception and allowed more intricate recognition of objects by texture, weight, shape and wetness. This practical use of the hand as coordinated with vision was as Engels had presciently anticipated: "the most essential stimuli under the influence of which the brain of the ape gradually changed to man....along with the development of the brain came development of the senses." It seems that the ability to discern between the massive variety of foliage and minerals in the environment to "understand the habits and anatomic vulnerability of hunted animals, and develop coordination of extremities and eye against moving targets" as well as to scan areas for safety created the necessity for a highly perceptive visual ability linked and integrated with the other senses. "As organisms became more complex, each new sensory capacity had to be integrated centrally with the other sensations." The result has been a development of the nervous system's multi-sensory capacities. One can comprehend how these abilities and recognitions are primal, often happening on levels that are very hard to verbalize, rationalize and even be conscious of. It can be noted here that because of this, philosophy, poetry and literature are often the most successful examples for conveying these insights. For some writers, notably William Blake, D.H. Lawrence and Baudelaire, the formal arrangement of their language along with the imagery successfully expresses the interconnecting nature of the senses in the same way as does an artist's formal arrangement of art materials and color in the facture of a painting. The technique of poetry operates, therefore, as a kind of facture in language.

The intricate subtlety of this highly developed aspect of cognition is lent further dimension by Hering's psycho-physiological understanding of vision. This was developed in contrast to Young and Helmholtz's emphasis on a chemical-based theory. In Hering's concept, there are several parts to the perception of color: the source of the light, the chemical nature of the object that interacts with the light, and the eye and its receptors. Color is totally integrated and dependant on the materials upon which light waves fall and by the distinct way that the waves are affected by them. This phenomena is itself differentiated into three distinct categories: the absorption of some light wavelengths and the reflection of others; irridescence or diffraction, where contrasting wavelengths interact to create color and shapes; and finally, diffusion, such as the effect of light passing through a prism. Accordingly, it is possible to conceive of color perception as entirely integrated with the physical nature of the material substance that creates the color and the enormous possibility of both obvious and subtle variation within this. In this sense, there are as many different types of perceptible color as there are perceptible substances.

In view of how perception incorporates facilities like mindsight and blindsight, it is possible to understand how infinitesimal changes in the construction of art materials can affect the body as a complete physical mechanism. Slight changes in the amount of specific resins, the use of one material underneath another, and tiny changes in mixing components are all discernable and detectable as different colors, textures and effects. As noted above, this use of materials can be and has been made into the main subject matter of certain works of art. The subtlety and variety of color and texture perceptible within the natural environment is reflected in the variety and specific combination of art materials used in these artworks. In their choices, artists have at their disposal all of the discrimination and intricacy of the development of human perception through evolution and all its physical/visual reactions to matter in the environment. The artists combine this knowledge with subtle use of the physical mechanisms of perception through color relations in order to stimulate these facilities within the body. This is why some artists experiment for years to find specific combinations of ground and paint using the materials available to them—and sometimes even when they are not easily available to them. From Italian Renaissance painters such as Duccio and Uccello through 20th century masters like Popova and Mondrian, the history of art evinces many examples of artists who have followed this course.

3. Industrial Production and Color in the Built Environment

Organic synthetic dyes, particularly coal tar dyes, are today the main source of colored material in the environment. About half of these dyestuffs are used for printing and graphic inks, a quarter for architectural paints, and the rest for plastics, cements, ceramics, pharmaceuticals, cosmetics, food, automotive finishes, textiles and candles. Before the invention of synthetic dye in the 19th century, color in the designed and built environment usually came from more diverse and directly natural sources. It was often quite difficult and expensive to extract color, and vast amounts of raw materials were required to make small quantities. By modern standards, the profusion of dyes was limited, and therefore color in man-made products was limited also. This began to change in the 1860s when Perkins extracted an artificial mauve dye using aniline or coal tar, a byproduct of coal and oil processing.

