When Neutra Met Brains and Buildings: A Reader's Guide to 'survival Through Design"

Michael A. Arbib

> Individual and social psychology will ultimately merge with brain physiology to guide the designer in his observation and creation of response patterns.
>
> Neutra. 1969, Chapter 28

> In our own age of both industrialism and collectivism, our advancing knowledge of physiologically based psychology must rectify the picture of heroic independent creation by investigating the interlocking chains of group stimulation and reaction and chains of nervous events, mutually sparked, through which complex design is originated and executed, and on which its reliable survival value will depend.
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> Neutra. 1969, Chapter 40

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Introduction

In 1954, Richard Neutra (1892-1970) published a prescient book, *Survival Through Design*, in which he synthesized his experience as an architect and as someone who had experienced the first half of the 20th century in both Europe and the United States with his reflections on physiology, broadly conceived. He set out ways in which humans must plan and design to ensure the survival of the human race.

(Left) The cover of the 1969 Reissue of the 1954 Edition, introduced by Raymond Neutra. (Right) The cover of the 2023 Edition, introduced by Barbara Lamprecht.

The Neutra Institute for Survival Through Design invited me, as author of *When Brains Meet Buildings: A Conversation Between Neuroscience and Architecture,* to recount my experience reading the book and reflect on how well it stands up in light of 70 years of advances. The talk was presented at the Institute's Offices in Silver Lake, California, on November 5th 2022.

Raymond Neutra, son of Richard and President of the Institute, asked me to transform my copious notes on *Survival Through Design* into a reading guide that would help young architects (and others) to select chapters to read if they wished to focus on particular topics. This document is the result. As we read Neutra's view of the physiology of 1954 and earlier, it is worthwhile to ponder the way in which certain concepts have endured, other have been subtly modified, while others have been proven wrong.

In the opening pages, Neutra employs a very special rhetoric when he presents the long view: "The confused wreckage of centuries, unrelated to any current practical purpose, is mixed in a most disturbing manner with our often feeble, often arbitrary, attempts at creating order." Throughout the book, Neutra enriches his discussion with historical and literary allusions, as well as references to then (1954) recent research in physiology, including that of the brain.

Neutra looks to physiology to help the designer direct and check technical advances in the constructed environment. Among the issues that arise through the book are to what extent the architect can combat special interests, and to what extent the emergence of diverse cultures over-rides the "basic" biology of brains in bodies in social groups in natural and unnatural environments. Designs must be conceived by a profession brought up in social responsibility, in aiding the survival of the human race which is in danger of becoming [we might say "has already become"] self-destructive.

Neutra assesses the design of buildings and cities impact human well-being, and offers critiques that are still highly relevant with wit and broad reading that takes the discussion far beyond a focus on "mere" architecture. He repeatedly suggests how studies of physiology may inform new designs, and outlines scope for possible experiments. The architect will find that some then futuristic ideas have now been realized, and our experience with them suggests pluses and minuses that were not evident in 1954.

Survival through Design combines a large number of essays written by Neutra in the decades leading up to 1954. While the essays have been edited to form an integrated whole, there is some overlap between the chapters. I greatly enjoyed the weeks I spent "with" Neutra, studying his insights into history and literature as well as the practice of architecture, and the challenges of using physiology – and developing new experiments – to adapt buildings and cities to support human well-being, an effort that also includes thoughtful analyses of the social implications of design.

In linking Neutra's ideas to more current research, note that he often seems to speak of physiology when we might today speak of cognitive processes that operate at several levels above the basic physiology. Moreover, Neutra speaks far more of experience than of behavior, though he does note the physical , and thus mental, economy of automatization of habitual forms of certain routines.

Although Neutra talks about culture and about evolution separately in many places, he only uses the phrase cultural evolution a few times and wrote before development of studies of niche construction. As is well known, organisms adapt to the ecological conditions, the *niche*, in which they find themselves. A modern refinement talks of *niche construction* – just as beavers building dams create ponds that offer a new niche both for life and evolution for themselves and other species, so does human culture and the patterns of buildings and interactions that support it continually create new niches for further *cultural evolution* of humans even when no change in the genome is required to underwrite it. Building on these ideas, I espouse an *EvoDevoSocio* framework that fits well with that sought by Neutra: *biological evolution through natural selection* (*Evo*) sets up the basic mechanisms by which *the individual develops* (*Devo*), but the development depends not only on the physical environment but also the *social environment* (*Socio*); and more than any other species humans can modify both through , including by architecture and cultural evolution (where culture is consider in broad terms, not just as "high" culture). To a great extent, cultural evolution is cumulative, and it involves systems such as language that are not mentioned by Neutra in this regard. However, he does consider the formation and transformation of habits, and this provides the engine of cultural evolution.

When I read a book like Neutra's, I am continually asking three questions: What can I learn that I did not know before? Where do I want to argue with some of the author's assertions? And what new challenges might they offer for my own future work? My main effort in this guide is to help readers address the first question, deciding when to read a full Chapter as Neutra wrote it. My further hope is that each reader will develop their own answers to the latter two questions.

I have culled the extensive annotations on my copy of *Survival through Design* to offer a Commentary on each chapter, but I encourage the reader not only to enjoy and learn from what Neutra has written but also to engage in an imaginary dialogue with him while continually asking what new studies might enrich our understanding of the relevant physiology and its implications for further progress in architecture and urbanism that addresses Neutra's concern for survival through design.

Survival through Design combines a large number of essays written by Neutra in the decades leading up to 1954. While the essays have been edited to form an integrated whole, there is some overlap between the chapters. I greatly enjoyed the weeks I spent "with" Neutra, studying his insights into history and literature as well as his insights into the practice of architecture, and the challenges of using physiology – and developing new experiments – to adapt buildings and cities to support human well-being, an effort that also includes thoughtful analyses of the social implications of design.

Format of the guide

The original 1954 edition had no illustrations. It was reissued in 1969 by Oxford University Press as a paperback edition with a Foreword by Raymond Neutra followed by a generous selection of photographs of Richard Neutra's works, placed at the front of the book rather than linked to the text. 2023 sees a new edition published by AtaraPress with an Introduction by Barbara Lamprecht, the leading scholar of Neutra's work, and with copious new illustrations that this time are distributed throughout the text.

The format of the Guide is as follows:

The chapters are gathered into themes with related content. These themes are my invention, not Neutra's, but the idea is this – with 47 chapters it is hard to search them individually to find those of interest. However, it is relatively easy to choose a theme according to its headline, and then read the few pages this guide devotes to it as a basis for choosing which chapters to read in more detail.

For each chapter, the format is:

- **Title:** The title is followed by the page numbers in the 1969 edition.
- **Neutra:** This reproduces the sentence or two Neutra placed on the first page of the Chapter – it may be informative, ironic, or simply rhetorical.
- **Synopsis:** This is my attempt to summarize Neutra's ideas presented in the Chapter.
- **Commentary**: My own comments on what Neutra has written.

The charge for my talk at the Neutra Institute was to reflect on the book in the light of work of the last 70 years, and especially ideas associated with the Academy of Neuroscience for Architecture (ANFA). I thus add an Appendix with 2 parts:

- A brief account of ideas presented by the architect John Eberhard, FAIA, Founding President of ANFA, in his 2008 book from Oxford University Press, *Brain Landscape: The Coexistence of Neuroscience and Architecture.*
- Some key concepts from my 2021 book, also from Oxford University Press, *When Brains Meet Buildings: A Conversation Between Neuroscience and Architecture.* it carefully explains a range of concepts from cognitive science and neuroscience and explores their relevance to the experience and design of a wide range of buildings.

The aim of this Appendix is to invite the reader to explore ideas linking science and architecture that emerged in the first two decades of the 21st century and to take part in the expanding conversation.

Theme 1: Setting the stage

1. THE NATURAL ENVIRONMENT, DOCTORED UP AND WARPED (3-7)

Neutra: The natural environment is doctored up continuously and warped by the acts of the human brain.

Synopsis: Neutra declares that modern humans have reached a stage of crisis and calls for new ideas for design, rooted in physiology, that will contribute to human survival. Physiology must direct and check the technical advances in the constructed environment, with organic evolution extended into a man-shaped future. Long term investments in the constructed environment will be legitimate only if the designs have a high provable index of livability and social responsibility. Naive parochial outlooks needs supplementation by global forethought, experience, and contemporary know how. Tangible observation rather than abstract speculation will have to be the proper guide. And drifting will no longer do.

Commentary: When Neutra speaks of survival of "the race," but means the human race generally; racial divisions play no role in his work. When he speaks of survival, he presumably had in mind the terrible destructiveness of two World Wars and the challenge of the breakup of empires following World War II. Reading his work today, we are likely to think about climate change, so that the sourcing and use of energy become as pressing to human survival as reduction of conflict. However, the 'survival" that is being designed for in this book is more the development of buildings and cities that support the physical and mental well-being and healthy development of individuals than to global challenges at the national or global level.

2. IS PLANNING POSSIBLE? CAN DESTINY BE DESIGNED? (8-16)

Neutra: Is planning possible? Can destiny be designed?

Synopsis: Neutra notes that various religious and philosophical traditions question whether man is really separable from the world at large so that he can act upon it. There is a never-ending combat between two trends, to plan or not to plan – to be provident or to let things happen. But we seem born and built to make anticipations equipped with brains, as we are, we must plan and design. This world of gigantic industrialized production hardly knows any bound set by biological wholesomeness, and Neutra concludes that we must plan and design and never lose sight of the ultimate consumer – the human species as a whole. Neither physically nor biochemically nor sociologically can the individual really be segregated or isolated as a separate entity. The organism permits no severing of the hereditary from the environmental.

Commentary: Reading this Chapter raises varied questions to hold in mind as one reads other Chapters. To what extent is architecture an exercise in the remolding of minds, and not just physical conditions? Indeed, to what extent can mind and environment be separated? We must note the crucial role of the brain in adapting to the environment (natural, social, and constructed) and thus modifying our ongoing interaction with the physical and social environment.

Neutra studied the work of George Coghill (1872-1941; author of *Anatomy and problems of behavior*, Cambridge University press, 1929), who concluded that there is no behavior is 'spontaneous," not caused from the outside. However, behavior reflects both external and internal states. We must understand how internal state interacts with external inputs, and how the resulting outputs affect the state changes of other subsystems with which the given cell or subsystem is in interaction.

3. MANKIND CANNOT – JUST VAGUELY – FLOAT TO SURVIVAL (17-22)

Neutra: Mankind precariously floats to its possible survival on a raft, rather makeshift as yet, and often leaky: Planning and Design.

Synopsis: We need criteria for design that go beyond the needs of selfish clients to address challenges on a global scale – such as post-WW II reconstruction, for Neutra in 1954 [and climate change for us]. the spread of carelessly caused decay, waste of natural resources within about us, destruction and blight, approach a most alarming and desperate magnitude.

Physiology has discovered no separate senses for beauty and for utility and one thus cannot have two kinds of design, one dedicated to beauty, ideals, goodness and truth; another meant for supposedly practical utility.

The high geared yet unevenly spreading planetary industrialism of the second-half of the 20th century, has given rise to fantastic figures of consumption, creating a biological situation without precedent for architects and urban planners. We need reliable values which can guide future efforts. The entire organic evolution that had seemed to culminate in the social and physical structure of human culture must not end in chaos simply because humans cannot learn to control by the brain the constructions and multiform products of the brain.

Commentary: A major challenge is to balance diverse criteria set by a range of stakeholders rather than simply those who want to get the job done at minimal cost or at maximal profit to themselves. Public housing and rental properties exemplify these challenges. Or consider a freeway that divides an area of a city with the possible destruction of a community that has been bisected. The general issue is how to respond when a system well adapted to one regime (the town before freeways) is confronted with one that is very different, or even inimical (speeding ever increasing road traffic).

We need a blend of cognitive science and neuroscience (extending Neutra's notion of physiology), but must not forget the power of social structures – the way in which different historical settings may modulate both the perceived challenges and the individual response of architects in establishing new approaches to design.

4. MAN-MADE SURROUNDINGS – SOURCE OF NEVER-ENDING STRAIN (23-28)

Neutra: From a baby carriage to a metropolis, our man-made surroundings, top-heavy with technological trickery, have become a mold of destiny – and the source of never-ending nervous strain.

Synopsis: The nursery in which a child spends its first formative years, the bathroom in which it is taught the essentials of modern cleanliness, the house containing these rooms, the street of which this house stands, the neighborhood to which the street belongs with its schools, places and work, worship, and recreation are all part of our constructed environment. It can be friendly or hostile to the human organism on which it perpetually acts. Neutra recounts how his childhood experiences taught unspoken lessons in appreciation of space, texture, light, and shade, the warmth of wood, … and laments that college lectures on architecture never touched on such basic sensory experiences, or on the subtle relationship between physical structure and human physiology.

The process of adjustment by early humans [e.g., before agriculture and the first cities] to the environment was largely automatic. The man-made environment, however, is subject to far more rapid changes. There is no time for slow biological adjustment to novelties which at any moment may become technologically feasible. Experts in organic requirements and reactions must help us steer clear of precarious maladjustment.

Commentary: Here Neutra advocates cultural evolution and niche construction guided by a deep understanding of physiology. If human survival is measured only by population growth, then the growth of world population 1954 from 2.7 billion to reach 8 billion in November 2022 could be counted a success – but we know that climate change, competition for resources and destruction of the rainforest suggest that this view is mistaken

Neutra wrote before the digital age of personal computers, smartphones, social media, AI, and the Internet of Things. Building on his insights thus requires not only a deeper understanding of the last 70 years of biology but also an extended assessment of the pluses and minuses of this new techno-ecology.

5. ARCHITECTURE: A BELATED CAMP-FOLLOWER OF NATURALISM (29-42)

Neutra: Rational thought versus traditional bias in design: architecture, a belated camp-follower of "naturalism."

Synopsis: Neutra offers a broad historical perspective that includes the rise of science in the 19th century even as architecture was still captive to old ideas.

The new industrial technology showed that science really "worked" – yet the 19th century saw the rise of an industrial proletariat, living in shockingly crowded slums with hordes of sickly and neglected children. However, the same century saw the emergence of social psychology and the experimental and physiological psychology initiated by William Wundt.

19th century biology [especially Darwin's account of evolution by natural selection] showed that every living organism must be adjusted to its environment, and that species and genera had indeed been

molded by their environment through millions of years – but Neutra laments that evolutionary terminology was glibly introduced into 19th century interpretation of man's comparatively fast moving history to justify slums as a natural necessity. By contrast, Engels showed that the slums had sprung up on the outskirts of almost every large community into which a greedy industrialism had crowded the laboring population.

Neutra contrasts the radical naturalism of Zola's novels with the overstuffed nature of his apartment, very different from the current idea of a clean and airy room. Zola worked in a study encumbered with antiques and slept in a Louis XIII bed in an airtight compartment – and died from suffocation in a hermetically sealed sleeping chamber.

