1939 Frederick J.Kiesler

On Correalism and Biotechnique: A Definition and Test of a New Approach to Building Design

Frederick Kiesler (1896–1966) was an Austrian architect, artist, set designer, and writer. He began his carrer in Vienna, studying at the Technische Hochschule and the Akademie der blidenden Künste. He worked briefly in the office of Adolf Loos, and then in Berlin as a set designer, before emigrating to the United States in 1925. During the 1920s and 1930s, he belonged to De Stijil, the American Union of Decorative Artists and Craftsmen, Buckminster Fuller's Structural Studies Associates (SSA), and the theater faculty at Juilliard; he also formed the Laboratory of Correalism at Columbia University, and through his association with Marcel Duchamp and the exiled Parisian art community, became the "offical" architect of the surrealists, He completed a few architectural works, notably the Film Guild Cinema, Peggy Guggenheim's Art of This century Gallery and the Shrine of the Book in Jerusalem, the home of the Dead Sea Scolls.

Kiesler maintained a position within the avant-garde for most of his career, beginning with the Space House of 1934. While he constantly adapted his work to his context and period, his fascination with continuity endured, first explained according to notions adopted from physics, then from evolutionary theory, and later from surrealist theories of the images.

The following essay on Correalism was written during Kiesler's association with Buckminster Fuller and the SSA, which began in the early 1930s and was most visible in the 1932 transformation of the *T-square Journal* into *Shelter,* described by Fuller as as "Correlating Medium." The abbreviated technicak language of the SSA is visible throughout Kiesler's essay, as are the themes of technological transformation and evolution, though Kiesler translates them more completely into the concerns of architects than any other contributor to the SSA. The defiing point of the essay was his distinction between the building techniques of nature (biotechnics) and of man (biotechniques), who builds by assembly. He meant this to support his claim that continuous construction could solve the problem of human construction, which fails at the joints of assembly, but it also leads to proposals for truly organic architecture (see Katavolos, 1960; De Landa, 20020). His other fundamental observation, that the "needs" which define functionalism are always evolving and so health is the only poses one dilemma of the age of systems.

In this paper[1] I propose to show that the perennial crisis in architectural history is due to the perennial lack of a science dealing with the fundamental laws which seem to govern *man as a nucleus of forces;* that until we develop and apply such a science *to* the field of building design, it will continue to exist as a series of disparate, overspecialized, and unevenly distributed products; and that only such a new science can eliminate the arbitrary divisions of architecture into: Art, Technology, and Economy, and make architecture a socially constructive factor in man's daily activities.

Today we face the task of formulating the *general* laws of the foundations that underlie the many specialized sciences, not in terms of metaphysics (such as religion or philosophy) but in terms of work-energies; and the *specific task* of formulating those that govern building design. But the two are intimately related and we in the building field cannot solve our special problems without comprehension of the foundations of such part-sciences, e.g. physics, chemistry, biology, etc. Thus, it would seem imperative that we summarize some of the concepts of modern science and investigate their validity for our specific problem.

Concepts from science for the building designer

Man is born in evolution of hereditary trends. He is the nucleus of forces which act upon him, and upon which he acts. Forces are energies. We assume, with contemporary science, that they are of an electromagnetic nature. The inter-relation of organic and inorganic matter is a mutual bombardment of energies which have two characteristics: those of integration and those of disintegration.

By means of gravitation, electricity generates energy into solids of visible matter. This is integration. By magnetism and radiation, electricity degenerates energy into tenuous, invisible matter. This is disintegration.

If this general principle of anabolic and catabolic energies were the sole principle of existence, we would have a static, unchanging world. But these two forces (positive and negative) interchange through physico-chemical reactions, one force striving always for a preponderance over the other. In this way *variations* are constantly created; and in this process of creation, new nuclear concepts and new environments are in continual formation.

Reality and form

The mutual biological interdependence of organisms is, in the final analysis, the result of the primary demands of all creatures: proper food, habitat, reproduction, defense against inimical forces. Life is all expression of the cooperation, jostling, and strife of individual with individual, and of species with species, for these primary needs.