Over the next hundred years, a number of industrialists seized on the opportunities afforded by raw coal tar and began to transform it into usable, saleable commodities. These included Carl Bosch of BASF, George Eastman at Kodak, and E.I. Du Pont de Nemours of the company that bore his name. Color technology was also developed at companies such as Monsanto, Olin Corporation, and the German cartel IG Farbens (*farben* means "colors" in German), whose subsidiaries have included BASF, Bayer, Hoechst, and Agfa. These companies worked closely with the coal and oil companies that produced the raw coal tar material and shared technology with them. In the USA, John D. Rockefeller's Standard Oil company, for example, shared technology with IG Farbens, while BASF, Bayer and Hoechst were all involved in petrochemical production in the 1930s and 1940s as they, too, cooperated with Standard Oil. The Esso brand name was created as a phonetic version of the initials SO, and Esso became the first foreign affiliate of Standard Oil. These companies also tended to merge. In the 1950s, Arco and Continental Oil were made into a subsidiary of the chemical manufacturer Du Pont and renamed Amoco, and during the oil crisis of the 1970s, Du Pont, by then a processing giant, took over the oil producer, Conoco.

Oil producers have distilled great quantities of coal tar raw material. By the 1940s this reached 3 million tons a year, and today BP petrochemicals alone sells 26 million metric tons annually. The fact that coal tar and other raw petrochemical materials are an economically profitable byproduct of oil production reflects the fact that up until now, petroleum has been plentiful and relatively inexpensive. This has enabled coal tar dyes to be produced in vast quantities, leading to the rapid growth of the synthetic dye industry in the 19^{th} and 20^{th} centuries, when colors derived from coal tar gradually took over from natural dyes. A mere 50 years after Perkin's first invention of aniline purple, there were more than 2,000 synthetic colors, the presence of which suppressed the production of many natural dyes and pigments. The impending era of "peak oil" is bound to introduce new degrees of crisis to this situation. Nevertheless, as a result of the capital investment in petroleum-based and industrially produced dyestuffs, we are going to have to contend with them for the foreseeable future.

4. Chemistry of Synthetic Coal Tar Dyes

Synthetic organic pigments (coal tar dyes) are fabricated from five basic raw materials: benzene, toluene, xylene, naphthalene and anthracene—also known as the aromatic hydrocarbons. Chemically, all of these substances contain one or more benzene ring, which is a structure of six carbon atoms connected by delocalized electrons that can be written C_6H_6. These raw materials are first converted to compounds known as intermediates. A few of the great number of intermediates are aniline, which is made by replacing the hydrogen atom in one corner of the benzene ring with an amino acid (NH_2), and phenol, which is created by replacing one corner of the ring with a hydroxylated hydrogen atom (OH). Various dyes and pigments are then created by combining these intermediates in various ways. Thus a great variety of organic synthetic pigments are produced from these few materials and processes. The key to this lies in the chemical flexibility of carbon atoms, which can combine in countless ways into atomic structures, rings, chains and branches. These structures in turn can attach to other chemicals and to each other to produce many variations, including some that contain a large number of molecules with intense color attributes. Of these, the least toxic, most lightfast, and economical are manufactured as colorants.

Synthetic organic dyes and pigments are classified into groups or families according to their molecular structure and the methods by which they are manufactured. The largest group, the azo pigments, accounts for about 60 percent of synthetic pigments and dyes and currently comprises 336 manufactured varieties. The azo pigments are created using the process of diazotization, which binds carbon into the chains of six (benzene rings) and links them to complex chains with nitrogen and oxygen. Azo pigments can be made into any hue, but they tend towards yellow, orange, red, and brown. Another large class of pigments, the phthalocyanines, are used in the fabrication of low-cost blue and green colors and chemically have an affinity with the plant pigment, chlorophyll. This again involves a manipulation of four carbon rings linked by nitrogen with the addition of chlorine to produce a greener or less greener version.