Before the American Revolution, sizeable democracies had existed only in ancient Greece and Rome. Graeco-Roman patterns of life and artistic expression were therefore promptly revived to serve and symbolize the new order. In a manner hardly compatible with the dawning machine age, Americans built banks in the forms of Greek temples. Neutra closes by pointing the way to an approach to design that exhibits an attitude of sharpened, objective, all around observation – while insisting that intensive human art can thrive in this new atmosphere.

Commentary: The Industrial Revolution moved many people from rural settings to live in crowded tenements with their lives controlled by work in the factories. Slavery still played a huge role after the American Revolution while the French Revolution was succeeded by the Terror and the rise of Napoleon – and racism and religious strife persist to this day. The conundrum for today's architect is thus to understand patterns of historical change and their implications in today's world in a way that develops new insights into human needs and what architects can do to support them -- seeking ways to affect large scale social change given all the special interests that are at play. Even today, architects focus on the buildings of the wealthy and the upper middle class rather than on the needs of the poor.

47. DESIGN AN ART – NOT CRIPPLED BY SCIENTIFIC CURIOSITY (381-384)

Neutra: The art of design can associate itself with scientific skill, and do so without an inferiority complex.

Synopsis: Although this is the last Chapter in the book, I place it here since it may best be read as the completion of Neutra's stage. It is a call to arms rather than offering new insights. Here, Neutra exhorts the architect to learn basic knowledge from science, and especially physiology, which may inform design for human well-being and survival, while insisting that designers cannot be wholly governed by scientific attitudes or methods, or aspire to be scientists themselves. They must rely on intuitive insight often telescoped almost into an instant. Neither can they have the laborious slowness of science. The art of design which is part of the art of living cannot be replaced by science or technology

The designer must aim to contribute to the growth of the smaller organic community within arm's reach, as well as to suit the now evolving planetary society. The current technological accomplishments, after they have been carefully sifted, must be shared universally for the true benefit of the human race, and for peace on a shrunken globe. Physiology, the science of life, will support us in arriving at a truly contemporary set of objectively valid criteria for determining the requirements of the consumer, the uses of appliances, vehicles, equipment, buildings and societies and cities.

To round out this peroration, here is an extended quote from Chapter 45: Using all available means, we may hope to design and build more soundly for the multitudes of human beings who cannot extricate themselves from the confines and the fastnesses of contemporary industrialized environments. Step by step, we may thus erect a safe stairway leading to more wholesome and more spacious level of human-conditioned existence – even if the topmost landing and a panoramic view to reward the long ascent may never come into our sight during our own brief span of life.

Commentary: Neutra's call for survival through design implies that we must not simply accept ill health and poverty but instead look to how to *reconstruct the niche* for the betterment of all people – while also taking the ecosphere seriously. However, different sciences, arts and practices have different domains of applicability, and so I argue for a fruitful conversation between architecture and the sciences, not that the practice of architecture be reduced to the results of physiology or neuroscience.

Theme 2: The age of mass production

6. PERFORMANCE GUARANTEES VS. OLD "QUALITY" (43-52)

Neutra: Performance guarantees versus old "quality" ideas. Forms around us become dictated by an industrial technology and justified by "operation."

Synopsis: In America, pragmatism and behaviorism attracted wide attention, proclaiming that an idea was true if it worked and arguing that a thing had truth because it worked and had beauty because it functioned. However, Neutra rejects the notion that perfect functioning guarantees a "beautiful" form – but stresses the transition, personified by Louis Sullivan, from an architecture inspired by old models like the Greek temple to one that addresses the needs of the vast American public in a machine age of mass production. The interdependence between *morphology*, the science of organic shapes, fabrics, and textures on the one hand, and *physiology*, the discipline of life functions on the other permeated Sullivan's profound conversations – which inspired Neutra.

Modern life and production are no longer based on the skill of the individual craftsman but determined by the machine and based on a mass consumership. Even the simplest building is a complex structure whose "raw materials" are the results of complex manufacture. Even the architect is unable to judge the "quality," in the craftsman's sense, of these materials, and instead relies on operational measures like cost, performance and reliability. Quality specifications have thus been replaced by performance specifications and so the pragmatic concept of commercial values, gradually came into being.

Commentary: The scientific framework rejects the notion of eternal truths, noting that new data make for new (or updated) theories, but cannot determine the unique theory that accommodates them. Neutra does not address his notion of beauty in this chapter, but the slogans "form follows function" and "form follows feeling" may give us a sense that we are to balance multiple objectives in design – and so, in particular, excellence of function cannot guarantee that other excellence we recognize as beauty.

Sullivan appeals to evolution, but note that evolution can preserve irrelevancies and what may be a local selective advantage may not prove advantageous in the long run. Biological evolution involves random mutations affecting diverse functions – whereas our design should yield targeted changes affecting specific functions. But how do the multiple criteria change when we address the loop between humans changing "culturally" and humans changing the natural, built, and *social* environment that provides the constructed niche to which they may be adapted?

7. QUALITY – ONCE RARITY – NOW "INDUSTRIALIZED" (53-62)

Neutra: Quality once was rarity. In an industrial age, however, quality is no longer aristocratic, and "Beauty" is now on two fronts in battle: with the monster of monotony, and all the novelties of salesmanship.

Synopsis: Neutra notes that mass-production has made objects available to the masses of a quality unavailable to the rich in the past, but laments the cheap "variety" of modern housing, based on salesmanship rather than quality. The lost unity of traditional housing must be restored but that this cannot be done now on any other basis than that of machine production. If a community is to regain mental comfort, "beauty" must be based upon the broad acceptance of standards of its own mental and

technical age, fully harmonized. In this fashion, individuality is not to be a matter of superficialities but the outcome of profound physiological traits that are not honored by just random diversity.

Neutra notes that the electric light bulb has [well, *had* – we now have LEDS, but the same point applies] a metal filament with qualities of fineness developed in hundreds of laboratories... It is the potential and actual market of a billion users of electric bulbs that brought into existence this new type of quality.

And yet, when the idea emerged to evolve creative standards for housing 90% of the population, an activity in which billions of dollars could and should be soundly invested on industrialization, sentimentalists resist the trend to standardization in the name of so-called individualism. They neglect issues of both well-being and improved performance with lower costs.

The natural objective for neighbors is to admit common denominators instead of being victimized by a variety often introduced by mere salesmanship. Neutra argues that lost unity that the 'standardization" of houses in a traditional Swiss village or Japanese cannot be restored if human life, a function of human nervous systems, only adopts a new production reality at the price of a crude and flimsy stage setting.

Commentary: Neutra complains that even wholesale housing projects were doctored up to achieve a spurious individualistic variety. However, we may note the work of William Krisel (1924–2017) who designed affordable homes in Palm Springs with a modern aesthetic based on rearrangement of relatively few features in varied combinations.

In today's Japan, we admire the surviving examples of old architecture, yet also admire the high-speed train, the shinkansen. The challenge is to understand why a building has the features it has, and then assess to what extent modern technology (for example, air conditioning) let the architect override some of the basic sensitivity to geography and community that characterized traditional villages.

Much of Neutra's concern for housing that takes advantage of mass-production is addressed to middle-class concerns – saying little about the individualized design of houses for the better off (let alone the excesses of the wealthy) or to address the needs of the poor living in shanty towns or the homeless.

Neutra argues that, if the community is to regain mental comfort, "beauty"" would have to be based upon the broad acceptance of fully harmonized standards of its own mental and technical age. However, this under-rates the extent to which certain forms can be judged beautiful across diverse cultures, and the physiological understanding of this commonality may be the key to the success of cities where multiple cultures can live side by side and also intermingle.

8. STANDARDS: ANCHOR IN A TYPHOON OF NOVELTIES (63-72)

Neutra: Only with standards as anchor could the typhoon of insecurity be weathered when industrialism broke loose over the world. Earlier, eternity had been cherished, and it called for quite different standards than does calculated period of amortization.

Synopsis: Humans find comfort in following habits, but new materials and new means of production require us to think of new ways of employing them to further human well-being. Learning, transformation of habit, is required on the part of the designer who offers these innovations, to be followed by adaptation on the part of the user to accept the new approach. The challenge is to ensure that this does not involve the choice of novelty for novelty's sake, but rather the ability to evaluate whether an innovation will contribute to an improved quality of life.

The United States seems predestined [as of 1954] to play a leading part in the industrial realization of a new environment [and yet refuses to go metric].

In Egypt the realm of obsolescence, which is that of life, was not considered worthy of great effort and such permanent building material as could be quarried on the rock banks along the Nile valley. Eternity without maintenance was here the aspiration. But slipping out of the chain of ever new is an ideal we cannot possibly entertain. To our science, interrelated events in time compose the universe.

Our minds and nerves intimately relate buildings to the living dynamics of producing and consuming. The finished product and its mode of production, perceived or remembered, are closely linked. The method of creating things color their value for us -- "beauty" is not a static absolute, standing alone.

Commentary: Neutra notes that we can no longer build for eternity. Shortage of resources may demand change, while the positive impact of scientific progress (e.g., development first of electricity and then of solar panels) imposes a new dynamic opposing what is "God-given." Our buildings are now built for anticipated finite periods of duration or deterioration … and yet we want some historical preservation. To what extent does such a balance improve our well-being, balancing the cost of changing habits (even those for judging beauty or a feeling of historical continuity) against the optimization of the use of new technology for human well-being. As new digital devices and social media change and demand our attention, we must learn to adapt these, as well as new construction technologies, to support our own neuro-mental well-being. And we need to develop systems that can respond humanely to unexpected side effects—while stressing that there is no simple separation of physical, social and mental (including "aesthetic" and, in some sense 'spiritual") well-being.

Theme 3: The inseparability of utility and aesthetics

9. "BEAUTY" HONORABLY MAROONED ON AN OCCASIONAL PEDESTAL (73-79)

Neutra: While beauty is proclaimed timeless, relegated to an occasional pedestal, and there honorably marooned, civilization is liable to turn into blight.

Synopsis: The Stone Age collection of the anthropological laboratory at Santa Fe NM contains specimens of amazingly perfect rotation or pottery, made without a turning wheel. The ideal of perfect shape and texture was present in human hearts much earlier. It corresponded to a need of the nervous system which existed long before tools were invented to satisfy it.

But now we have mechanical precision and mass production. Precision, formerly a luxury, has turned into a prerequisite for economical production and maintenance, because the possible market, the scope of consumption, depends on. The first machine products were crude and primitive, but the machine soon proved superior in precision, the quality that craftsmen had proudly regarded as their prerogative.

Birds and insects equipped with exquisite sense apparatus undoubtedly have primitive aesthetic senses, but the human brain, through the associative powers of the forebrain, has developed incomparably more demands and solutions [so that our judgement of beauty may rest more extensively on cultural evolution than on biological evolution].If we look at a pine tree bent by the wind on a coastal bluff, sensory perception ushers in an automatic process of higher brain activity. From beginning to end our emotions are co activated. You feel the present function in relation to external forces, that telling expression of *functional preparedness* – the tree bracing itself in the direction of prevailing winds – and all this is hardly separable from what we look upon as the form and beauty of the tree. Where does the utility of a tree stop and its beauty start? Separating utility and beauty has dangerously harmed, not helped, an understanding of design of a well-integrated environment.

Commentary: This chapter has a rich set of allusions to capabilities of the human brain. The Appendix offers some pointers to current research and possible implications for architecture. In particular, Neutra's chapter foreshadows much of the current concern relating empathy and 19th century Einfühlung ("feeling into" a work of art or architecture) to mirror systems in the brain. Imitation (Chapter 10), like empathy, has been linked to mirror neurons, though my own work has emphasized that mirror neurons are only effective though their integration into neural systems "Beyond the Mirror."

Neutra ask not to separate the form and beauty of a tree, but this may be somewhat misleading. Given a range of trees, we judge some more beautiful than others, even though each is equally successful in its

growth and survival. Moreover, we do not appreciate roses for their functionality so much as their perfume and their visual beauty. Thus the architect seeking survival through design must seek ways to present the necessary functionality in ways that are aesthetically pleasing. And consider how cars may compete on taillights and hubcaps as much as aerodynamics and mileage.

The scientist does indeed need to conduct separate studies isolating brain mechanisms supporting key features of vision or action or memory or a host of other functions – though these may be that basis for higher-level studies of system integration. As for the architect, the many submissions to an architectural competition may vary greatly in form even as each seeks to meet the functional requirements of the brief; and both during the design process aspects of functionality and beauty may be designed somewhat separately in alternation with their integration.

10. NATURALLY "GROWN STRUCTURE" AND OUR "CONSTRUCTING" (80-90)

Neutra: Nature's forms grow quite differently but they often are models for those designs which man produces, accepts, and, before long strangely tires of.

Synopsis: Designers should make peace with the creation which long preceded our own, yet in recent times the specifically human capacity of troubling nature has increased way beyond all [previous bounds]. Much human activity goes into imitating nature but the result may lack what makes the biological system of great value. Whether or not biological inspiration is involved, much human effort is expended on novelties which soon become boring. We need an understanding that matches organism and environment to inform technological evolution whose rapid pace too often yields results that are not conducive to human well-being.

Neutra repeats his claim that a distinction between a *constructivistic* and a *functionalistic* aspect in nature would be a theoretical segregation of what in fact is a concrete unity: growth, but now concedes that in human production this division is real and can never be fully overcome.

Our human products will have to demonstrate their wholesomeness over long periods not only for the individual consumer but to aid the survival of the human race itself, attuning human ways to nature's order. Yet humans change increasingly the natural [or just "previous"] surroundings. Houses, road networks, and cities are created [and keep changing], changing the nervous makeup of generations.

In nature, even minor deficiencies in adaptation have in the long run obliterated entire species. Obscure, seemingly insignificant elements of our man-made environment may produce disastrous effects if given sufficient time [and there may also be adaptations that appear beneficial during a current stage for an ecological niche, yet may prove harmful once that stage is passed].

Imitation aims to reproduce a desired pattern of stimuli that has earlier elicited one's positive response, and imitation plays an important part in the history of design. Imitation – along with suggestion and sympathy – is a primary psychological force. But imitation, like other primary forces, can easily become a scourge to life. A static changelessness seems especially unfit for the more highly developed human neural mental system. Our fatigue may concern the shape and color of our automobile, furniture, or house, the texture of upholstered fabrics, the smell of a carpet, the tunes of popular music.

Commentary: While human products will over long periods have to demonstrate their wholesomeness, it is the unfortunate case that humans may lock into a system that is inhumane, yet persists to support the powerful – or is captured by fads and fashions that may amuse temporarily but have no long term positive benefit.

While Neutra talks of humans "troubling nature," it could be debated whether agriculture is attuned to nature, or rather is providing a "new nature" which, depending upon the means employed, may or may not be sustainable in the long term. There are no humans unaffected by their social as well as physical environment. We thus must condition our designs for survival on an understanding of what is now

"natural," and not only (but still to some extent) on what is "truly natural." EvoDevoSocio reminds us how malleable phenotypes are, and today we begin to have the means of rewriting the genome and affecting other cellular machinery. Can this be done in a way that is beneficial to humans and their environment?