The visible result of these activating forces is called *matter* and constitutes what is commonly understood as reality. The reason for this superficial interpretation of reality lies in the limitation of man's senses in relation to the forces of the universe. For matter is only one of the expressions of Reality, and not reality itself. If matter alone were reality, life would be static.

What we call "forms," whether they are natural or artificial, are only the visible trading posts of integrating and disintegrating forces mutating at low rates of speed. Reality consists of these two categories of forces which inter-act constantly in visible and invisible configurations. *This exchange of inter-acting forces I call CO-REALITY, and the science of its relationships, CORREALISM. The term "correalism" expresses the dynamics of continual interaction between man and his natural and technological environments.*

Natural, social, and technological heredity

Biology has divided these forces into two main categories: Heredity and Environment. Man had to evolve a method for dealing with the effects of these overwhelming forces upon himself. For this purpose he created technological environment to help him in his physical survival even within the short span of the age-potential of his own species. This is made more difficult because man is biologically unfit to transmit his experiences to his offspring: each child has to begin anew its adaptations to nature. In short: contrary to prevailing belief, acquired traits and habits of parents can not be transmuted into the make-up of body cells and, by way of procreation, given to their children.[2]

By providing unchangeable genes within the germ-cells *Nature* has safeguarded herself from man interfering fundamentally with her aims, whatever they may be. This "sealed order" of the germ cell contains nature's will which man can influence *during his own life-time, but not beyond that*. This places a deep responsibility upon those who "design" technological environment, because the restriction of its application to only *one* life-span makes it so much more needed as part of man's defense-mechanism. It appears, then, that the only human experiences that can be inherited by children are those of customs and habits by way of: training and education, thus "social heredity" is the only tool man can rely upon. Just as all living organisms are generated through their own species from a long chain of generations, so do ideologies or man-made objects generate from a long line of older ideologies or objects of similar functions. Thus a contemporary chair, for instance, is the product of many generations of other tools for man to rest his body in fatigue. This is heredity in technology.

What is technological environment?

When the biologist speaks of environment, he invariably means the geographical and animal environment. This definition is perhaps accurate for all creatures except man. For man alone has developed a third environment: a *technological* one which has been his steady companion from his very inception. This technological environment, from “shirts to shelter,” has become one of the constituent parts of his total

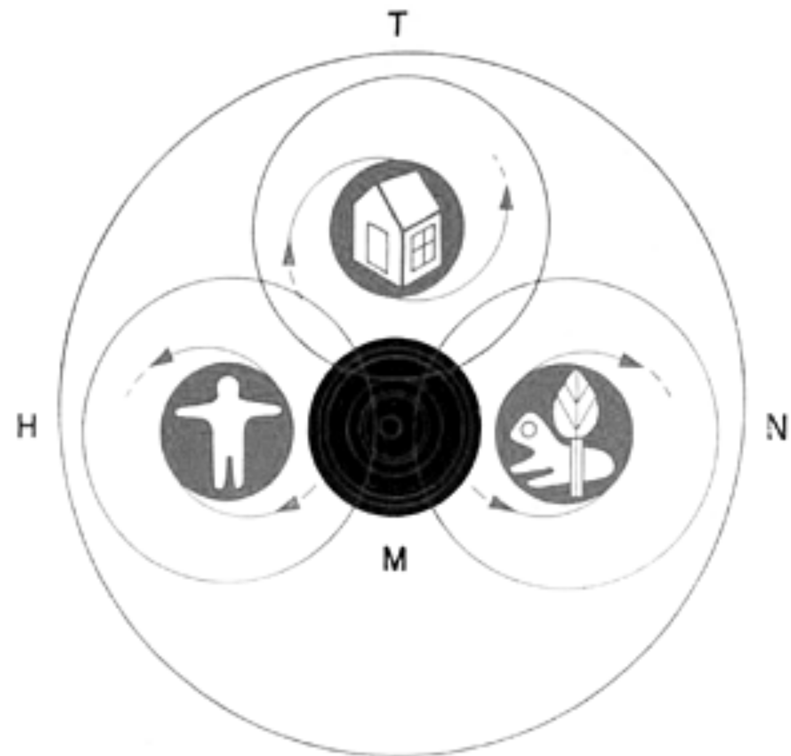

Fig 1a “Man=Heredity + Environment. This diagram expresses the continual interaction of both the total environment on man and the continual interaction of its constituent parts on one another.”