Industry's economic interest in using these byproducts has led to the incorporation of dyes into all sorts of commodities, particularly pharmaceuticals and food, where their prime—and often only—function is "cosmetic." Fresh fruit is sometimes sprayed with synthetic dyes, and they are ubiquitous in processed foods such as ice cream, jelly and tinned vegetables as well as in most cosmetics and toiletries. These artificial colors are known to cause allergies and numerous other health problems in humans, as well as tumors in mice. Among the best known of these problematic chemical colorants are: E102 Tartrazine, E110 Sunset Yellow, E133 Brilliant Blue and E142 Green S. These have been linked to a variety of diseases, particularly among workers who have some of the highest exposures. As a result, great concern has arisen about the toxicity of these chemicals in recent years.

Dyestuffs (and other recently produced chemicals) are so dangerous to human health, because their molecular structure is able to mimic various hormones, particularly estrogens, which then attach to estrogen receptors in the body. Thus, a very small amount of dyestuff can trigger substantial organismic chaos and disease. A number of health problems are now linked with the presence of these substances, in the body, including infertility, sexual alterations, and some cancers. These xenoestrogens, as they are called, are found in hair dyes, cosmetics, plastics, hygiene products, and pesticides, and they are generally produced from petrochemical byproducts. Two commonly used petrochemicals, benzene and xylene, which are also used in the process of making a number of synthetic colors, have particularly been singled out in relation to a number of health problems. Workers in occupations that come into regular contact with these toxins include carpenters, auto mechanics, painters, commercial fishermen, furniture workers, dentists, electrical workers, potters, radiologists, and staff in clothing and textile industries.

In contrast, the colorants of the pre-petrochemical era, where the majority of substances used included mulberry juice, alkanet, cochineal, ardil, ochres, gypsum, pumice, chalk, lime, and natural resins extracted from tree bark, posed little or no health risk. There were, of course, some exceptions, such as chlorite and mercury, which do pose a risk of toxicity if they are consumed or used without care. The toxic nature of lead paints and pigment has also been known for a long time. From as far back as the early 20th century, the industrial exposure of housepainters to lead paint meant that the average lifespan in this profession was 11 years shorter than the general population. Both lead and cadmium may increase the risk of peripheral artery disease, and much of the intake of lead and cadmium today is said to be through smoking. However, the sheer variety of natural sources for paints and pigments makes it possible to avoid the use of cadmium and lead in paint in favor of less toxic substances. This is not the case with coal tar dye products, which are inherently toxic and comprise most of the color in the modern built environment. Under these circumstances they become difficult or impossible to avoid, and there is no control over their effects. Pre-industrial colors, on the other hand, stand outside of petrochemical production. For these reasons there was a far less toxic environment in connection with color production in the pre-coal tar era.

5. Comparison of Production of Art Materials and Industrial Colors: The Interdependence of Color and Form

To recapitulate, when light and color are perceived in nature, it is through the various media of their structure, i.e., what they are physically composed of. This factor plays a role in the visual perception of the vast variety of materials in nature inasmuch as color and structure are interdependent. That is to say, the atomic structure of the chemical components of a substance determines its color. It determines which light rays are reflected from it and which are absorbed, or how intensely the light wavelengths combine or are split. The subtlety of this structural/textural/color relationship is manifest in the astute and integrated nature of the perceptual system which has evolved to be discerning on both rational and non-rational levels, since it involves intuition, feeling and sense.

However, in contrast to the diverse interaction of chemicals and substances that create color in nature, industrial synthetic color is largely reduced to five basic raw materials, the aromatic hydrocarbons, each of which is chemically based on the carbon benzene ring. More specifically, in the case of the widest category of synthetic pigments, the azo pigments, it is based on reactions between benzene rings, nitrogen and oxygen. In the case of the other widely used group, the phthalocyanine pigments, it is based on a reaction between the benzene ring and chlorophyll. Synthetic color dyes are strong and uniform in color, and they are used to color objects and materials, plastics, woods, and metals. In other words, synthetic colors are *added to the object from the outside* without any of the subtle integration of color with the substance of the object. The color is radically divorced from the structure of the physical object.