Noting that we may become tired of a socioeconomic order or political administration, Neutra adds that this desire for change is much less noticeable or prevalent in a primitive tribe than it is in a more civilized society. This last distinction merits further discussion – to what extent must survival through design establish a stable substrate [and what might that substrate be?] and to what extent must it offer enlivening variety?

11. NATURALNESS TO BE REGAINED AGAINST COMMERCIAL PUSH (91-96)

Neutra: Acceptance of design naturalness can be regained when the acceptance of design is guided physiologically and not just commercially pushed.

Synopsis: A feature that cuts costs for the manufacturer may be touted as a benefit to the consumer without evidence that it really is beneficial. An element of design may be habit forming and thus attractive but still incompatible with the requirements of our physiological systems. Designers of the future must neither cater to harmful habits nor gratify arbitrary desires. The decisions must abide by every increasing physiological information. Throughout the book, Neutra argues for the importance of experiments that can better link understanding of physiology to improvements in design. This chapter is one of the few places where he suggests an actual experiment where conditions in our constructed environment are to be physiologically probed

Neutra gives the example of marbleized linoleum. The manufacturer may advertise this linoleum as marble-like and then suggests a functional plus of his article: "dirt does not show." But this apparently positive feature may be negative if it diminishes the cleanliness of a home. Inspired by this example he suggests that experiments could yield data about fatigue of visual receptors through exposure to the test surface for a definite period, and then the total nervous system will have to be checked under the influences of the particular surface for lack of relaxation. Over an even surface, tactile and visual sensors can move without abrupt changes in innervation. If such external obstacles occur at rhythmic intervals, their effect seems more pleasant than that of irregular and haphazard interruptions.

The concept of cleanliness is not merely a matter of visual appearance but can also be influenced by culture. Neutra observed that in a poor but neat Japanese house pre-1940, odors indicated that the sense of smell was less involved in the relevant concept of cleanliness, while thousands of Hindu faithful spiritually cleanse their bodies by submerging them in waters that seem polluted to tourists. The Western concept of cleanliness, imparted through parental admonition and public health pamphlets, are neither merely visual nor spiritual but has a biological basis conceived almost as a scientific survival aid.

Thus, contrary to the advertisement for marbleized linoleum, conditions closer to our natural wants can be gained in our constructed environment if productions are physiologically probed.

Commentary: One must confront the challenge of meeting multiple goals – individual, social, and environmental, and the availability of resources and to whom they are available.

In relation to Neutra's proposed experiment, note that the nervous system is specifically constituted to detect changes in space and time so that our perception is attuned to the structure of the environment that affords us various practical actions and aesthetic pleasures. Staring at a blank wall is not our ideal.

12. NATURE's WORKINGS PRODDED WITH A LITTLE MAGIC (97-100)

Neutra: Nature's workings, so inspiring to man, were imitated by him and then prodded with a little magic.

Synopsis: Human products are not self regenerative or self adjusting, even when changing conditions demand such adjustment. Despite our temporary contentment with a new construction, we may be conscious of its imperfection. In earlier times, tools that were to some degree functionally imperfect seemed capable of improvement by spoken conjurations. This assumption depends on a mental mechanism similar to the one that performs the identification of a tree with a nymph, or the magic by which a child transforms an old towel into a cherished doll.

The functional parts of the building can be augmented in the same manner by means of symbolism in shape, detail, and color. While applied images are fundamentally divorced from any natural functioning, they may allude to it symbolically, and thereby become operative, if not in the objective world, at least in man's wishful thinking.

Commentary: Neutra suggests that our mental economy makes temporary contentment mandatory, yet at the same time we remain conscious of the imperfection or faulty function of the product and are perturbed. However, I would think that often we remain content, and do not seek imperfections.

Talk of "the magic by which a child "transforms an old towel into a cherished doll" as related to the process of becoming an adult seems worth further investigation as something that remains relevant even to those of us who reject magic as such.

13. MAGIC WANES AS TECHNOLOGY ADVANCES (101-106)

Neutra: Magic wanes as technology advances but some of the "old" is saved as ornament to warm the heart.

Synopsis: New materials may be given excessive decoration until the proper use and appreciation of those materials has developed. Neutra suggests that the primitive mind may shrink from a blank space, but the connoisseur can appreciate how such spaces contribute to an overall composition. When a piece of plain furniture is appropriately placed in an overall composition of a room, the accent of quiet achieved by an interval of emptiness may mean delight, not revulsion. He sees this as an outstanding example of how more complex cortical activity may reverse an earlier effect of emotional brain centers; a basic phenomenon for design evolution that deserves full attention.

Turning from objects designed for their function, creative paintings including murals cannot be regarded as intended just to embellish the base on which they are superimposed. They are not decor, or features merely added to something else.

Fossilized forms remaining from an obsolete technological situation often continue to provide a certain strange mental comfort, even though the gratification they yield could now be obtained in an entirely different manner. Thus we derive pleasure from installing fireplaces in houses that have heat-radiating floors. Chandeliers may be retained when indirect, wholesomely diffused light could be supplied. Nonetheless, it seems somehow pleasing to see the primitive and the modern side-by-side; It stimulates the mind. An old piece of furniture in a modern house may open up a perspective from one age into another, and outlook from our own little moment onto the broad landscape of history.

Commentary: The taste for decoration of buildings varies greatly across cultures and across centuries. In his book, *The Architect's Brain* (Blackwell Publishing, 2010), Harry Mallgrave traces the varied contributions of various architects (whose brains differ primarily through enculturation, not genetics) and then reviews a variety of brain processes that underlie the work of architecture. Cultural evolution means that our criteria for judging new things rest in great part on what has gone before, and Neutra returns to the attendant challenges to creativity in later chapters.

Neutra sees the positive effect of the artful display of furniture in a room as exemplifying an ability of complex cortical activity to reverse an earlier effect of emotional brain centers and calls this a basic phenomenon for design evolution. I suggest that the key point is that the brain does not evolve to

confront uniform stimulation, but instead to assess changes in space and time for their behavioral relevance – and so humans may proceed from general impression of a scene, rather than a single object, to support the aesthetic emotions. The relatively new field of neuroaesthetics and the linkage to neural mechanisms of motivation and emotion are in their infancy, but we can hope that they will Increasingly yield findings of great relevance to architects.

14. "FUNCTIONALISM" CAN TURN INTO A SUPERFICIAL CREED FOR EXTROVERTS (107-110)

Neutra: "Functionalism" can turn into a superficial creed for extroverts, but it can also be guided to honor the functions within our skin and the innermost life.

Synopsis: Neutra admires Sullivan's principle that "Form follows function" but stresses that it does not answer all problems of design motivation, since people may find certain personal features of their environment supportive and thus in some sense functional, opening the door to arbitrary notions of function. He suggests that physiological analysis can help us help break the habits which misinform function, and invoke basic physiological mechanisms to link function with wholesomeness.

But how does one limit the notion of "functionality"? The bric-a-brac on Zola's writing table seemed to him functional in helping him write. Few if any of the items was in itself functional but as a result of the conditioning of the user they become functional in a sense. This poses the challenge of discovering the physiological principles to enable reconditioning us from harmful addictions. It is hard to keep the concepts of the habitual and the functional apart, or to illuminate their interrelation.

Commentary: Is the emphasis here on "form follows function," or vice versa? See next chapter! Consider the architect who interviews clients to learn something of their idiosyncrasies and adjusts the design of the building to these personal and enculturated needs.

Sullivan appeals to much the same evolutionary notions as appealed to Neutra, but in suggesting that the tripartite functionality of a skyscraper be expressed in different forms at the three levels of the building, Sullivan only lightly constrained the variation of his designs.

The linkage of functionality to personal conditioning highlights the challenges of designing a public building for a group versus a private home for the known occupants and their idiosyncrasies.

Neutra advocates developing our knowledge of physiology to support reconditioning humans to want what is healthy – but what is healthy or wholesome may indeed be culturally conditioned, and the challenge remains to agree on objective measures of well-being that can be brought into play.

15. FUNCTION MAY ITSELF BE A FOLLOWER OF FORM (111-118)

Neutra: Function may itself be a follower -- for example, when form and color excite sex in courtship.
Synopsis: The bee is equipped with such receptivities that the azalea can offer stimulations, optical, olfactory, and tactual that appeal to the bee. But the more involved gratification a human mind, as when we admire flowers, seems to rest on quite other grounds than the logic of function. We humans have added through biological evolution a forebrain to our nervous equipment and makes us capable of intricate satisfactions. Still we have retained the ancient bottom layers of the structure as well. The study of the anatomy of the nervous system shows that the emotional tract connects with each level of this stratified and well communicating structure.

The male Australian bowerbird construct peculiar bowers and decorate these idiosyncratically through brain mechanisms that have evolved to support competition for mates. Appearance precedes and clearly seems to evoke an operational event. Function follows form.

Brief and direct responses that exclude highly evolved and refined cortical activities, such as differentiation, association, and abstraction, are quite normal in animals, but may well be called subnormal when they predominate in man. Human judgment of the environment, whether we call it aesthetic or something else, will have its full share of cortical ingredients.

Commentary: Modern neuroscience insists that the forebrain is divisible, and that we can understand it by charting the roles of diverse structures and exploring how they may act together through both competition and cooperation.

Many of us recoil from snakes or spiders, yet these creatures mate successfully. Moreover, some of the subspecies we do find beautiful, and others we do not. Thus, it may be dangerous to separate criteria for beauty from the effects of enculturation. In particular, look at the way in which color names and the range of color they characterize vary from culture to culture. Nonetheless, it is worth stressing that neuroscientists learn much about the human brain from comparative studies, whether it be with creatures with brains similar to ours, such as monkeys or rats, or whether it does indeed involve turning to bees and flies where the interplay of the form and function of neural circuits with changes in genetics can be more fully explored. However, the general ground plans of the invertebrate nervous system and the human brain are very different. Turning to the evolution of mammals, there are basic structures that are somewhat preserved through evolution, but in the case of human evolution have become dominated by the outgrowth of the cerebral cortex. This not only offers new capabilities but also provides new patterns of inhibition and modulation that increase the capabilities of the "lower" structures. I reiterate the importance of EvoDevoSocio as setting the frame for these studies.

In response to Neutra's discussion of the bowerbird I argue that here function follows form *on the evolutionary scale*. There has been co-evolution of the male and female brain through sexual selection. As females find certain patterns attractive, males evolve to decorate their bowers to better attract them, and females may in turn evolve to better associate certain patterns with more intrinsic capabilities in a mate. In each case, it is the function of mate attraction or selection that drives the development of forms that hold the key to functions that support survival.

16. FROM SHOCK TO HABIT, ALL DESIGN PLAYS IN TIME (119-122)

Neutra: For our responding nerves design is always involved in time – from sudden shock to a great steadiness of appeal.

Synopsis: Neutra here refers not to the design process but to the impact of the design upon the observer. He stresses the time element in aesthetic appeal, arguing that complex associative operations are involved that go beyond mere sensory function. Obsolescence and fatigue phenomena play their role everywhere. Assessing the foraging of insects attracted by flowers, Neutra argues that there must be an inhibitive mechanism to prevent the exhaustion that would result from endless repetition of reflex responses. The principle that "form follows function" is not restricted to operate for a limited time. He argues that only human upper brain mechanisms support longer lasting effects that are called abstracted concepts and may guide us through a lifetime. Their satisfactions are comparatively steady.

There are certain basic shapes that have almost constant appeal, whereas other aesthetic stimuli operate on a fluctuating sensory level. But all appeals should be graded with respect to their duration or rather the duration of our receptivity.

Commentary: Neutra suggests that excitation is imparted like a shock to insects cooperating with flowering plants. This seems misleading to me. The insect extracts pollen from a flowering plant until some level of satisfaction or depletion is met. It then withdraws and searches for a new plant. We thus see an alternation between foraging and consummation.

Von Frisch described the ecstatic dance of the honey-gathering worker bee upon her first return to the comb. Neutra suggests that the others catch the scent and then, guided by their olfactory equipment, swarm out to the new strike. However, von Frisch has shown that the waggle dance indicates direction and distance through tactile means, and the flight to the flowers is guided visual assessment of distance.

A key notion for long-lasting effects of stimuli, is that some may lead us to initiate a course of action, others may remain relevant and held in working memory only during certain stages of the behavior. Humans may maintain plans for days, weeks or even years as they act upon them, hoping for success.

17. EARLY AND LATER FORMS OF HUMAN SATISFACTION (123-128)

Neutra: Early and later forms of mental satisfaction closely fit the early and later stages of civilization.

Synopsis: Neutra contrasts the attempt by Ancient Greeks to understand the stars by naming the constellations and the scientific effort of recent centuries. He claims that the ability to attack problems through controlled mental exercise and operating inhibitions developed late in the evolution of human thinking; whereas methodologies associating dreamlike images came first.

Kinesthesia deals with the feeling we experience in moving members of our body. We subconsciously put a high value on regularity or order. We are even induced to ascribe such order of our own making to natural phenomena which for the most part are devoid of simple patterns and proportions.

The Hellenic concept of the cosmos actually equates the universe to a great, beautiful harmony. In this view, the phenomena of nature seemed purposefully interrelated. Compare the experience of sitting on the bank of a stream that rushes along between boulders. The sound of the current fills the air with diffuse and subtle reverberations from rocks and foliage and we cease to place much value on cause and consequences. The ability to attack problems on the high and strenuous level of controlled mental exercise and operating inhibitions developed late in the evolution of human thinking; The expenditure of certain guarded quantities of energy offers a clue to the understanding and tracing of nervous happenings, and offers clues to the vagaries of production and consumption of design.

Commentary: I would suggest that when hunting and foraging, neither animals nor humans are operating in a dreamlike fashion, but must be attentive to the dynamic subtleties of the environment around them. Again, those same Greeks who operated on a level of superstition with respect to astrology developed geometry and ideas in philosophy that remain important to this day.

Complementing kinesthesia, we have strategies for pursuit eye movements that provide prediction to compensate for delays in the sensory-motor loop, but with that prediction being best for certain types of regular trajectory. More generally, a major function of the brain is to process current sensory input to extract a plan of movement that will satisfactorily affect the world at the time the plan is put into effect.

Neutra notes the pleasure we may get from an object or a scene without having to understand the details. Compare the pleasure of offered by a well composed painting that requires no attention on our part to the brush strokes – in contrast with the conscious placement of the brush strokes that is required by the artist. At times we are content to perceive passively, in others we wish to control the situation, and then must have an understanding (however limited) of what possibilities that situation offers to us for that control. The architect must effortfully plan for both passive and effortful experiences in a building, and assess the prospects for well-being that each offers.

Theme 4. The tension between conserving old habits and mastering new ones

18. THERE IS NO “PURE REASON,” OR “PURE BEAUTY” (129-132)

Neutra: There is no pure reason, just as there is no pure beauty. Emotion most naturally tinges every mind operation, the medical task or creative design.