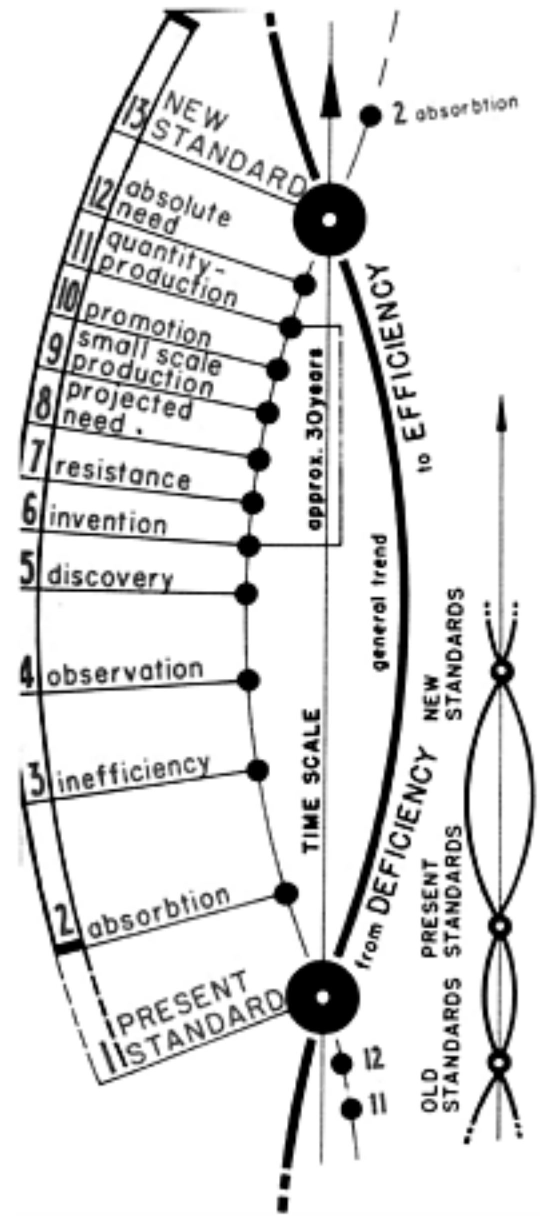

Fig 1b “Every need follows a characteristic pattern of development. A minimum of twelve progressive stages can be detected in progression from one standard to the next.”

environment. Then, the classification of environment becomes three- instead of two-fold:

1 natural environment
2 human environment
3 technological environment

But it is this last factor of technological environment which concerns us here, since it is in this field that the architect works. Man-made, technological tool-objects have been in existence since the Ice Age. *But no branch of science so far has undertaken to investigate, analyze, chart, and measure the direct and indirect, voluntary and involuntary effects of technological environment upon man;* nor has any branch of science charted and formulated the laws which govern the development of technology. We have had numerous accounts of the history of technology but no study of the need-morphology of its growth.

In studying the history of the science of biology one can find with amazement the lack of observation and systematization of natural phenomena: for twenty centuries after the Greeks, no new theory of natural science came until the appearance of Lamarck and Darwin. The scientific theory of evolution is essentially the product of the last hundred years.

An analogous situation exists in technology, and we need not be surprised that no new theory on the phenomena of design has been forthcoming. Just as the scientists of the Middle Ages thought that horses produced wasps; asses, hornets; and cheese, mice, so modern men think that it is industry which produces the technological environment. In reality, the technological environment is produced by *human needs:* absolute needs and simulated needs.

Of what does this technological environment consist? In its simplest terms, it is made up of a whole system of tools, which man has developed for better control of nature. I use the term “tool” advisedly. It is generally agreed that the difference between a machine and a tool is the power by which it is driven, whether manually or by the forces of man’s environment—e.g., natural (water) or synthetic (electricity). But this distinction of isolated technological fields must be replaced by an understanding of technological invention as a whole. For the purposes of this analysis, I therefore define “tool” as: *any implement created by man for increased control of nature*. The term “tool” is preferable to the term “machine” because it brings us back to the origin of the machine, and to its ultimate purpose: *enabling man to reach levels of higher productivity*. In this sense, *everything which man uses in his struggle for existence is a tool* and, as such, part of a man-made technological environment, from shirts to shelter, from cannons to poetry, from telephones to painting. No tool exists in isolation. Every technological device is *co-real:* its existence is conditioned by the flux of man’s struggle, hence by its relation to his *total environment*.