The present common notion of the quality of color, judged by its strength and its "shining out" independent of its physical structure, is based on the proliferation of coal tar dyes. This is the tendency to divorce color from the physical effect of the structure and forms that it takes. It even permeates the thinking of scientists. When physiologists say we can see about 200,000 colors, this disregards color as a physical medium that interacts with the structure that forms the color. The green of a plant and the green of a rock may measure up as exactly the same colors in terms of hue and saturation, but this does not mean they are the same color or even look the same, because their chemical/physical components, the vehicles for the color, are different. This is often disregarded by the makers of synthetic color. As Ball says, even when scientists manage to reproduce molecules such as indigo and alizarin color synthetically without any recourse to the raw material, they were keen not to differentiate. "They had no qualms about naming a new pigment after its classical equivalent, as if deciding that 'indian yellow,' 'vermilion,' and 'cobalt blue' designate not a substance but a hue."

It is possible, however, to make a virtually infinite combination of materials using the synthetic raw material of carbon atoms. This in itself would make the color yielded from coal tar much wider than it is, but it is limited by commerce. Coal tar and plastic producers have worked together in groups and cartels to establish the dominance of coal tar pigments and dyes in the designed environment. The competitive nature of this has minimized and limited the type of product to large classes of pigments such as azo, which are the most economical to produce. This, then, is the political nature of design and color production as a sensual affect that is bound to have many repercussions on other areas of cognition. With the subtle relationship of the substance to the color removed and its replacement by an external source with limited facture, the color no longer stimulates the senses as they have evolved to perceive it.

6. Modern Contradictions of This in Art: Yves Klein

Yves Klein used the industrial technology of color to produce artworks. This was possible because Klein was able to stand outside the standard capitalist relations of color production and transform them according to artistic practice. To achieve this took a great deal of research concerning materials. Klein's initiation with industrial methods was a long and technically rigorous process that began with an exploration of the production of art in all its physical aspects. He worked as a picture framer in London where, while preparing glues, colors, varnishes, and gilding, he "got closer to materials." Klein later began to manufacture his own pigments, working in conjunction with the chemist, Edouard Adam. Together they experimented for a year by manipulating the coal tar process that produces synthetic ultramarine pigment to make a blue pigment with a specific chroma. This was eventually registered under an international patent and named International Klein Blue, often referred to as IKB. The next stage was to develop a resin that would enable this pigment to stick to various surfaces while maintaining its dusty powdery effect "without diluting the color."

In the so-called IKB series produced by this technique, color emanates from the physical object as opposed to being added from the outside, as is the case with commodities bearing synthetic color. The artist has transformed the medium to directly link it to the surface of the object; the result is a series of works that are visually quite shocking inasmuch as the distinctiveness of the colored surface immediately becomes apparent to the viewer with its brilliance, intensity and physical effect. By creating their own pigment and binder, Klein and Adam demonstrate a shift in the economically pre-determined circumstances controlling the mass production of coal tar dyes and their proliferation in "everyday" life. Klein's quest to intervene in this process can be compared to some of his contemporaries. In my opinion, for instance, while Warhol's ironic stance to some extent demystifies art and reveals the technique of the printing process, it also heralds popular culture and mass production through its subject matter and its means of production in what he called "the factory." Compared to Klein's extreme measures, Warhol conforms to a conventional use of mass industrially produced art materials in many of his works. For example, in the *Campbell's Soup Can* series, Warhol uses artist's quality acrylics, different kinds of paints, and printing inks.

One cannot produce all of the objects of everyday life with the skill of a work of art. The few artists who specialize in color and facture in relation to the senses as their full-time occupation stand in contrast to the industrial producers who have neither the interest nor the facility to incorporate this objective as a primary factor. The contrast between the ordinary everyday industrial world and certain kinds of *extraordinary* artistic production gives such art a rare quality. Art that targets human perception in a fuller sense is very unusual and may even seem incomprehensible to the layperson. What is, in fact, very skilled use of materials on the part of the artist starts to seem incredible, when the materials manifest into a rare creation that, as its prime objective, heralds the human faculty.