Synopsis: Neutra defines satisfaction as relaxation after a given problem has been solved and sees this as implicit right from the start of the design effort – anticipation supplies us with the hopeful mood needed to tackle the task. A physiological understanding of habit and tradition relates them to neuro-

mental economics – the effort required to solve a problem contrasted with the comparative ease of applying that solution when the problem gain arises, and this is mingled with emotion. Consequently even a very involved, seemingly wasteful design may remain long in force when the nervous energy being saved in this by this adherence discourages the effort required to master a new approach. What is commonly called *conservatism* – holding on to old habits – thus seems to be an attitude derived from a primary survival mechanism, which must not by any means be ignored or despised.

A physiological understanding of habit and tradition in design thus relates them to neuro-mental economics, and this is forever mingled with fleeting emotion. A neuro-mental performance is acted out on a multiple level stage. Emotion is near to all the levels and never exits.

Commentary: Neutra defines satisfaction as relaxation after a given problem has been solved but perhaps one might better say that satisfaction can have many dimensions (sating hunger, quenching thirst, having sex, escaping fear, for example) and so one may relax from effort once a goal has been reached – unless another goal has become pressing. Both psychological study and work in artificial intelligence have benefited from the modern theory of *reinforcement learning* – learning strategies to adapt to varying circumstances to act in ways that increase the total of positive reinforcement and decrease the negative reinforcement acquired across a time span – and neuroscience has linked this to dopamine mechanisms in the brain.

Adherence to a particular way of doing things may result in part from social pressure on those who break precedent, but the key issue here of "mental economy" is the immense effort in changing from one form of behavior to another. The effort required to change may *seem* to require too much energy when one discounts the future savings offered by the change.

19. MENTAL ECONOMY IS MANIFOLD – FAR FROM SIMPLE (133-137)

Neutra: Mental economy is manifold, from simple regularity to the ease that comes from even complex habit. Also magic shortcuts have been seen to supplement the more laborious satisfactions of the mind.

Synopsis: A Chinese junk has a well designed prow to cut the waves but when a typhoon blows, this design cannot not always assure against wreckage. An engineering brain did ingenious work as far as was possible at the time, but Neutra argues that a means of mental insurance was sought in dreamlike wishful association with a triumphant dragon ornament on the prow to give victory over evil storms, and eyes were painted on to find the way through the turbulent and darkened waters. But once radio beams guide vessels through air and over the foggy ocean, dragons and painted eyes fall gradually into disuse because they are no longer legitimate in the neuro-energetic terms of design's current phase [though pilots will still have distinctive good-luck symbols painted on the fuselage of their warplanes!].

We must strive cautiously to appraise the physiological function of consuming, absorbing, assimilating forms be they simple, organized entities, habituated complexities, magic remnants, or novel and puzzling technological necessities – requirements of the industrial age in which we find ourselves. [Note here that simplicity of use must not be confused with simplicity of the design or product itself – as the "under the hood" complexity of cars that "anyone" can drive demonstrates.]

Commentary: Ancient forms of stone toolmaking lasted hundreds of thousands of years without any change we can discern in the archaeological record. One may achieve a satisfactory arrowhead without being disturbed by the fact that there are more effective means of hunting animals. Thus, I do not think that the mental tension Neutra mentions need be relevant when current designs meet our perceived needs. Moreover, I am not convinced of the relevance of magic and mysticism as stated by Neutra. Rather, one might say that with increasing mastery of language, humans acquired the ability to ask questions and seek explanations, and the systems at their disposal long ago were not those that are available to a culture like ours in which science has been well established.

It is only when certain stages are consolidated that what might have been a fantasy can become a technologically realistic goal. Meanwhile, the general public may have no sense of a need for further innovation. Those who used horses for transport saw no need for motor cars until a long process finally made cars effective and affordable, and roads were restructured to accommodate them. More recently, the use of smartphones and the Internet has catalyzed changes in society that make use of these devices, formerly in the domain of science fiction, a practical necessity.

Reverting to Neutra's discussion of mass consumption: the effort expended in innovation involves not only the design of a new product but the development of suitable manufacturing resources and advertising campaigns whose costs must again be balanced against the sufficiently many consumers being convinced of the benefits so that their purchases cover the costs. The issue of money in relation to physical and mental effort is of course a major challenge. Returning to architecture, clients with deep pockets will pay immense sums to have a building whose distinctive form will confer prestige, even though that form may be more costly than an alternative that supports equivalent functionality.

An addendum on "magic": Language is indeed a powerful magic. By commanding or requesting something of another person, we can achieve it without physical effort on our part, and much of magic can be seen as an attempt to find the right words to persuade inanimate objects to do our bidding. We can see much of current computer technology and artificial intelligence as an attempt to extend that magic. "Open Sesame" was once the stuff of fantasy, but is now a part of everyday technology.

Theme 5. Multi-sensory perception and physiological space

20. ARCHITECTURE ILLUMINATED BY LIGHT AND SOUND (138-144)

Neutra: Architecture is illuminated not only by light but by sound as well; in fact it is brought into relief for us through all our senses.

Synopsis: We should be interested not only in the role of vision but in all the nonvisual aspects of architectural environment and design. The acoustics of a theater have become a design factor of the first order. But we have more in mind than the mere audibility of a speaker or a singer. When we walk through the nave of a medieval cathedral, the impact of our steps on the stone pavement becomes essential to our impression of the architectural space. Like light, sound will bring into bright relief architectural bodies and spaces and leave portions of them in the shade.

The classical architect did not use the terms geometrical or mathematical in their modern sense, but thought in terms of simple relations. When it comes to curves, free shapes have been a recent daring introduction; the Euclidean architect [Neutra's term for architects working before modern science and mathematics were established] loved a circle or possibly an ellipse.

Some of the newly developed electrical instruments make it possible to adjust illusionary acoustics while the piece is being performed. It is then not merely amplification of the instrumental sound which takes place. The audible, but illusory, dimensions of the rooms may change from a small enclosure to gigantic space [an application for post-Neutra advances in augmented reality].

The size-weight illusion is what Helmholtz calls an unconscious inference. It is based on experiences in which several senses originally colluded in the perceiving of one piece of coordinated information. The designer can make a structural member seem strong or heavy by giving it large apparent dimensions although it may be merely composed of inflated surfaces around a hollow. Often the designer operates unconsciously, employing rudimentary illusions and suggestive devices, perhaps without even knowing.

The straight line is so strongly directional that it takes on a seeming dynamism. This can be used to counteract our feeling of the space limiting character of a wall by producing a subconscious supposition of void space behind a thin surface. [Neutra has used a related illusion in several of his buildings.]

Meanwhile traditional styles (such as the classic Japanese house of which Neutra speaks fondly in this book) can be impacted by changing sensory conditions. In a [classic] Japanese interior of oiled paper and thin silk, privacy depends on hushed voices in rooms which could be closed off temporarily by sliding screens – but are not acoustically insulated. In such a house, noisy music in another room is a destructive turmoil. Future instruction in environmental design and architectural training will instill detailed awareness of the basic physiological actuality that the human nervous apparatus is continually stimulated through a large number of sense receptors.

21. PATTERNING OUR SENSE-DELIVERED ENVELOPE (145-155)

Neutra: The designed environment can and does pattern for us many kinds of sensations which derive from air currents, heat losses, aromatic exhalations, textures, resiliencies, and from the all-pervading pull of gravity.

Synopsis: Neutra reminds us of the many senses that act outside or in concert with vision to shape our experience. Odors can provide a key to memory, and may also modify – for better or worse – our experience of a space. The cut stone of a medieval cathedral has its peculiar gaseous exhalations, supported by those of moist microbiotic life, which makes certain ancient interiors recognizable to a blindfolded person. Even slight traces of bodily perspiration give well marked, though often subconscious, accents to any ill-vented interior. And no slum is picturesque to the nose.

Future designers may learn to control the pertinent physiological effects due to the exhalations of the materials that form the enclosures of human life. They will not just add a sprinkling of decorative smells. Yet, if hermetical air conditioning prevails, there will be no auxiliary fragrance as offered by a breeze from the garden. It remains a significant precedent for constructed environments that gardens at least have been sensitively designed on an olfactory basis as well as on visual principles.

Air currents are forced into certain perceivable patterns by the shape of the enclosure and the location of air vents piercing it. Some wall materials, such as wood or cork, that store warmth; some conduct heat away from us and thus are cool. Tactile stimuli can affect manipulation, locomotion and more. Detailed experimentation is needed [Neutra notes some had then been recently conducted] before we know how certain tactile stimuli, combined with resiliencies, for example, appeal to our fingertips, to our toes and soles when we walk, to our back when we lean, and so affect our total nervous system.

Neutra is most concerned with the way in which the constant pull of gravity affects us, and the way in which the design and placement of furniture in a room can contribute to fatigue or comfort as we conduct different behaviors in which resisting the pull of gravity is often an important but non conscious component. Some of the relevant sense receptors are stimulated by tension, some by compression. A chair determines our posture. A couch may be planned and placed in poor relationship to a magnificent window and make us crane our neck in vain to enjoy the view. The problem of posture relates a vast number of other sensory experiences to vision.

He emphasizes *stereognosis*, the way in which the multiple senses act together in determining how we behave, and what we find fatiguing and uncomfortable. This stereognostic coordination is slowly acquired from infancy and affects glandular secretion and blood circulation as well as sensorimotor coordination. A mystery house disrupts the collaborative working of the senses. The floors, walls, ceilings, although tilted, keep their usual relationship so the eyes are deceived and gravity becomes a surprising phenomenon of almost painful intensity and vertigo may overcome us. All this exemplifies how deep down the disturbance will reach if we break the coordination of visual experience and gravity.

Commentary: We need to note the difference between a comfortable middle class home whose inhabitants' sense of well-being can be improved by various rearrangements, and the problems of the poor who may not be able to afford even the basics. What can be done to address their well-being?

Neutra emphasizes that the design of furniture and relative arrangements of furniture may force us habitually to assume unhealthy postures. Here we can note the recent advances in ergonomics and workflow analysis– while noting the drawbacks of excessive Taylorism that unduly inhibits the personal feeling of freedom of workers and reduces them almost to automata in the old, limited sense.

To the senses of the external world, we must note the importance of systems (like breathing and heart rate) governed by the autonomic nervous system, and their relation to the visceromotor underpinnings of emotion – while still noting the overlays of neocortex in interaction with lower level systems.

22. "PHYSIOLOGICAL SPACE" – HAS DIRECTION AND RANGES (156-170)

Neutra: Einstein seems closer to our energy bound space-time of the senses then were classical Euclid and Newton – physiological space has in its very origin pronounced direction and ranges onto which man has later slowly planted his many meanings.

Synopsis: The sense of gravity contributes to our awareness of the upward and downward in space. Our nervous apparatus registers physiological space not as abstract space but as something intimate to the daily life of the organism as it moves, grows, and exercises its senses. We perceive space in front of us as something quite different from the space behind us in relation to the control we have over it. What the various senses bring in is worked into a space concept by a practical lifetime's experience, studded with diversified meaningful associations but may be badly warped [or refined] by social conditioning. Nonetheless, social space concepts may be of great effectiveness in environmental design.

The original design of the Rotunda of Saint Peter's in Rome emphasized circular symmetry. However, the processional involves forward facing toward the holy as an immortal part of all naturally found ritual. Thus circular symmetry was overwritten, placing the impressive altar in the background to be approached by an elongated nave. Everything was done to establish direction [but direction based on . the notion of the holy as well as the approach, blending social and physiological concepts].

The physiological concept of space also underlies the need to position various physical objects. In a bedroom the first objective may be breathing air which is replenished through well-placed window openings. Further, there are items we desire to have within arm's reach. Other necessary things must be readily accessible, but for some we may allow a few steps. Any poor arrangement of objects that we use may become a perpetual nervous irritant in the routine of our daily life

The ranges of possible control surround each individual in concentric rings. The closer ones are more easily negotiated than the farther ones [consider manipulation, reaching, locomotion over a few meters, and locomotion over hundreds of kilometers]. Physiological space is emotionally egotistic. Three steps taken toward us are quite different from three steps away from us. Sociologically evaluated space also has its distinctly inward sequences toward more and more privacy; and the spaces in which we live are sociologically graded by a commonly accepted symbolism, albeit one consistent with physiology.

Commentary: I agree with Neutra's emphasis on physiological space, but consider his rejection of Euclid and Newton and support of Einstein to be a misunderstanding. Neutra complains that the space of Euclid is nondirectional but (together with coordinate geometry), it provides the abstractions we need for diverse applications, including construction drawings for architecture. In designing an actual building, the architect must match the construction drawings to the site to come up with an essentially static structure. However, in the design process that leads up to these purely spatial measurements, a consideration of the activities and experiences of people within the planned building, and thus the linkage of space and time, must play a crucial role. Moreover, Einstein's special theory of relativity does not touch on these physiological aspects, and the general theory considers gravitation in a way that only makes sense for cosmology but is less effective than a Newtonian analysis for the work of architects.

Neuroscience has demonstrated that there are many maps in the brain, not only those that organize sensory data from different modalities, but those that are related to different types of behavior so that

one part of the brain may map space in terms of reaching, another in terms of shaping the hand to grasp, while a third plans the metrics of locomotion. In addition, cognitive maps that encode within our brain the knowledge we need to find a way around a house or a neighborhood. While the first three are egocentric (as Neutra explains) the last is *allocentric* – *other-centered*, as when we mentally imagine spatial relations in the way we physically examine a subway map. The role of allocentric maps has been an important component in the neuroscientific study of the hippocampus, a brain region that also plays a crucial role in episodic memory. And yet in normal behavior these distributed representations are effortlessly coordinated so that we have the illusion of a unity of consciousness.

A useful concept is that of the *Umwelt*, the notion that different creatures have different physiological worlds even in the same environment because they have different sensory apparatus and different modes of action and behavior – and humans with different enculturation may experience, and behave in, the same space very differently.

Neutra's discussion the sociological grading of our personal spaces should remind us of the importance of considering physiology (including neuroscience) within an EvoDevoSocio framework.

23. DESIGN IN TUNE WITH LIFE PROCESSES – AID TO SURVIVAL (171-178)

Neutra: Design as an aid to survival must always have an intimate kinship to the life processes it serves within time.

Synopsis: Various terms of survival such as adequacy of circulation, resistance to fatigue and to infection, and capacity for recovery and regeneration all involve a time perspective. Design meant to favor and preserve life processes cannot be rigid, conceived only to fit static situations. Growing, aging, fatiguing, and recovering are the physiological means by which we actually gauge time. A classic architecture that adapts the proportions of the Parthenon to a suburban bank cannot use the same scaling for door handles – these must retain their meaning relative to gripping hands. We need design with a time implication, designed to fit a bundle of processes rather than a fixed state of affairs.

As we grow we change. This change seems pleasant enough when we are young and our faculties increase, but when we decline change becomes an increasingly wistful affair. During this process our body changes its relative proportions, and so we depart from a measure of self-similarity. Even in a house, self similarity is impaired when the various parts do not give out all at the same time. All this spells a need for design with a time implication, designed to fit a bundle of processes rather than a state of affairs. A family group has a twofold growth period: first we refer to growth in number of children but this growth is limited and is supplemented by another growth of the members of the family. Their interrelationship develops with specific articulation of each. Neutra suggests that the type of growth, proliferation, and articulation we can observe in both the family and the individual nervous system occurs similarly in the most comprehensive product of the human brain, the cultural community and its man-made outer of shell– the city.