The persistence of technological environment is marked by constant, if only indirect, infiltration of converted forces embodied in the manufacture of our homes, workshops, transportation shelters, etc. The ratio of fabricated environment to natural environment varies according to the ways in which men make their living. Today, men in urban areas spend about 88 percent of their time indoors; in suburban areas about 70 percent; and in rural areas about 43 percent.

A qualitative classification of tools

But we must keep in mind that the *technological environment affects man's development, and that technology itself follows laws of heredity in its own development*. We then observe that the principle of heredity also operates in technology. Thus the progressive development of any tool—a knife, a factory, a home—does not follow a straight line any more than does a species of plant or animal. On the contrary, production of any tool in our industrial era seems to develop along three characteristic lines.

The Standard Type, developed by absolute need.

The Variation, evolved from the *Standard* Type for auxiliary purposes.

The Simulated springs directly or indirectly from one of the two foregoing types.

This third group of products—and it is by far the largest—distinguishes itself from the *Standard and* the *Variation* chiefly by a lack of material efficiency and insignificant changes in design and materials.

Each of these three types has its special fertilization grounds in which it develops. The Standard grows out of scientific knowledge. The *Variations are a* natural adaptation of the *Standard to* specific conditions, and are therefore valid. The *Simulated* product and its temporary survival is only made possible by a lack of knowledge within its social environment.

The *Simulated are* the widest in distribution, the shortest lived, and the most rapidly replaced. The result is a dispersion of energy and a conflict of creative forces whose destructive effect is to slow down the rise of the original *Standard to* higher levels of efficiency.

Adjustments to the basic needs of man require the elimination of the *Simulated* and control of the *Variations*. In the readjustment of industry, the forces (man- and machine-power) which are producing the *Simulated* will be absorbed into the areas of the *Standard and* its *Variations,* thus reinforcing their productivity.

Evolution of need: from deficiency to efficiency

Since nature demonstrates her will toward *mutative continuity,* man's aim seems also to be: to *sustain and prolong life*. By experience he learned that he was unable to do so with the physical equipment which he inherited. He was therefore compelled to extend the powers of his natural equipment to meet the forces of environment. He had to add to his natural equipment, artificial equipment of defense and offense. Tool-making began. *Man's inherent desire for higher productivity began* to find its material expression.

Man, then, builds tools; and from them arises that man-made complex of relationships which we have called the technological environment. But in order to correct the many obvious maladjustments of this environment, it is necessary to ask: What is the nature of its origin? What is a need? How do needs arise? Are they natural or artificial? Are they static or in evolution? A definition of needs has today become of prime importance to the designer of technological environment. *Investigation on this crucial point cannot be based upon the study of architecture but must be based upon the study of man.* Our duty would therefore be to re-define needs, and upon this basis to re-organize the technological environment. The accompanying chart of the evolution of needs may help to clarify the problem.

We must keep in mind that science in all its branches is based upon man's deficiencies. The direction of man's creation tends constantly from deficiency to efficiency. The main stages in this recurring development are marked by a rise from one standard of living to another. Sociologists speak of "higher" and "lower" standards, but we can only speak of correalist standards, since concepts of higher and lower are entirely relative.[3] *Needs are not static: they evolve.* The intermediary stages of the evolution of needs, as Fig. 1b indicates, seem to develop in the following progression:

1 Present standard
2 Standard is absorbed
3 Absorption demonstrates inefficiency
4 Inefficiency leads to observation
5 Observation leads to discovery
6 Discovery leads to invention
7 Invention meets resistance
8 Resistance leads to "projected need"
9 Projected need leads to small-scale production
10 Small-scale production generates promotion
11 Promotion leads to quantity production
12 Quantity production creates absolute need
13 Absolute need becomes new standard

Fig. 1b shows that actual needs are not the direct incentive to technological and socio-economic changes, as is commonly assumed. Needs evolve, and that evolution is based on the nuclear character of the human structure and its environment.[4]

Health is man's ultimate need

The failure of an artificial tool to protect man, leads to impaired physical resistance. His health is unbalanced. If by the power of his tools the re-generation of his degenerated physique fails, man's health declines in a progression from fatigue to death. *The fundamental denominator, therefore, to account for the validity of any technological environment, is man's health.* Measured by this crucial, all-embracing criterion of health, technology is one of the most powerful factors for preserving man's energy.