The work of Yves Klein is harnessed to this end as an ideological referent for color in art as transcendentally detached from its physical component. Klein is often represented as the painter of "the void," who attempted to express color in its metaphysical or non-physical state. This characterization was emphasized in an exhibition in London's Hayward Gallery in 1995, that was entitled "Leap Into The Void" and continues to be found in the majority of printed matter about Klein, along with the omission of any discussion of the lengthy and extremely rigorous technical aspects of his practice. It can also be found in the comments that accompany his work in museums and galleries, for example, in the permanent collection at the Tate Modern Gallery in London. The statement on the wall at Tate Modern next to his blue painting, "IKB79" of 1959 claims, "like all great works it is beautiful beyond physical beauty…" and says that Klein wished to make painting immaterial and "beyond the visible or tactile."

In fact, the artist's manipulation of the pigment so that it is directly integrated with the physical surface of the object and its resulting effect on the "materiality of the senses" makes Klein's art precisely *not* transcendental or spiritual. The direct integration of the color into the physical surface of the object means that it is more intrinsic to the object and not transcendent from it. In addition, the integrated physical nature of the work is the result of industrial techniques of production that have been dissociated from the political-economic forces that control the struggle for dominance between cartels. Klein manifests, therefore, a form of practice which has become relatively liberated from mainstream capitalist forces of production. The transcendental emphasis given to this by the art establishment is an ideological marker that obfuscates this aspect and impedes the radical elements of the work.

7. Some Conclusions

While the natural world evolves a huge variety of perceptual experience through its interaction with the visual system, synthetic production reduces this to a highly limited number of materials and processes. Use of these strong, lightfast and inexpensive synthetic colors are at the expense of nuance, tincture and the plenitude of natural formation. Consequently, the body in the built environment is presented with synthetic materials of limited facture and subtlety compared to what it is capable of perceiving. Synthetic color has its own physical composition, of course, but this remains fundamentally separate from the physical nature of the objects that it colors. Thus, color and its perception become detached from the physical nature of the object, and factors such as brightness, color-fastness and cost-effectiveness take precedence. The organism's appropriation of the physical aspect of color, and beyond that, the materiality and physical effect of nature itself, is channeled into passively observing color divorced from structure. The perception of color becomes separated from the relationship between materials and structure, as well as from the intricate effect of this relationship on related cognitive processes.

The history of criticism of this state of affairs is implicit in the work of a number of theorists.

In the 1844 Manuscripts, Marx says that under capitalism the process of proletarian labor is separate or "is external to the worker, i.e., it does not belong to his intrinsic nature; that in his work, therefore, he does not affirm himself but denies himself, does not feel content but unhappy, does not develop freely his physical and mental energy but mortifies his body and ruins his mind."

More specifically, on the aspect of synthetic color production and its use, in 1883 William Morris said: "I want modern science, which I believe to be capable of overcoming all material difficulties, to turn from such preposterous follies as the invention of anthracene colors." As we have observed above, anthracene is one of the five aromatic hydrocarbons that enter into the manufacture of coal tar colors. Morris considers it to be one aspect of "the cheap and nasty wares which are the mainstay of competitive commerce, and are indeed slave-wares, made by and for slaves."

A method for analyzing the effect of this lies in Tedman's thesis, which adds another aesthetic level to the base/superstructure model at the core of the Marxian critique of political economy and culture. Tedman states:

> The authentic subject is the human subject as a member of a species that produces objects that confirm the humanness of the senses as they have evolved as a species, and not as the capitalist economic, conventional relations have enforced. Because all objects produced by labor are, under these exploitative conditions and circumstances, felt to be both these things—alien objects that estrange and confirmation of an authentic subject—it still remains just possible for a bittersweet pleasure to be experienced through labor. Again we must emphasize that this authentic subject itself is not fixed for all time (evolution takes care of that), but neither does it change with every change of conventional economic relations.

The ubiquitous nature of coal tar colors makes them the prime representative of color in the designed and built environment. As such, they are one of the prime sources for the confirmation of the potential of the organism's response to color in its multi-sensory aspect.