Commentary: Neutra offers a footnote related to the claim that if physiology attempted an explanation of vital processes, it would in the end have to be in terms of cell physiology. Much progress has been made since in behavioral and systems neuroscience and related study of receptors and effectors, but now with increasing study of the relevant genetics that shapes development, learning and function. Note that the book was published in 1954, a year after the Watson-Crick breakthrough.

Neutra talks of growing, aging, fatiguing, and recovering as the physiological clocks by which we gauge time. We now know much more about *circadian rhythm* – the 24 hour cycle of change in our underlying physiological processes. This has revealed diverse challenges for the architect, including the way in which to employ artificial light so as not to unduly disrupt this rhythm. At the other extreme, we may note time as involved in autobiographical memory, and its distinction from the time engaged in a single

action – which may depend more on parameters of a control system tuned in response to efficacy of control than on a measuring out of time in the seconds of an external time scale.

24. VISION – BRED AND TRAINED WITHIN THE NATURAL SCENE (179-187)

Neutra: Seeing, like other sensing, was decisively trained within the natural scene; time is of its essence, although seeing seems to deal only with space.

Synopsis: Neutra reports studies on physiology basic visual mechanisms. With such experimental findings we may expect to provide a firmer physiological ground for our planning. The natural scene furnishes the first and most powerful medium and precedent for human acquaintance with color and helps to account for his interest in it. It varies with time of day and the seasons. Time has a natural and important part in the experience. If man-made colors are to play a part as an aid to survival in a fully urbanized environment, it is imperative to minimize static effects and rigid color arrangement.

In contrast the statically set interior world typified by a windowless, dustproof, air-conditioned hospital ward, Neutra advocates lighting systems that automatically change patterns of illumination in a way which may prove more stimulating. Experimentation will advance, constructive design will follow, improvement will spread to lower economic levels by the propelling power of growing demand.

If we are limited in our interiors to permanently applied color coatings, we must reduce their harmful effects on the nervous system. Transparency of partitions between interior and exterior becomes important, replacing Victorian hermetic enclosure, window hangings, and dignified perceptual dimness.

Commentary: Neutra asserts that visual demarcation of boundaries requires that the eye be kept in rapid vibration whereas around 1960 Hubel and Wiesel demonstrated specific cells in mammalian visual cortex that provide the basic data on which higher-level processes operate to segment the various areas of a scene – processes that may also engage segmentation on the basis of depth and motion. We need an updated database of neural, physiological and cognitive data that can inform the architect's imaginings, and let us explore the extent to which higher level processes hide low level effects.

26. LIGHT AND COLOR EXPERIENCE IN STATIC INTERIORS (192-196)

Neutra: In interiors and in our urban existence, light and color call for a more informed watchfulness than eyes have needed for a life outside in unhampered nature.

Synopsis: This picks up on themes of Chapter 24. It is possible to contrive interior illumination that is not static and thus fatiguing. The varying effects of daylight can be enjoyed through large windows, well shaded by exterior overhangs. At night the room need not be monotonous monotonously lighted. Neutra comments that the use of pure white light, supplied from fixtures which are concealed in the roof projections over large windows, has long been a feature in his designs. [This is one of the few cases where he mentions a feature of his designs, but in only one place does he describe a specific project.]

Uniformity as well as steadiness of brightness is justifiable in a space used for concentrated work over given periods, but there are benefits in change and contrast. The illumination may be supplied from alternating directions, and from varying sources. For example, the unusual, changing light emanating from below our eyes in great part constitutes the charm of a fireplace.

The brightest reds and yellows in nature are not commonly found over extensive areas, but human retinas have been conditioned to tolerate immense expanses of green. For modern humans living in a closed interior, static color schemes are detrimental to well-being. Yet in a teeming metropolis with the bewildering traffic and disharmonious neon lights, too much variation in color may cause suffering. We must design living space in such a way that the neurologically salubrious agents of nature are freely admitted and kept active to as great an extent as possible. The effects of improper environment are often cumulative, and we pay a penalty for spending long periods of our lives enmeshed and entangled in abnormal surroundings, such as we now have to face everyday.

Commentary: However, many find life in a city far more stimulating than a "more natural" rural life.

Theme 6. An invitation to neuroscience (outdated but suggestive)

25. COMFORT AND FATIGUE LIMIT THE FIREWORKS OF DESIGN (188-191)

Neutra: Comfort and fatigue must be understood within the picture of organic events and will limit the possible scope of arbitrary fireworks of design.

Synopsis: Neutra cites early work on action potentials of neurons, noting in particular the finding of Adrian around 1930 that when stimulation occurs, receptors discharge a more rapid series of impulses for stronger stimuli, whereas when a stimulus is applied constantly, there is no corresponding continuous discharge. He then focuses on physiological dimensions of fatigue to infer that design must maintain a balance between consumption of energy and processes of repair and regeneration.

Action potentials may change under oxygen starvation when, for instance, blood circulation is disturbed. Such effects are often caused by unfavorable posture and postures are frequently affected by not only furniture design but even furniture placement. He refers to the 19th century Fechner-Weber psychophysical law that taught designers that intensities of sensations will not be directly proportional to the intensities of the stimuli, but are related more closely to their logarithms.

There is no reclining chair sufficiently well designed to ensure comfort for a night-long bus or plane ride. But fatigue does not depend simply on duration and intensity of stimulation; it might be surprisingly postponed and diminished by such a subtle device as rhythmic stimulation.

Comfort, as the subject of physiological knowledge, dawns significantly on the contemporary horizon.

Commentary: In this age of starchitecture, it is unclear what limits arbitrary fireworks!

In this chapter, and elsewhere, Neutra demonstrates that his comments on physiology are indeed supported by wide reading. The implications he draws for architecture remain worthy of our study today. However, the field of neuroscience has undergone rapid change since the time of his writing. 1952 saw the work of Hodgkin and Huxley that transformed our understanding of how signals are transported by the axons, or output lines, of neurons. The 1950s saw foundational work in the study of the firing of individual neurons far from the sensory or motor periphery, laying the basis for exploring in nonhuman brains the functional interactions that were supported by the neural circuitry that anatomy had revealed decades earlier. It took further decades for the development of techniques of positron emission tomography and, later, functional magnetic resonance imaging that allowed the study of neural activity in the alert human brain – though at a much coarser level than the neuron-by-neuron studies in animals. This localization of activity in brain-space complemented studies ongoing since the late 1920s on the time series of electrical activity that electroencephalography (EEG) supported without much in the way of localization. Developments in computational modeling have allowed increased understanding of how the human brain operates by testing models grounded in insights concerning neuron activity and circuits of the nonhuman brain.

Cognitive social neuroscience is a growing field. Work here will help us define various forms of mental well-being and link these not just to a building or work conditions but also to sociality. For example, are communal coffee or tea breaks in a workplace more beneficial than individual breaks?

Some aspects of Neutra's program have been realized under the umbrella of environmental psychology

Neutra asserts that we have outgrown an adolescence that enjoyed itself in a gross machine materialism once considered so progressive. However, contrasting 19th century steam engines with 20th century computers, we see that the conception of machine has changed to involve ideas like "program" which bring us closer to a mental analysis as part of cognitive science than to a mechanism in the classic sense.

27. NOT FIVE SENSES BUT MILLIONS OF RECEPTORS (197-201)

Neutra: Millions of manifold sense-receptors determine what design can actually do for us.

Synopsis: A multitude of sensory impulses reach us every moment. Neutra emphasizes that there are far more than the five classical senses. In addition to the distance receptors of ears, eyes, and nose, he notes sensors mediating pain, proprioception, and interoception. Schools that train designers will be obliged to familiarize them with the physiological keyboard of these senses on which they must try to play with understanding and harmony. Many inflowing stimuli act on the spinal cord and control many antagonist flexors and extensors. A vast muscular activity is continuously innervated in us even while we believe ourselves to be at rest. [Neutra is wrong in the description of synapses.]

Though the human sense of smell is weak compared to that of dogs, smells mean much to our feelings and may elicit strong responses from our viscera. A certain faint smell may make a room almost uninhabitable, just as it can render a person distasteful to us. The smell of a natural cedar paneling has another significance distinct from that of varnish and paints.

With the exception, perhaps of some of the interoceptors, a practical design is evidently engaged to manipulate almost directly with the entire and manifold sense equipment with which the architect's client, the consumer, is endowed. Schools that train students will be obliged to familiarize them with the physiological keyboard on which they must try to play with understanding and harmony.

Commentary: Here, Neutra summarizes some ideas about peripheral nerves in relation to cortex, and the role of synapses, but much of this is outdated. For example, rather than view sensory stimuli as prime movers, we now stress that behavior occurs in an ongoing *action-perception cycle* -- which stimuli we attend to at any time may be determined in great part by our search, often nonconscious, for relevant data. Thus, one task of the architect is to design an environment in which inhabitants of a building may find the stimuli relevant to a relevant range of behaviors and experiences.

28. DESIGN CREATES PATTERNS OF RESPONSE (202-206)

Neutra: Individual and social psychology will ultimately merge with brain physiology, to guide the designer in his observation and creation of response patterns.

Synopsis: We are habitually deceived by our own consciousness, which selects and highlights only a few phases of the underlying multitude of neural processes. The view that a neuron grows during a certain so-called embryonic phase or period of maturation, and then becomes fixed in form and function is erroneous. Through learning, the continuing impact of stimuli from the environment continues to mold the nervous makeup of even an adult.

For the designer, familiarity with brain matter and function is no less important than knowing the properties of steel, concrete, and glass fiber for their successful employment. The designer of a physical and environment is likely to stimulate our entire subtly organized being, not just a specific sense on a particular organ. Neurons continually act on a dynamic scale that includes both cell firing and rewiring. Neural growth by cellular multiplication is, however, a process that does not go on and on [though recent research reveals neurogenesis in, at least, the hippocampus].

Nervous tissue has a capacity to grow directionally to meet other nerve tissue of specific affinity or supplementary character. Moreover, when the connections are made, these synapses may be predisposed to support certain functions. Nonetheless, new synapses can be formed and old synapses change throughout life, to provide mechanisms that support learning throughout life.

Each neuron exploits the tiniest sums of energy, yet tens of billions work together in each human brain. The designer and his enlightened clients must keep this important fact in mind. They will then fully appreciate the enormous effectiveness and therefore the significance of the many stimuli which the natural environment and the ever increasing constructed environment continuously apply to all of us.

Commentary: Neutra rightly stresses that we are habitually deceived by our own consciousness, which selects and highlights only a few phases of the underlying multitude of neural processes. I add that such introspection hides the responsible interaction of diverse subprocesses that allows us to "dissect phenomenology" and more adequately chart the impact of various environments.

There has been much research on directional growth of axons. For example Roger Sperry showed that if the optic nerve of a frog is cut, axons from the retina can still find their way back to the visual midbrain, the tectum, and make connections that provide a good map from position on the retina to position on the tectum (a *retinotopic* map). Further research has shown that particular chemicals, ephrins, establish gradients on the tectum and the questing axons compete and cooperate to reorganize themselves to form the new retinotopic map. However, if the eye were inserted upside down before regrowth, then the excellence of that map would mean that the frog confronted with a fly above him would snap below him. They never adapt. By contrast, when humans don inverting prisms, they can learn to adapt, thanks to the expansion of forebrain and cerebellum, and come to see the world right side up.

Different regions of the brain have different types of neurons and different rules of synaptic plasticity that, in concert with other brain regions support different types of learning and memory.

The important fact that the connections between neurons can change throughout life and thus support learning is important for the architect who can develop designs that stimulate the learning of healthy new skills. On the other hand, disease and aging can strike both brain and body, and these changes too must be taken into account by the architect charged designing buildings for the diseased or aging.

29. THE INNER TARGETS OF OUTER DESIGN BALLISTICS (209-217)

Neutra: Certain desired inner distributions of force and stress within our nervous system are the real aim of all outer design ballistics. [Here, by "ballistics," Neutra seems simply to mean the outward movements of our actions.]

Synopsis: This chapter is guided by findings that build upon the original work on conditioned reflexes by Pavlov [a framework greatly modified by subsequent neuroscience research]. In the classic Pavlov experiment, a dog trained by repeated laboratory experiments to a combination of food stimulus and sounding bell will first tend to secrete saliva even in response to any abrupt sound, but by further continued training the response becomes tuned to one specific sound, that of a bell. The study of conditioned reflexes has cast light on the problem of differentiation, and it holds some clues to the differentiated perception of design – the differentiation of shaded colors, of detailed forms, and their subtle and willful combinations. All judicious consumption of design is based on trained differentiation.

If we could look through the skull into the brain of a consciously thinking person, and if the place of optimal excitation were luminous then, says Neutra, one should see playing over the cerebral surface a bright spot surrounded by darkness covering the rest of the hemisphere. [This is false. There are widely distributed dynamic patterns of activity, not a single peak.] A dominant focus of excitation absorbs the energy of other stimulations for its own reinforcement. These minor stimulations fail then to become competitive. A long, indifferent highway may accidentally become a scenic route in our memories because of the dominance in our mind of only two or three profoundly impressive stretches. However [in performance as distinct from memory] we cannot let our general judgment be overcome by just a few dominant impacts. While we are sitting at the steering wheel of an automobile, our life may depend on a continuing and well balanced coordination.

The test conditions in laboratory studies may curtail spontaneous natural activity. This poses a major challenge in linking the science gained by study of controlled experiments with the multiplicity of interacting causes and effects in the design and experience of a building.

Like a composer of music, designers can lead us into a meshwork of aroused anticipations and fragmentary disappointments or frustration. They also know how to produce calculated shocks here and

there. Forms or colors, either simultaneous or immediately successive in the field of vision, will modify each other's impact and impression. Often they will mutually reduce the clarity of each reaction.

One person may be capable of distinguishing design subtlety more quickly than another. Such physiological personality may be the result of innate capability, whatever that is, or may reflect training in distinguishing relevant aspects. The challenge then is to understand how individual personality, within the species, can specifically be served by a design. Accomplishment will have to come through empathy as controlled by subtle processes.

Commentary: Neutra's view of the brain is outdated, but he uses that view to raise questions that remain pertinent to architects, and thus can help motivate recent events to link issues in architecture to current neuroscience.

Neutra speaks of "reflex arcs", encouraged by using Pavlov's conditioned reflexes as the unit of cortical activity. However, a focus on reflexes is misleading. Just consider what makes it possible to read these pages to judge what Neutra means by 'survival through design." Concept formation involves generalization that allows us to form concepts – such as the general notion of "dog" abstracted away from the breed or size or fur color. Acquiring a skill, such as driving a car, complements this kind of generalization with one that supports flexible coordination. It requires us to master (in great part nonconsciously) the hierarchical control of a range of actions with perception of environmental details (such as speed, location, and more) providing appropriate guides to the performance of our actions. Crucially, such learning generalizes to let us perform successfully even in conditions we have never encountered before. The architect relies on this in trusting that the building they design will, despite novelties of form, be navigable and usable by the people who visit or inhabit it.