Health appears to be that bodily condition in which the various materials and processes that maintain life-activity are in functional equilibrium.

The resistance-capacity of an individual is the degree in which this equilibrium is able to withstand or absorb the impacts of the environment. There are two sets of these factors: external and internal. The external factors belong to the exigencies of the natural environment. The internal factors are psycho-physiological and are intrinsic to the individual.

Health was originally maintained by organic adaptation to environment. Some of these adaptations are essentially functional (digestion, temperature, blood pressure, etc.), or essentially structural (pigmentation, posture, etc.). There are also adaptations to the human environment, as represented by socio-economic relations (state institutions, industry, trade, marriage, etc.).

The concept of health recognizes fatigue as a part of a continuous natural process. Fatigue is normally produced by the expenditure of energy incident to psycho-physiological action (voluntary and involuntary). This, expended energy, under normal conditions, is replaced by means of physicochemical processes in the body. *When the processes of expending and replacement are in proper balance, we may speak of an optimum efficiency. When this is not the case, we have inefficiency, or waste of energy: de-generation.*[5]

Environmental control and the maintenance of health

What are the factors which impair the efficiency of the body? Obviously, maladjustments between the body and some parts of its environment, external or internal. Technological environment can be of vital importance in relieving such maladjustments by *protection against fatigue* (preventive) and by *relief of fatigue* (curative).

Unfortunately, history proves that this technological environment has not always been per se beneficial to man's health: on the contrary. Thus, we come to the second factor: In which direction, then, shall technological environment be developed? Development of industry for industry's sake is worse than art for art's sake. Imperative, therefore, is the control of direction of technological production. What is environmental control? Since the means of control are part of the environment, the term would appear to mean simply control of environment by environment. The term becomes clearer, however, when we remember that environment is threefold: natural, human, and technological. Environment control, then, is control of the human and natural environment through *technological environment*.

But control in relation to what? From the correalist viewpoint there can be only one answer: *in relation to man's health*. Control of environment becomes, then, control of health: not control of the environment's health, but control of the health of man and society by environment. The proper term will then read: technological control of environment or *environmental control by technology*.

The maintenance or adequate "management" of technological environment can have only one purpose: to maintain the equilibrium of its health. In turn, the maintenance of the technological environment in proper health can have only one purpose: the maintenance of the equilibrium of man's health.

Health, the criterion of building design

Hitherto architecture has been judged from four viewpoints: (1) beauty, (2) durability, (3) practicability, and (4) low cost. But these four factors have never altogether coincided in a single work. If a piece of architecture is not beautiful, it is excused on the ground of being cheap; if not cheap, it is excused as being durable; if not practical, it is perhaps beautiful. It would appear, then, that the only way to resolve these age-old contradictions is to find one criterion which will do for all. *This criterion, in my opinion, can only be health.* The rest may be left to personal idiosyncrasies on the part of the consumers and producers, so long as these do not impair the essential criterion.

Thus, architecture, in the future, will not be judged chiefly by its beauty of rhythm, juxtaposition of materials, contemporary style, etc., etc.; it can only be judged by its power to maintain and enhance man's well-being—physical and mental. *Architecture thus becomes a tool for the control of man's health, its degeneration and re-generation.*

“Form follows function” an obsolete design formula

In the early Twenties, there was again much loose talk about functional design. But when we examine the buildings which were then built, and the drawings which were then presented, we find that no new functions had been invented. All that happened was that, by debunking old decor and adding new gadgets, new forms had been wrapped around conventional ways of living. No one could define what function was. Worse still: no new building principles adequate to a new idea of environmental order had been conceived.