In the workplace, labor under capitalism is alienation for the worker, but it is also necessary to affirm the senses of the worker. At the level of consumption, objects colored with coal tar dyes are both necessary as part of the affirmation of the senses of the worker and alienating to the senses. As commodities they provide responses that solidify estrangement at the level of consumption. As color and its perception become detached from the physical nature of the object, a vital aspect of the connection with nature is channeled into observing color divorced from structure. Color as presented in this limited form may become inexpensive and practical but at the cost of impoverishing the sensual materiality of the body. In other words, color as a physical structure that corresponds with the integrated structure of the body, as this has evolved, is not articulated. Instead, color is separated from the relationship between materials and structure. As the intricacies of these relationships are lost, so is the sensual ground of related cognitive processes. Color therefore seems to become a Cartesian abstraction separated from its material and physical components and the repercussions of these on the human subject. Objects of this kind in the designed environment promote a transcendent metaphysic and utilize feeling to underpin estrangement on the bodily as well as aesthetic level. The emphasis is of mind over matter on the level of the senses—and along with this, of the triumph of capital as an abstract force ruling over labor.

It can now be seen that the capitalist forces of production which Marx speaks of as destructive to the worker's sensual capacities are, as he implies, not confined to the workplace. The disregard for the subtleties of the worker's mind, emotions and body existing in the workplace also act on the products created under these conditions. The low cost, limited facture, limited color, limited processing, and the competition between large monopolies in the instance of coal tar dyes are the prime forces that produce color with the same indifference for the consumerist senses as the capitalist process has for the productive senses of the worker. In this particular means of production, these forces therefore become embodied in the use values of those commodities in which color is embedded. The sensual affect of this color is one of disregard for sensual cognitive capacities. The facilities for perception and the development of the nervous system, the ability to perceive color relations, their facture, and their effect on the body characterized by the examples of the phenomena of mindsight and blindsight, and in the work of artists, go unheeded—and possibly atrophy.

Thus, the particular aspect of design in these circumstances neutralizes the sensual and perceptive potential of the subject. A different environment—one that took these facilities into account—would elicit articulated and subtle responses through the organism, physically, mentally, and creatively, giving rise to the possibility of much greater levels of invention and production beyond the mere use of the human "machine."

Although Marx and Engels themselves did not write a great deal on the theme of art and color, there is peripheral evidence that they were quite conscious of its immediate effects, even specifically of the role of synthetic color. In 1868 when Engels undertook to note his Confessions, the popular Victorian pastime that involved filling out a questionnaire of personal tastes, he was asked to name his favorite color. His answer was "any one not Aniline."