Contra a single "bright spot" of cortical activity: Human brain imaging has shown patterns of activity widely distributed across the cerebral cortex -- while also showing that the pattern of distributed activity during one task may be quite different from that during another. However, having less significant activity in a region during a task does not mean that there is no activity in that region. Recordings of the activity of single neurons in different brain regions in the awake monkey, for example, provide confirming evidence as we see changing patterns of involvement of those individual neurons as the external conditions, task, and action state of the animal change.

Neutra talks of the role of excitation in the brain in relation to a peak of excitation inhibiting all around it, even claiming that "designers could almost manipulate at will cortical spreads of excitation and ambition, as well as inductive effects." This is mistaken, but it is true that the brain crucially operates through the interaction of neurons that excite and neurons that inhibit, and this holds throughout the regions of the brain from early sensory processing to the spinal control of musculature. Basic mechanisms in the midbrain and spinal cord at times operate automatically whereas at other times they can be inhibited or modulated by descending signals from cerebral cortex – and remember that the cortex in fact has many different regions and can thus accommodate very diverse patterns of activity. The designer can thus seek to understand what patterns of stimulation from the environment can better elicit certain "lower-level" responses, and when it may be necessary to extend those features so that cortical influences can inhibit unwanted side effects while supporting some desired behavior and experience in the building.

30. ELEMENTARY MOTIVATIONS, RICHLY CONDITIONED BY LIFE (218-223)

Neutra: Elementary motivations of man become complicated when conditioned and variously molded in individual lives; They play their role in design as well as in the acceptance of it.

Synopsis: Neutra sees survival as a primary motive, deep seated beyond all speculative exercises of the mind. Individual survival and even more, survival of the human race, is a normally accepted value in the majority of known societies. He offers a number of reflexes as a basis for analysis: the startle reflex, the

defense reflex, the control reflex, and the precision reflex. Complications appear when the basic responses has been associated with secondary (or higher-level) conditioned stimuli, yet primeval motivation seemed to persist faintly in our design and can be traced there. Nonetheless, individuals are always encompassed by a socioeconomic geographic constellation – and responses can change.

The *startle reflex* is a definite involuntary response pattern. A designer has many occasions to use a startling feature and create corresponding reaction.

The *defense reflex* watches over survival and secures it by counter aggression, flight, or protective effort.

Maintaining clear visibility along the approach lines of a remotely possible attack or for a remotely necessary escape has been, as a variation on the defense reflex, an unconscious sub-motive of many a design decision. There is a natural gratification in feeling visually unimpeded and in being free for action, at liberty, not caged and incarcerated. Thus, [although a clear view through a window does not offer a direction of escape], a person may look at large view windows of a living room with their unobstructed panoramic possibilities and may feel like taking a breath of relaxation, gratification, and relief. However, another gratification is to be protected, and so another person, differently conditioned may look at the same wide, unobstructed glass with anxiety. Sitting with one's back to a wall may be valued as protection again surprise.

Clients of an architect may each voice their own concerns, an invitation for sympathetic "feeling in" that will factor into the design. A different role for the designer is to explain to the client design aspects that go beyond the immediate preferences of the client. This invokes a new neuro-mental level, the *verbal level*. In conversation, the architect [who shares Neutra's concern for survival through design] may now demonstrate feature values that have a bearing on well-being and survival.

The *control reflex* tends toward freedom of our body action and control of the surroundings by our grasp. An urge to possess is but a derivative of this primary need.

The *precision reflex* makes any nervously well developed individual react negatively to vagueness or imperfection and positively to accuracy. Such accuracy applies to perception into action as well and shows their close relationship.

Whenever gratification of such reflexive dispositions seems not fully attained, adverse emotional tonus is produced and purposeful action may be innovated to attain it. The James-Lange theory claims that emotional experiences are grounded in impressions from our muscles, viscera and so on.

Commentary: For most people the survival of themselves, then their family, and then some local tribe or community can predominate over issues of national or global survival of the human race.

The catalog of reflexes is useful, but I reiterate that much of our behavior is ongoing rather than purely being a response to a current stimulus. Neutra refers to basic human biology and what is natural for human well-being, but is nonetheless very much open to the realization that cultures change, and that there is no turning back the clock on mass production and large scale urbanism. The challenge then is to understand to what extent cortical overlays can enrich our experience, and how design can supply that enrichment and also respect the basic physiological needs such as access to clean air, good health, etc.

The emotions also come into play – some emotions are stressful but the nature of what is stressful may change from culture to culture. To this I would add a concern with the stress of poverty and the need for designs that transcend the scope of the individual architect to address inequality and exploitation. This comes up to some extent when later Neutra contrasts spurious forms of home ownership with the benefits of being a renter within a community of homes, and when he discusses future designs for cities.

"Reflex" is the wrong word for Neutra's so-called control reflex – and note that it does not involve the possession of the motor ability to control something but rather links to the social framework in which one may exercise that control. This invokes the debate over the nature of free will.

The "precision reflex" too is far from a reflex, and also seems far from universal. Herbert Simon (an AI pioneer as well as a Nobel Laureate in economics) taught us to realize that much of our behavior is guided by *satisfiability* – what is good enough for now – rather than *optimization*. Indeed, Simon's notion of satisfiability seems more apropos, and is relative to a current (immediate or long-term) goal.

We are not so much ruled by Neutra's reflexes as that we have a continuing pattern of changing motivations modulated by our very human ability to maintain long term goals of months or years of duration within which those fluctuating motivations such as feeding, fighting and family, etc., are positioned. The James-Lange theory remains influential, but I would update it to include cortical influences and ascending visceromotor influences in constant interplay – without denying that a visceromotor need may become so great that it becomes peremptory.

Theme 7. Habit formation and the dynamics of tradition

31. THE CUMULATIVE AND THE SUDDEN FEED INTO TRADITION (224-234)

Neutra: In the physiology of tradition two factors contribute – long habit formation and also brief but impressive shocks that become instrumental in the constructive memory of man and the [human] race.

[Throughout, I have replaced Neutra's use of the term *habituation* by *habit formation* because the former term is more commonly used in in physiology to denote the effect where a continually repeated stimulus may eventually become ineffective.]

Synopsis: Habit can streamline behavior through elimination of earlier complicating responses or by offering nonconscious mastery of entire chains of actions in glands and muscles – as when we sit down at the usual place for the usual meal and begin handling spoon, fork, and knife, followed by salivation and swallowing, all in the usual way. Tastes [in the non-gustatory sense] depend largely on the establishment of values through the process of *canalization*. The satisfaction of a drive reflects a disposition which may be rather general at first as accomplished in the end by specific stimuli and responses. At the beginning of a baby's life, a great number of substances put in his mouth cause swallowing. Later, the infant turns choosy. Thresholds have become higher for many stimuli which were originally accepted as adequate.

Design and design acceptance become eminent instrumentalities to brace individual by their adherence to themselves as well as the groups to which they belongs. Canalization of preference acquisition is a large part of the forming of personality. But the picture of a slow and steady shaping has to be supplemented if we turn our attention to drastic episodes which may and do occur. [Consider PTSD.] In contrast to prolonged habit formation, the shock of intensive emotion linked to the experience of a single strong stimulation may be decisive. One intense delight, one mortifying anguish, may become an almost unbeatable competitor to many earlier or later experiences of the mild habitual kind. For Neutra, then, a challenge of the designer is to offer shocks that are a source of delight rather than trauma. [Here we envisage, I suppose, the shock of the first encounter with part of a building that immediately instills a wish for later repetition of that "shock."] The value of a sliding door opening pleasantly onto a garden cannot be measured by counting how often and how steadily the door is used. The decisive thing may be a first deep breath of liberation when one is in the almost ritual act of opening it before breakfast.

The designer undoubtedly has to deal with both these principles of fixation and memory values: habit formation extended in time as well as shock.

Psychologists have observed that habit formation often terminates in only a partial dominance, and other competitive responses do not really die out but linger on in a repressed state. Neutra claims that If one truly wants a design feature to stand out as the essential one, one must make sure that all stimuli possibly militating against it are successfully silenced once and for all.

What seems hereditary in one's behavior is often influenced by the prenatal environment and the condition of a childbearing mother [and subsequent development – EvoDevoSocio, again]. Human beings belong to a society. In altering a tradition or in substituting something else for it, we must bear in mind that new habits or fixations cannot possibly be created but instead sedimented over older habits.

In a child, the assimilation of new habits need not waste much energy on the displacement or remodeling of what went before; and so habits formed at an early age are particularly strong and stable. By contrast, mature customers are liable to resent subjectively any deviations from established ways.

Tradition could be considered as the social establishment of stereotypes, for which the arch examples are gesticulation, facial expressions and verbal language made understandable within the group. Nonetheless, tradition may strangely stimulate an individual to rebel against its continuance; Or, conversely, a would-be reformer of design may easily induce or reinforce a reactionary attitude of the public against his person and consequently against his proposals.

The constructed environment is the shell which human society secretes through its manifold system-controlled, but often individually initiated, design activity. Neutra is convinced that patient research starting from the elementary and progressing to the complex can indeed gradually remodel the constructed world about us, to reach new levels of organic wholesomeness.

Commentary: Neutra emphasizes canalization, an active selection from among more or less adequate stimuli to make one of them dominant in the business of eliciting response. But in general, one learns to also seek stimuli not before noticed or accessible and may accept an increasing variety as appropriate. Moreover, the child masters the phonemes and syllables of the surrounding language to say and understand much that is new, rather than to master a few stock phrases.

Where Neutra sees the possibility of competition between habits or design features as possibly traumatic, I see competition as a normal property of life. Consider that you have two habitual routes from the bedroom to the dining room. One may be shorter, while the other may allow one to linger a while to enjoy the view from a window en route. The availability of such choices is a design plus, not something to be stamped out. In general, we need to take the whole scene into account and assess the possibility of diverse behaviors therein, rather than having a fixed stimulus and a standard response.

32. STRANGE IMPORTS AND MISAPPROPRIATION OF CULTURAL GOOD (235-240)

Neutra: Cultural evolution seems largely the evolution of habits and comparable fixations. This makes them worth the study of the brain physiologist but also a crucial issue for the designer and his consumers. It is in diet and dwelling that habits are hardest to react against. Moral attitudes may also have habit character but are less hardy because they are introduced later in life and are consequently reflected upon more consciously.

Synopsis: Sometimes social tradition has a strong biological foundation. Essentially and originally, it is a survival aid of the first order, but may turn nonsensical with the passage of time.

Certain patterns of response have somehow been preserved from cave days to the present. Mystically inclined conservatives may revere them as quasi sacred. [Recall that, for Neutra, conservatives are those who adhere to old habits; he does not use this as a political term.] Sometimes social tradition is conservatism's only subfloor; sometimes it has a strong biological foundation. Essentially and originally, it is a survival aid of the first order, although it may turn nonsensical with the passage of time.

Civilizations are wide open to cosmopolitan traffic. Clashes of habit and above all a controversial borrowing from strange incompatible traditions can ensue. The history of design is full of such transfer.

Neutra illustrates the breaking and supplanting of habits, the glory and downfall of tradition, by the impact of the Western importations initiated by Admiral Perry on Japanese building traditions. The changes not only changed styles of living but also led to the loss of traditions for workers whose

livelihood was rooted in them. Here, a prototype of well-conditioned human functioning became sadly obsolete. In this way, an intensely interlinked complexity of causes and effects ultimately succeeded in effacing neatly established neuro-mental patterns.

Commentary: In a later discussion, Neutra addresses the problem of importing colonial building conventions to an island in the West Indies – and the need to discard these imported "habits" to take advantage of local conditions. Conversely, in a community hosting groups from different cultures (such as religions), buildings (such as houses of worship) can vary to offer a sense of cultural identity. The designer must then assess to what extent such buildings should retain a traditional symbolic form or whether new ways can be found of meeting these symbolic function.

33. CONSCIOUSNESS MUST NOT BE OVERESTIMATED IN DESIGN (241-246)

Neutra: Consciousness must not be overestimated, as so much occurs in our being unawares. Still to direct awareness remains a paramount task of the designer.

Synopsis: A proposed environmental change through design must be carefully prepared for acceptance; this is often achieved through verbal explanation. Yet conscious affirmations may appear only after seldom accounted-for emotions have already established a strong attitude toward a design. Our responsive contact with design often operates in a direct physical manner, such as actually sitting on a designed chair – and the muscular sensations are for the most part beyond the orbit of consciousness.

However, it is more than hazardous to permit acquired likes and dislikes to govern consequential design decisions without screening and interpreting them skeptically. No matter what the role of the subconscious in design, awareness remains a great issue to designers. They have to acquire a vast operational knowledge and must learn that, according to experiments, awareness of almost anything can be strengthened or blocked if appropriate means are used.

How, and how drastically, can design and the individual designer operate on such a sociological product as tradition? How tenaciously will the consumer cling to it? A proposed environmental change through design must be carefully prepared for such acceptance. This is often achieved through verbal explanation. It works through a frequently repeated intellectual appeal that must be accompanied by one of emotional nature and is best introduced with judicious gradualness.

Yet we deal with the brain phenomenon of automatic association, and conscious control here is only minor. Layer upon layer of conditioning must be placed to build up our habit structures.

We must guard against any overvaluation of consciousness. Even conditioned responses are largely characterized by unawareness of the processes that generate them. A person may become attracted to a certain musical selection by hearing it repeatedly in the background during pleasant meals at a resort hotel, or may value it because it is remembered it as part of a romantic interlude. [This captures something of the difference between a procedural and an episodic memory].

The designer, who wields the tools of sensory and cerebral stimulation professionally, can perhaps be recognized as a perpetually and precariously active conditioner of the human race and thus acquire responsibility for survival. Unfortunately, short range commercial roles dominate the designer – and these are seldom practical for survival. To the latter end, designers will have to employ consciously the involve responsibility of their job as gardeners of nervous growth.

Commentary: Whether developing designs that affect the awareness of the inhabitant of the building or affect them at a level below consciousness, the architect must remain conscious of the intended effects and how they are to be achieved. However, elements of the design may themselves spring from nonconscious activity of the designer's brain that plucks relevant ideas from the storehouse of memory.

Neural networks may adapt through systems of positive and negative reinforcement that allow us to reach judgments of good and bad without necessarily engaging any reasoning, though we may offer reasons post hoc for decisions already made.

Theme 8. Exploring the notion of "ownership"

34. "CONTROL" CRYSTALLIZES IN OWNERSHIP, COLORS OUR SETTING (247-251)

Neutra: "Control" crystallizes in ownership. The map of towns, architecture, and the entire constructed and fabricated environment have actually been dyed in the wool by ownership.

Synopsis: Ownership means control if it means anything at all. The natural precedent for ownership is perhaps the conscious possession of our bodily and mental faculties. When human beings began to provide tools to supplement their physical faculties and produce commodities for their use and consumption, they extended the concept of possession further.