The problem was posed in the manner of the Scholastics: should function follow form, or form follow function? Architecture was thus saddled with a new version of an old conundrum: which came first, the hen or the egg? What was overlooked was the very essence of the problem: the inter-relation of form and function with *structure* and the fact that, genetically, all three are contained within the protoplasm of thought.

If we abandon the Scholastic approach, the contemporary designer can learn a valuable lesson from the hen and the egg. In 1912, at the Rockefeller Institute for Medical Research, a hen’s egg in process of hatching was opened. The developing chick was removed, and the tiny fleck of its heart was cut out. This bit of living tissue was transferred to a solution in a test tube. There, protected from germs, poisons, heat, and cold and provided with a never-failing supply of oxygen, sugar, and other nutrients, it lived and flourished far better than the heart cells in any living chick ever did.

This experiment confirms the view that, while life comes only from life, it is also dependent on its technological environment. By changing the physical environment, life may be quickened and increased, retarded or destroyed.[6]

What was done for the bit of living tissue at the Rockefeller Institute, experimenters have not yet been able to accomplish for the animal as a whole. But the experiment indicates that a planned chemical environment can be as beneficial for man as for other animals; equally important for man is a properly planned technological environment.

The question investigated in connection with the chick’s heart is: at what point and by what means does inanimate matter pass over and become alive? “To find that bridge between nature and man has become the grand quest of science.” Similarly, finding the bridge between man and artificial, man-built, technological environment must become the grand quest of future building design.

New definition of function

We must examine what function has meant, and what function will come to mean in the future, as it concerns the designer. We cannot conceive of function as something static, else growth would cease. The inter-action of environment and man, and the evolution of that inter-action to new possibilities, is not a direct result of environment. It is rather the development by environment of something which was *already inherent* physiologically in the organism.

Function depends not only on natural environment, but also on artificial environment. If functional design depended on the *status quo* of man, it could never develop. It would take care only of man's traditional aspects. But man's evolution has proven that changing environment increases or decreases man's potentialities. Technological environment, being a part of the complex of environmental forces, must consciously contribute to the extraction and development of man's inherent possibilities into a higher order. What these possibilities are depends on the designer's ability to envision and realize them.[7]

Any form is incomplete in itself: it is identified by what it emanates, visibly or invisibly, voluntarily or involuntarily. The new designer will therefore define function as: *a specific nucleus to actions*. It is erroneous to suppose that form follows function. This concept must be replaced by the proper progression of: (1) structure, (2) function, (3) form. All functions and all forms are contained in the structure.

Defining design and Biotechnique

As in the case of electricity, a polarization creates a nucleus of relationships. These relationships are latent potentialities for further development. In this respect, *all possible needs of man are ever present, but it is only by the demands of the special environmental stimuli that the specific need is brought to the fore*.

Thus it appears that not only is the formula "form follows function" inadequate; the "functional design" based on that formula is likewise inadequate. The term "design" must be re-defined. Since the building designer deals with *forces, not objects,* design is therefore, in my definition, *not the circumscription of a solid but a deliberate polarization of natural forces towards a specific human purpose*.

Such a science of design I have called BIOTECHNIQUE[8] because it is the special skill *of man which he has developed to influence life in a desired direction. Biotechnics,* a term which Sir Patrick Geddes has employed, can be used only in speaking of *nature's* method of building, not of *man's*. There can be no interchange of these two methods, because nature and man build on two different principles:

nature builds by cell division with the aim of continuity; man can only build by *joining parts together into a unique structure without continuity*. Nevertheless, man-made joinings are ultimately controlled not by man but by nature. The process of disruption through natural forces becomes imminent from the very moment of joining parts. Building design must, therefore, aim at the reduction of joints, making for higher resistance, higher rigidity, easier maintenance, lower costs. Such considerations led me to develop *Continuous Construction*.[9]

The more man recognizes his limitations in building "fora lifetime," the more valid is his structure. As a biologist has said:

We doubt that an engine might be conceived to which we might bear witness that, after we might have broken it into a hundred pieces, it would reform immediately into a hundred single complete engines. But take that graceful animal, the fresh-water polyp, that is found attached to water lilies in the pond, and cut it into pieces: tomorrow you will find that each piece has become a complete polyp.