Bibliography**

Perry Anderson, *The Origins of Post Modernity* (London: Verso, 1998).
Louis Althusser, *For Marx* (London: Verso, 1969).
————— *Lenin and Philosophy* (New York: Monthly Review Press, 1969).
Paul Azzopardi and Alan Cowey "Is Blindsight Like Normal, Near-threshold Vision?" *Psychology*, Vol. 94, December 1997.
AVRC, Clinical and Physiological Optics Research Group. City University website: http://www.city.ac.uk/.
Philip Ball, *Bright Earth* (London: Penguin, 2001).
R. A. Buchanan, *The Power of the Machine* (London: Viking, 1992).
Victor Burgin, *The End of Art Theory* (London: Macmillan, 1992).
W. Burton, *Designing for Machine Made Goods* (London: Penguin, 1927).
Althea Cullen, *Techniques of the Impressionists* (London: Burlington Books, 1993).
Elizabeth Cumming and Wendy Kaplan, *The Arts and Crafts Movement* (London: Thames & Hudson, 1991).
Francois Delaware & Elizabeth Guineau, *Color: The Story of Dyes and Pigments* (London: Thames and Hudson, 2000).
Jacques Derrida, *Writing and Differance* (New York and London: Routledge Kegan Paul, 1985).
Max Doerner, *The Materials of the Artist*, trans. E. Neuhaus (London: Granada, 1970).
Fredrick Engels, *The Dialectics of Nature*, trans. and ed. Clemens Dutt (London: Lawrence and Wishart, 1941), p. 284.
Lucien Febvre, *A New Kind of History*, ed. Peter Burke (London: Routledge Kegan Paul, 1973).
Adrian Forty, *Objects of Desire* (London: Thames and Hudson, 1989).
Simon Garfield, *Mauve: How One Man Invented a Color that Changed the World* (London: Faber and Faber, 2000).
Rosamund D. Harley, *Artists' Pigments 1600-1835* (London: Butterworths, 1970).
Ewald Hering, *Outlines of a Theory of the Light Sense*, trans. L.M. Hurvich and D. Jameson (Cambridge, MA: Harvard University Press, 1964).
David R. Hilbert, *Color and Color Perception: A Study in Anthropocentric Realism* (Stanford, CA: Center for the Study of Language and Information, [distributed by University of Chicago Press]), 1987.
Joel Kovel, *History and Spirit* (Thetford, VT: Glad Day Books, 2001).
Yves Klein, *Long Live the Immaterial* (New York: Delano Greenidge Editions, 2000), p. 81-82.
—————*Selected Writings*, edited by J&J (London: Tate Gallery Publications, 1974).
P. Lambert, *Color and Fibre* (New York: Shiffer Publications, 1986).
S. G. Lewin, *Formica and Design* (New York: Rizzoli , 1991).
Joanna Marchant, "Review: Insight Into Sight and Experience," *New Scientist*, November 14, 1992, p. 45.
Karl Marx, *The Economic and Philosophical Manuscripts of 1844* (London: Lawrence and Wishart, 1981).
————— *The Theses on Feuerbach*, English translation: Lawrence and Wishart, 1970 (London: Lawrence and Wishart, 1977), p. 121.
William Morris, *Art and Socialism* (London: Kelmscott Press, 1934), p. 129.
S. Mossman, *Early Plastics Perspectives 1850-1950* (Leicester: Leicester University Press, 1997).
Conrad G. Mueller, Mae Rudolph and *Life* eds., *Light and Vision* (New York: Time-Life Books, 1969).
Norihoro Sadato, Alvaro Pascual-Leone, et al., "Activation of the Primary Visual Cortex by Braille Reading in Blind Subjects," *Nature*, Vol. 308, April 11, 1996, pp. 526-528.
Helen Phillips, "Do We Perceive Using 'Mindsight?'" *New Scientist*, July 2, 2004, p. 14.
————— "Vision Enhances Perception of Touch," *New Scientist*, September 9, 2002.
Jean Piaget, *The Origin of Intelligence in the Child* (New York and London: Routledge Kegan Paul, 1979).
Ronald Rensink, "Visual Sensing Without Seeing," *Psychological Science*, Vol. 15, No. 1, January 2004.
R.L. Rutsky, *High Techne: Art and Technology from the Machine Aesthetic* (Minneapolis: Minnesota University Press, 1999).
Sarnat and Nevsky, *Evolution of the Nervous System* (Oxford: Oxford University Press, 1981), p. 389.
A. Siegfried, *America Comes of Age* (London: Jonathon Cape, 1930).
Iona Singh, "Vermeer, Materialism and the Transcendental in Art," *Rethinking Marxism*, Vol. 16, No. 3, 2004.
Penny Sparke, *Design in Context* (London: Bloomsbury Publishing/Quarto, 1987).
Gary Tedman, "Ideology, the State, and the Aesthetic Level of Practice," *Rethinking Marxism*, Vol. 11, No. 3, 1999.

—————— "Subjectless Aesthetics", *Rethinking Marxism*, Vol. 16, No. 1, 2004.
John A. Walker, *Design History and the History of Design* (London: Pluto Press, 1990).
Richard Guy Wilson and Dianne H. Pilgrim, *The Machine Age In America* (New York: Brooklyn Museum, 1986).
Jonathon M. Woodham, *Twentieth-Century Design* (Oxford: Oxford University Press, 1997).