The primary concept of possession is a functional one that refers to actual use, or the freedom to use. Humans condition their children by handing them goods as gifts on a long-awaited festive day, telling them: "they are now yours." This magic phrase and ritual connotes a transference not merely of use but of ownership – a symbolic act that adds to its emotional complexity.

For Neutra, we own portions of the constructed environment that we are physically able to modify or make use of at will, and he notes that such ownership has pleasurable associations. In architecture, the question of ownership of buildings turns into a gauge of socio economic controls. This raises the question for Chapter 37 of whether a renter can be said to enjoy the of ownership of their home.

Designing a building means inherently dedicating it to specific controls, but humans claim ownership of various parts of their natural surroundings as well. A portion of the land, water or woods may belong to an individual or to a community or nation. Home owners often like to claim that they were the authors of their home and seem to begrudge authority to an architect, because they sense that these rights are somehow competitive with their full enjoyment of ownership. Commercial provisions and legal definitions of an author's possessive right are to this day quite vague in architecture.

Commentary: They extension of the body by the incorporation of tools, or its diminution through brain damage has long been a study of neurologists under the name of *body schema* – though in the context of perception and control rather than ownership.

As for the architect's authorship, I saw architects' signature panels affixed to buildings in Montevideo, an excellent innovation.

35. MONUMENTAL "ETERNITY" AND "DEDICATION" IN ARCHITECTURE (252-256)

Neutra: The "eternal" character of a monument is admixed to architecture, making it a token of glorified dedication and belonging. Fixing this idea over ages is all the function a monument is expected to have.

Synopsis: Neutra is concerned here with those monuments like the Egyptian pyramids that were to symbolize and exist for eternity, rather than the monuments designed to serve as physical reminders of important events. However, much discussion focuses on what may be misguided use of traditional forms. A tire factory in Los Angeles may be symbolically dedicated to California by being designed with the outward appearance of a Franciscan mission. In this way, a regional community is given some mystic partnership claim to the building.

A complementary theme is that buildings may be preserved inappropriately. A physiologically sound, dynamic integration of the constructed environment is often hampered by private ownership. At least, it may clog urban rehabilitation, which the individual owner himself longs and hopes for when he happens

to live in a district blanketed by blight. Such blight must often be resolved by condemnation of obsolescent ownership.

The Cheops pyramid was erected by masses of exploited humanity in a way that made it an offering to eternity. Such a building erected by electrical derricks would, Neutra feels, be but a shallow offering to the gods. While concentration of power and mechanized effort are now stupendous as regards operational potential, they are too impersonal and fluid to lend themselves easily to connotations of static dedication or eternal belonging. Monumentality will have to be truly of our own version to prove successful in an age which has such different and staggering perspectives on time.

Commentary: Perhaps one can think of the practice of restoring old buildings and adapting them to new uses as a positive mix of monumentality and functionality, maintaining something of the quality of a monument even though the function changes.

If we turn from the Cheops pyramid to the great cathedrals of Europe, we see buildings constructed for eternity by the labor of anonymous craftsmen whose labor extended over a century or more. Nonetheless, people still build churches, though far more quickly and exploiting modern machinery, which are in some sense to be viewed as God's house even few are designed to last "forever." A neighborhood church may be deconsecrated, whereas the great cathedrals are to be preserved.

36. OUR BELONGINGS AS ACTIVE BODILY EXTENSIONS (257-261)

Neutra: We no longer cherish treasures kept buried and in abeyance, our choice is a continuous handy control of what we need; Our belongings shall be ours after the fashion of our well exercised limbs, and we hate atrophy, decked out and splendidly draped.

Synopsis: Abodes are conceived as containers not only of inhabitants but also of their belongings. Properly understood, possessions reflect the individual's personality, their personal biases, and those generally current at the time. Storage requirements are not secondary. The architect designing a house, needs where possible to meet with the family to understand the possessions that will be of use to them.

The emphasis of ownership of objects has shifted away from precious objects to be displayed to usable objects that are readily accessible. This tendency to impermanence seems unavoidable in a civilization of inexpensive, mass produced commodities. It involves carefree and abundant use with less subsequent toil to restore, to repair, to clean. Our ideas of cleanliness are broader, more scientific, and then those of any former period, but we want to spend a minimum of time and energy in the achievement.

Consider a future house designed for the many – small, well and conveniently planned, but with limited floor area. Its usefulness will be tested by the intensity of easy, logical, flexible usage of each part of this floor area, with square foot hours of usage per diem providing an index of livability and dwelling value.

Commentary: Despite the increased emphasis on usable objects, dwellings have always contained kitchens with diverse objects used for cooking and eating, while many homes contained areas where craftsmen or workers could use their tools. People still like to display artworks or, at least, family photographs and meaningful souvenirs. We still have various items of (possibly) built-in furniture that provide the background for both display and for access to usable objects. Nonetheless, an understanding of objects that people want to display or have at hand places conditions on design.

The Frankfurt Kitchen of 1926–7 by Austrian architect Margarete Schütte-Lihotzky, provides a fine example of workflow design combined with clean lines and unadorned surfaces. The design sought to combine functionality with limited space in an ordered, hygienic world designed to improve the well-being of the housewife – though the design left little space for accommodating the particular food choices or objects of the individual user.

Recent decades have seen the rise of digital devices and the Internet to become necessities for much of the world's populations. This, coupled with rapidly increasing power of Artificial Intelligence, offers further challenges for the architect's consideration.

37. "OURS" IS ONLY THE MEAL WE CAN DIGEST (262-271)

Neutra: Only that meal is "ours" which we can digest. A house, neighborhood, a huge megalopolis, all beyond our organic controls, are not our house, our neighborhood, or our city.

Synopsis: In Chapter 34, Neutra asserted that if we own something we are physically able to modify or make use of at will – thus the metaphor here is that food is "ours" only if we can eat [though you can't have your cake and eat it too]. The safest way to achieve belonging would seem to be to design our environment so that we can assimilate it with a degree of nervous comfort. An American pioneer in his forest clearing truly owned his humble cabin. Contrast the home "ownership" who has limited choice of a house built from standardized, marketable materials on a small lot in a previously established subdivision. There is little spiritual content, only the ever recurrent irritation of meeting financial obligations connected with it. Such ownership is pitifully pinched. Buying your home on the monthly installment plan is like paying rent, but with the added responsibility of maintenance – and yet the idea of "ownership" retains its "magic power." Humans do not necessarily live by actual experience but more frequently because of early conditioning. Neuro-mental conditioning represents a greater problem to designers and planners than all the technical difficulties or resistances of physical material. It can be changed by gradual retraining, but hardly by argument.

Neutra recalls how, before WW II, he was seated beside a labor leader who explained that American workers cannot wholeheartedly embrace the idea of rental projects because "they carry the nostalgic longing for a home of their own." In response, Neutra argues that a certain form of rental property would be more beneficial then subjecting oneself to a mortgage and "bogus" ownership of a tract home. [He does not discuss the way the well-off may work with an architect to design their own home, or the problems of the poor or homeless.] If, by their payments, proportional-benefit tenants acquire a say in the neighborhood community, they can influence a wider setting beyond their restricted four walls. Biologically studied and restudied, the natural, physiological terms of symbiosis (living together for wholesome survival) can apply to such a scheme and such a design for a well-fused neighborhood.

Commentary: Certainly, a megalopolis will be beyond our organic controls, but we may nonetheless see it as "our" city if it contains venues (parks, theatres, shopping areas, vistas, etc.) that enrich our lives.

How is physiology relevant here? Presumably at the level of habits formed by the social context, and the widespread social disapproval that may block change. Another issue is the contribution to well-being offered by having a sense of community, and a sense of control of ones own dwelling within that community. Neutra lays bare the problem for potential "buyers" of the rapacious developer of a tract of housing, but does not address the problems of renters with unscrupulous landlords who default on maintenance, overcharge, and never respond to the needs of the non-existent "community" of those who rent from them. It is worth pondering the political as well as biological issues here, assessing the way the "socialism" and "unions" have been demonized in the US.

Neutra's repeated assertion that the workers should live near their place of work and thus rent their housing may seem appealing when the trade-off is between mobility of a home versus long commutes. However, moving children from school to school as a parent changes jobs may not be to their well-being, and then there are the complexities that arise when both parents work, rather than having the wife generally stay home as in the period when Neutra was writing.

Theme 9. The challenge of the adoption of innovations

38. "DESIGN ACCEPTANCE" MOULDS CULTURAL EVOLUTION (271-280)

Neutra: The problem of design acceptance is basic for human evolution and foreign to evolution in nature. Nonetheless, natural laws do govern what minds can assimilate; there is no use lamenting these laws but much use in learning about them.

Synopsis: Conservatives are rightly worried by novel design. Designers always add something to the natural, organic equipment of humans. Human architecture is distinguished from animal architecture. by the fact that the former may constantly introduce innovations that seem to originate from individuals [and, we would add, focused teams – see Chapter 40] whose newly modified patterns may be pieced together from various sources by associatively gifted brains.

Anthill and beehive are foolproof, but no ingenious effort or inventive protagonists or novelties of design are involved. To some extent, though, animals can learn new behaviors within their own groups. Neutra notes modifications of hunting methods used by wolves and prairie dogs that are originated by one specimen and imitated by the pack. This would foreshadow the role of the leading designer.

Consumers act in various degrees from a flagrant yielding when faced with the dominant compelling force of authority to something that looks like convinced consensus. Innovations are often ridiculed and rejected when they first appear. The need then is to understand how introduction of new designs can support a possibly gradual process of assimilation, rather than encouraging rejection.

However ridiculous it is in certain instances, there exists the fundamentally sound attitude that unless an innovation in design is assimilated into a well integrated order, it may disrupt that order and threaten survival. The individual designer seems less interested in fending off such a possibility than he is in his own pet invention. Rejection may testify more against the injudicious methods of introduction than against the design product. The pioneering designer, therefore, will always have to engage in a series of steps rather than in just one design, or disclose its new features and consequences gradually instead of in one stroke. Cultural evolution or technological progress is not achieved by means of intellectual persuasion. Rather its fate is determined piecemeal by the laws of nervous economics which underlie affirmation, acceptance through habit formation, and resulting emotional gratification. Anticipation of trouble is typically elicited in us whenever something new threatens our neuro-mental balance.

Commentary: It could be fruitful to further the notion of *the balance of neuro mental economics*. Here it seems to involve weighing the effort of mastering a new habit against the discounting of future economies of effort after the new method is adopted. We can reiterate with Neutra that a change will be accepted more readily if its long term benefits are made clear. For example, the adoption of smartphones involved a series of incremental changes in the United States and other Westernized countries, but could be adopted in other countries without the intermediate steps because the benefits and enticements had been well established. But what does this imply for architectural innovation? Perhaps introduction of more awareness of climate change and the use of solar panels might be one such example that calls out for architectural innovation as well as simple adoption of the technology.

The discussion of novel hunting methods relates to recent research on "animal culture" – neither as complex as human cultures nor enriched by the ability to use language. Such work may not directly impact our architecture, but does offer new data for assessing the "biocultural" in linking comparative and evolutionary studies of animal behavior to accounts of human behavior.

Recall the earlier discussion of mass production. Immense development costs for an innovation may be justified only if one can guarantee a very large market for the result, and even well-adapted systems may have unintended consequences or, like freeways, benefit some at the expense of others.

39. THE "VESTED" EXPERT AND THE ONE-TRACK INNOVATOR (281-286)

Neutra: The "vested" expert – witty or just sour – rises against innovation more often than the common man. On the other side, innovators frequently have one-track minds, and cannot comprehend all the doings of their own brain children.

Synopsis: Here, Neutra further considers some of the forces opposing innovation, including the way in which crowds may be influenced by particular individuals, the problem of reconciling innovations with symbolic traditions, the initial cost of transitions before they are well established, and the difficulty of extrapolating the positive impact of an innovation from its early inception.

Human groups are complicated in their psychological constitution, and values are formed owing to leadership and followings. Many innovators may suffer at the hands of a renowned authority whose mental patterns and imagination are weighted backward rather than forward in time.

Among several examples of conservatism, Neutra notes that opposition use of the metric system of measurements in the United States has been based on sentimental appeal as well as upon arguments based on the costs of the change [a resistance even stranger today when only the United States, Liberia and Myanmar have not adopted the metric system for (most aspects of) everyday use].

An example of Neutra's sense of humor: He recalls the story that when US President Fillmore installed a bathtub in the White House in 1851, there was an outcry against it as a monarchical luxury that could well be dispensed with inasmuch as former presidents had got along without them.

Appliances and equipment brought into buildings have gradually taken a place equal in importance to structural elements. But until very recently [written in the 1950s] any attempt to integrate such utilities with the structure, and to see their problems combined for mutual benefit, was rare. Architects took a less lively interest in plumbing facilities than did politicians and moralists.

Commentary: Consider the way in which the Internet of Things has penetrated the house and the office and the factory. But in the house there is still little attention given to the architectural implication of these devices. Nonetheless, the modern kitchen and the modern bathroom reflect in their design the availability of utilities as well as the related devices that have become inseparable from a certain style of living. To what extent will the integration of virtual reality, augmented reality, and physical reality become prime concerns of architectural design?

40. ORIGINATOR, TEAM, AND THE PHYSIOLOGY OF PRODUCTION (287-290)

Neutra: The grand, Godlike originator must throughout civilization descend more and more into a merger with a cooperative team which then reveals its own peculiar physiology of production.

Synopsis: The producers of Stone Age flint implements may have been isolated individuals, but the number of people who must collaborate in the production of a television transmitter or a fully equipped prefabricated house is incomparably greater and more highly differentiated. Successful design can hardly be divorced from production planning. To make clear the mental workings of a creative team would be a most significant example of sociometry – the graphic illustrative study of productive human group relations. Our advancing knowledge of physiologically-based psychology must rectify the picture of heroic independent creation by investigating the interlocking chains of group stimulation and reaction and chains of nervous events, mutually sparked, through which complex design is originated and executed, and on which its reliable survival value will depend.

The latter day originator thus has little opportunity for God like freedom and solo creation. In another display of his ironical sense of humor, Neutra comments that no such limitations are imposed on the Creator in the Book of Genesis, but even God soon met with that disappointment of the innovator, the lack of acceptance and cooperation on the part of his public. Because of this failure a new start was undertaken, cleansing the earth by the Deluge. In spite of His saddening initial experience, the Lord in

the next attempt adhered to His original design. He decided to improve the consumership of His product rather than His design of the world.

We increasingly depend on many communal facilities outside our own four walls. In Chapter 46, Neutra considers the neighborhood and the entire community around our dwelling place as a telling example of a finished product – probably the most significant package of design environment for our survival.

Commentary: In Chapters 39, 40, and elsewhere, the relevant science shifts from the neural to the sociological level, and emphasizes physiology less than social interaction. Neutra charts how one change may depend for success on a whole system of changes. For our conversation between architecture and neuroscience, I thus include the cognitive and the social in our broad view of neuroscience.

Theme 10. Towards the fuller study of design's impact on physiology

41. CHANGE IN THE PRODUCER CHAIN MAKES STYLE "UNSTABLE" (291-300)

Neutra: An ever-new make-up in the producer chain makes "styles" unstable.