The new designer will learn to understand the methods by which nature builds to meet her purposes (biotechnics): but he will not imitate her methods. He will draw the necessary conclusion from the disaster which befell London's Crystal Palace.[10]

The Biotechnical approach tries to develop the possibilities of specific actions contained in any nucleus of human physiology. These potentialities remain at first undiscovered. Only with time are they individually or collectively developed until finally they are consciously demanded. The result will be entirely *new functions* within the old framework of what was considered "human nature," sustained by inventions.

The objective: minimum biotechnical standards

The two approaches—biotechnical and functional—develop from unlike sources and lead to unlike results. On the one hand, functional design derives from the traditional behavior of any tool; on the other hand, biotechnical design derives from the evolutionary potentialities of man. Functional design develops an object. Biotechnical design develops the human being. Functional design is oscillating. Biotechnical design is inventive. A functional object is inert. A biotechnical object is re-active.

The biotechnician emerges as an important factor in the evolution of society toward a higher standard of living through the control of elements of fatigue and forces of re-generation. This leads to the discovery that no part of the human body is mono-functional; rather, each minute detail is again of nuclear make-up with corollary functions.[11]

Such development can be furthered by the biotechnician who formulates and helps to realize a *biotechnical minimum standard*. Such a biotechnical minimum standard must be based on Correalism and not on mere architectural derivations, which tend to house lower-income groups in dwarf reproductions of giant villas. The *biotechnical minimum standard is that technological environment of home, work-place, and their corollaries which meets the optimum needs of man's health*.

Every object that meets a need is living: it is only dead when it ceases to meet a need or when the need itself disappears. Anything of nature's creation which fulfills a need is a living organism. Similarly, every creation of man's technology is a living organism, whether it be a pillbox, a house, or a motor. Since the criterion of life is activization, we assume that a man no longer active is dead. By analogy we assume that because an object does not express itself in visible activity, it also is dead.

Here our judgment is determined by the limitations of our senses; for, as a matter of fact, when an object moves (a moving locomotive, a flashing electric bulb) we automatically say: it is alive. Conversely, when an object does not move, we automatically assume: it is dead. Our assumption of what is alive or dead is chiefly the result of optical observation. But this nerve center is "short-sighted." With a microscope we can see that a dead piece of cheese is very much alive. The revision of our judgments as to what is "alive" or "dead" must, for the time being, depend solely upon a more profound observation of facts.

Architecture: generator and de-generator of human energy

The floor on which one walks, the chair on which one sits, the bed on which one rests, the wall that protects, the roof that shelters, and all other units of the man-built environment are significant for what they are: but they also possess *nuclear multiple-force*. It is commonly assumed that these are dead objects; actually they represent an interplay of action with one another and with nature. They are a constant exchange of anabolic and catabolic forces within themselves, and in their coordination with human beings, and through human beings with themselves again, they constitute high potential energy centers.

The modern physicist speaks of constant bombardment of the earth by invisible cosmic rays, of radiation and radio-active elements which cannot be seen or felt, but which, in time, can exert a deadly or beneficent effect upon all life. *This is equally true of the "inter-stellar" organization of a house, a town, or a city.* But here the forces at work are composed not only of animate and inanimate matter, but also of artificial technological bodies.

Biotechnique as a force of re-generation

The orbit, region, and scope of the activity of technological bodies (be they houses, machinery, or any other tool) are the objectives of the future biotechnician. He will find that any structure he builds is *worth only as much as the ratio of its force of regeneration*.

Despite the imperative need for health-yielding technological tools, obsolete manufacture clutters the market.[12] As far as the building designer is concerned, his contribution to halting such anti-social types of production will be the constant use of the biotechnical approach.

The biotechnical approach has led me to the *evolutionary method of design which, instead of taking its departure from prevailing commodities, employs the study of general physiotechnics*. This enables the biotechnician to avoid giving a mere narrative survey of phenomena, and—on the basis of a genetic account of an unfolding process—to create the necessary need-service. The Mobile-Home-Library shown on the following pages, represents a test of the validity of biotechnical design. The storing of books in the home was chosen as an objective for the first laboratory test because: (1) it is a need in every family's home, and (2) it has become so standardized in the form of a "bookcase" that its re-design seemed at the beginning a wasteful undertaking. The Mobile-Home-Library thus constitutes a documentation for this general statement: *Functionalism shifts the strain from the technological tool to the human being: but, here, biotechnique shifts the strain from the human being to the tool.*

NB Not all figures mentioned in this article have been reproduced.

1 In an earlier manuscript of Mr. Kiesler's ("From Architecture to Life," for Brewer, Warren and Putnam, 1930) the groundwork of this paper was laid; it was first read in approximately its present form at a Symposium on Science and Design held by the Alumnae Association of the Massachusetts Institute of Technology, June 6,1938; this is its first appearance in print.—Ed.

2 The part of Darwin's theory which stated that *"acquired characteristics are inheritable"* has been disproven (August Weissmann, 1880). Thomas H.Morgan: "the belief in the inheritance of acquired characteristics is not based on scientific evidence but on the very human desire to pass on one's acquisitions to one's children."

3 PROGRESS OF TOOLS RELATIVE TO TIME STRATUM: There is no abstract technological progress. Each stratum of the social development in man's history has produced its own tools to deal with various old and new forces. Each new environment creates new varieties or new standard types of tools which lose their validity if applied backward or forward in history.

4 Examples of nuclear production in industry: corn, subjected to mechanical and chemical treatment, also yields starch, dextrin, glucose, oils, feeds, and other valuable by-products. The hulls of oats yield furfurel, a valuable starting point for chemical synthesis. Waste sugar cane,

from which the sugar has been extracted, forms the raw material for making wall-board and insulation. Saw mill wastes are converted into building materials. Similarly, carbon is the nuclear factor for many products: we encounter it in our heating arrangements in the form of coke, charcoal, and coal; we use it in our pencils as graphite, etc.

5 FATIGUE—Fatigue may arise in: (1) the central nervous system, (2) the muscular system, (3) in both combined. "Fatigue may be subjective as experienced by the worker or objective as noted in his actions and output. From a thorough consideration of the literature it is quite evident that a vast amount of emphasis has been laid upon the mechanical or extrinsic factors influencing the working capacity while the multiplicity of original physical and mental states that may limit the working capacity have become almost wholly neglected." From *Waste in Industry,* published by Federated American Engineering Societies, Washington, DC.

6 Jickeli (1902) and Carrel (1912) put forward the hypothesis and finally experimental proof that aging (and death) result from imperfect metabolism within the cell and the subsequent clogging of the cytoplasm with injurious waste. Carrel has shown clearly (tissue-work) a relative potential immortality of the cell, and at the same time its subordination to the fate of the whole organism.

7 In attitudes toward the technological environment, we observe three tendencies as to morphological principle: (a) the functional or synthetic, (b) the formal or transcendental, (c) the mechanical-materialist disintegrative. The mechanical-materialist attitude is not distinctively biological, but is common to nearly all fields of thought. (It dates back to the Greek atomists. The self-deceiving triumph of mechanistic science in the nineteenth century led many to accept mechanical materialism as the only possible scientific method.) Even in biology, but especially in design, it is more akin to the formal than the functional attitude.

8 The term "biotechnique" appeared first in my treatise on "Town Planning"; as "Vitalbau" in "De Stijl" No. 10/11, Paris, 1925, and in America first in "Hound and Horn," May 1934.

9 Not actually formulated until my plans of The Endless House were exhibited in Paris, 1925, and New York, 1933. View of my Space-House (New York, 1933) showing first continuous construction in shelter design and also continuous window framing (right).

10 That structure was built in 1851 by Paxton in imitation of the structural principles of the African water lily's foliage, with its longitudinal and transverse girders. This was an essentially romantic attempt to fashion a man-built structure by *literal application* of nature's design principles. The collapse of the Crystal Palace (1936) was inevitable (Fig. 8). (The fireproofing of buildings—then as now—is far more important than the pursuit of "new forms.")

11 J.R.de le H.Marett: *Race, Sex, and Environment*. Hutchinson's Scientific and Technical Publications, London, 1936.

12 *Waste in Industry.* By the Committee on Elimination of Waste in Industry of the Federated American Engineering Societies, Washington, DC, 1921.