Synopsis: Neutra does not make clearly the "instability" of concern here One idea, not addressed in the book, is that when products depend on a complex supply chain, the unavailability of even a single component may halt construction.] However, the main point here (extending the discussion of Chapter 40) is that in this age of projects that require working with many people with different expertise, from fellow architects to workmen, architects can no longer consider themselves as a lone creator, but must understand how to bind different portions of the team together – and this is a matter not only of formal specification but of explanation and motivation.

In the past, the originator of a design usually communicated his idea directly to his working crew, and clarified it by showing them what to do. Drawings and blueprints are a rather recent development. Neutra recalls meeting a native architect at work in Ceylon [Sri Lanka], who had been directing workers constructing a large temple for 30 years, with no schedule or budget in evidence. He contrasts this with the need for the Western architect of comprehensive over-all planning, with pre-budgeting of space, energies, and funds. But developing plans as construction proceeded was here first, and the world is studded with monuments to afterthought – bright and otherwise. Afterthoughts are extremely natural. Brain physiology would indicate that there are no thoughts, only afterthoughts in endless sequence.

Person to person explanation and demonstration of a creative scheme stimulates the working personnel when these are addressed to many senses and supply intellectual and emotional impetus that is lacking in the "formalistic verbiage" of specifications and legal contracts. The freelance designer preparing plans for competitive bidding does not know what crew he will have, or how well it will grasp his ideas, or the psychological factors with which he may have to cope with in obtaining needed, willing teamwork.

Free contracting, whatever its advantages, tends to eliminate certain types of creative people who were able to function constructively in former periods, and assures dominance and survival of other types who perhaps were never before found in the field of building a human environment. We must hope that while certain values have been irretrievably lost, the process of communicating design ideas should not be dehumanized and mechanized any more than is absolutely necessary. Any depersonalization or freezing of these processes tends to inhibit the living evolution of design itself.

Commentary: Perhaps Neutra's arresting claim that "there are no thoughts, only afterthoughts in endless sequence" is related to the idea that imagination works as diverse prior images come to mind -- but the resultant process of mental construction involves many combinations and changes that make the cumulative effort very different from a sequence.

Tying into the notion of collaboration, consider how models and drawings and language are used to provide communication concerning preliminary designs as the overall design proceeds towards the detailed construction drawings and then continues through the physical construction of the building.

In some sense, we now have mass production of workers as well as components. However, although the architect cannot coordinate all those involved, the use of foremen and other group coordinators can supply that role to the extent that they can interface with other groups to understand the large scale issues while interacting with individual workers to ensure that their form of the contract is successfully carried out. In any case, we certainly need to better understand how the brain supports various forms of cooperation and coordination, whether based on language or the recognition of facial signals of emotion or bodily indications of ongoing and intended action.

42. A HUMAN TIE BETWEEN DESIGNER AND WORKING CREW (301-306)

Neutra: Increasing shop fabrication may revive the human tie between designer and working crew, the contact that was sorely lost in the bewildering fog of an age only partly mechanized, an age of paper specifications and competitive contracting, of footloose freelancing and design, and of plodding along on construction premises.

Synopsis: The contemporary architect has been trained to use visualizations, but good architects do not confuse the paper presentations with their overall understanding. Some sketches provide an effective method of being understood by clients, bankers, contractors, etc. In turn, these people are helpful to the architect in the full realization of the design – but only to the extent that they grasp and visualize the architect's intention and enter into it with an emotionally favorable attitude.

New ways of gratifying demands of form must and will be developed under the mutually changed conditions of mind and construction process. The publishers of 18th century Paris hired artists, often painters, to devise ornamental forms for sale. Such designs undermined the artistic prestige and initiative of the artisan and the shop. Pattern sheets wiped out normal tool-bound design concepts founded on shop practice rather than on dexterity with the pencil. New forms of fabrication may restore a sense of workmanlike initiative that has too long been obscured by detached draftsmanship.

Commentary: Note the distinction between mental representations and their partial expression as a basis for communication, and the iterative effect of this communication in refining the design as it proceeds. And contrast the compelled exercise of a skill and a satisfying exercise in a cooperative environment. Even when workers do not feel cooperative with the higher-ups, there may still be a companionship amongst themselves that can create a positive workplace.

Turning to the current day, how does delegating many of the details to computer-guided tools affect the experience of workmanship? Can a worker in a large factory or on a huge apartment block find their job a source of pride, not just of wages for survival? Unions have arisen to try to improve working conditions, but may be unable to increases the worker's engagement with specific projects.

How do we trace the line back from here to "design for survival of the human race"? Perhaps the general issue of well-being focuses here on the well-being of the workers who produced the buildings whereas elsewhere Neutra emphasizes the well-being of those who will use or inhabit the buildings.

43. DESIGN MUST GUARD LINKAGE OF ALL LIFE'S NEEDS (307-313)

Neutra: Life's needs are thoroughly interlinked but this linkage is rarely observed with care. Neither speculative thought nor piecemeal technology can make up for such essential carelessness.

Synopsis: Neutra's goal here is to stimulate interest in obtaining objective physiological data as guides in constructing environments more beneficial to human well-being. He presents one case study at length, the experimental design of elementary classrooms in Texas. The study was led by D.B. Harmon, who began with a physiological interest in how the optical environmental influences development of

schoolchildren. “We do not see to see,” said Harmon, “we see to act.” An interdepartmental Commission was formed for the state of Texas -- composed of physicians practicing internal medicine, dentists, orthopedists, educators, illumination engineers, color, paint, and optical experts -- for the purpose of studying the light and brightness distribution in elementary classrooms and diverse factors that thereby influenced the growth, health, behavior, and learning performance of 160,000 Texas schoolchildren. Brain wave (EEG) recordings were made of children while in visually stimulated action, under both ordinary and corrected classroom circumstances.

In the traditional grade school room with several windows along one of its long walls, the children are regimented. They are seated parallel to each other at fixed desks placed in straight rows, all directly facing the blackboard. The light comes from the left. The studies proved that the difference in brightness between the left and the frontal portion of the field of vision should be reduced to a minimum to obviate eye strain, leading Harmon to an unusual arrangement of the seats in curves. Neutra concludes that we have been suffering from a roughshod and arbitrary individualism that interferes with the kind of harmonious setting other cultures have enjoyed, but we may in our designs come closer to a truer understanding of the individual and its nature.

Commentary: This is one of the few places where Neutra reports on an actual study of the kind he repeatedly advocates – assessing the impact of physiology on human well-being of different architectural strategies. Of particular importance here is that improving the health of children can have a long-term effect on their well-being and survival as adults. Turning to this specific study, note that Harmon’s design rearranges the seating within a conventional classroom. In Chapter 44, Neutra discusses classrooms he designed that could be opened up to allow children to sit both inside and outside to gain the benefits of fresh air and natural lighting.

44. DESIGN CHANGES OUTER LIFE AS WELL AS INNER BALANCE (314-324)

Neutra: Design, never a harmless play with forms and colors, changes outer life as well as our inner balances.

Synopsis: Physiological psychology dates back to Wundt. Since this work, acoustical intensities and pitch, tactile impacts on pressure, gravity pull, and so on, have been investigated in their role as stimuli and the effect of changing their values measured in an orderly fashion. All influences of our surroundings – be they accidental or of our own design – should become engageable similarly as, for instance, the effects of the thermal and other physical or chemical properties of the air that surrounds us.

In our technologically advanced state of affairs, the physical environment is largely a pile of often incoherent constructions interfering with life processes and adulterating them. Such design often disturbs many inner balances and thus manifestly affects our individual well-being. Reducing such disturbances is crucial to the development of a generation of growing, still pliable children, and thus, for the survival of the human race.

Neutra offers here the single case study of his own work in this book – a school in the Caribbean in which the rejection of colonial design led to improved airflow and comfort for the children in ways that improved the environment for their education. He was called in to devise the layout and structure for simple, rural classrooms on a tropical island [presumably Puerto Rico] where obsolete regulations, imposed from Europe many years before, required a legal minimum of static air storage per child in the room. Most of the stored air was to be in a volume stagnant under the ceiling, while the windows were ordinarily placed much lower down, all on one side of the room, without regard for cross-ventilation.

But cost, structural safety, and combating the spread of disease, are not the only things we cope with through design. We are also concerned with sensory comfort and with general well-being – concepts badly needing physiological understanding. Sultriness, an object of complaint, can be mitigated by

opening up the building and orienting it into the steady Trade Winds, which are equally West Indian and a glorious asset to the climate if one gives the air a chance to pass over our skin, where it dries sweat droplets and causes a delightfully cooling sensation. For Neutra to take advantage of this, the most difficult part of the assignment was to overcome the bureaucracy backing the old ordinances. But classrooms are for children and for education and with this concern in mind a new layout offered a great many advantages. Neutra observed that a lower room under the tall tropical trees may be, as a shelter, in much better scale with the child's stature. Projecting roofs and broad fold-up doors would help extend the room outward through a wide opening onto a classroom patio and augment the floor area for the horizontal expansion and activity that is so welcome to normal children as well as to modern teaching processes. And all this was possible when air storage was replaced by air passage.

Airflow is reckoned in time. Architecture must serve living beings who themselves operate in time. The pulsing of our blood, our breathing, and all the many rhythmical processes that go on simultaneously within our bodies provide the processes – much in need of accommodation in suitable space-time, in which we live and survive. Those parts of our brain that serve willful activity are in constant interaction with those that regulate our nonconscious vegetative processes. Our vegetative functions are not isolated from those of the senses. The sympathetic ganglia supply the involuntary muscle tissue of heart, viscera and glands, and are engaged in those processes that formerly were called vegetative and later automatic. But a great deal of preganglionic fibers and other conductive bridges intimately connect the central spinal system and this autonomic system to make it really one interdependent unit.

Shock, such as a frightening sight, may upset intestinal functions. Walter Cannon's studies of *homeostasis* show the sympathetic system as an instrument of automatic adaptation to routine change of the environment. Designers are perpetually concerned with what adaptation to their designs an individual or the public as a whole can accomplish. Aware and willful activities are relatively few and directed from the motion areas of the frontal lobe [and the brain more generally]. Tellingly, the product of upper brain power called design will affect ever greater portions of the innermost human being.

Commentary: In the last 70 years, much has now been achieved under the banners of ergonomics and environmental psychology in research descended from the work of Wundt. There are now masses of data, and the challenge is to organize them to best aid architects supporting "survival through design."

Anatomically, we can distinguish the autonomic nervous system from the central nervous system. Thus we need to understand more about the interaction between the two systems. Their communication is related to the integration of visceromotor effects and higher cerebral processing in human emotions.

Since we now live in the age of Cyber it is worth noting that Cannon's work on homeostasis was an important topic in Norbert Wiener's seminal book of 1949, *Cybernetics: or Control and Communication in Animal and Machine* since it showed the importance of feedback (in this case on departure of oxygen levels and glucose from desired levels) in physiological systems. Neutra does not use the word *feedback* in this book, but it is clearly crucial to any analysis of design for survival. The thermometer is the basic feedback system, so we can consider HVAC as offering fertile ground for further automation of homeostatic functions in architecture, while agreeing that in many cases passive air conditioning may be better than the use of machinery, which is expensive in both initial cost and in energy consumption.

45. INTUITION AIDED BY A MANIFOLD RESEARCH (325-336)

Neutra: Outline of the manifold experimentation that may point to greater wholesomeness in the design of our general setting for life.

Synopsis: The human organism must be enabled to perform successful habit formation while the designer and architect must aim at nothing less than the steady improvement of the human-made environment in the direction of an enhancement of all biological values. Neutra cites Ivan Pavlov's book on *The conditioned reflex, neuropsyche and cortex* and the post-Pavlov literature that provides the key

framework for his thinking about the brain. A post-Pavlov study in which a dog's salivation reflex was conditioned to an object assessed the significance of relative location. The object was placed at various heights, requiring a tilting up or down of the subject's sense organs in various degrees. Orientations upward and downward were, for most natural reasons, characterized by different effort and are of different valence, emotionally, as well as physically. Neutra cites N. E. Ischlondsky's picture of acquired responses functioning in rich variations over the base of primary reflex patterns. The variations arise first from the countless accidental conditioning experiences of man's life in the natural scene. The conditioned responses that a designer must support are often very complex; nevertheless it seems feasible to devise laboratory experiments that will gradually throw light on relevant problems.

Neutra illustrates the physiological basis with four responses (compare the four "reflexes" of Chapter 30): the orientation response, the defense response, the control response, and the precision response:

Orientation response: "I am ready to act or am already acting to gain a position so that I can be fully aware of a particular event which I must face. I raise or turn my head or my whole body, I dislike anything that is interposed between me and the source of stimulation [or the resources that I am now seeking]."

The orientation response consists of an involuntary turning for reception. Neutra emphasizes aspects of static forms, such as centering on the axis of a symmetrical object and then turns to our effort of orientation if an object is asymmetrical and in motion.

Defense response: (a) Escape: "I'm alerted to flight, should it become necessary. I have quickly checked my general perception that I am not surrounded by an obstructing enclosure or any other obstacles impeding escape." (b) Protection: "I like to be fully protected, should any circumstances require it. I have checked by perception that I am well surrounded by an enclosure to shelter me safely."

Control response: "I desire to be at liberty, free of shackles and impediments, in order to have full control of my limbs and of all objects or tools that may be required for the gratification of my intentions, whatever they may be. I have checked my perception that everything I might want to make use of is handy. None of it seems to be out of reach; nothing and no one is positioned to interfere or stop me."

Precision response: "I am acting to get everything in which I'm interested clear, sharp, and distinct to my senses. My perceptual checkup shows me that I have succeeded in eliminating all vagueness, all blurred uncertainty from my sensuously accessible surroundings or from their impressions on me. I want to be satisfied that everything I intend to pay attention to is well in focus and defined."

An adverse emotional tonus is in turn linked with various measurable effects in the vegetative system, which on their part are felt, either plainly and pointedly or just vaguely, as unfavorable to well-being and survival. We are irritated, disappointed, depressed. No basic response pattern can be subjected to prolonged frustration, none of the basic cravings can be starved, without marked discomfort.

The designer will need to gather objective information about which responses are wholesome in a given situation, ascertaining the environmental influences affecting the organism generally, clarifying data on specific sensory responses and their relation to inner somatic equilibrium, eliciting the responses elicited in our brain by simple design elements and then the interrelations and mutual dependencies and interferences of these responses. Design is perceived and specifically planned not as a sum of design elements or of separate stimuli but as an integration of such stimuli, but recognition of this fact should not deter us from analytical exploration as far as the current state of information permits.

Neutra lists five overall objectives for the study of physiological data relevant to design:

1. To ascertain the force of influences of environment affecting the organism generally, not through the senses. [What does Neutra mean by "not through the senses"?] Special consideration will be given to stimulations that are man-made or modifiable and therefore within the province of the art of design.

2. Clarify data on specific sensory responses, to show how sensors work, singly and in combination.

3. Study the relation of such sensory stimulation to an inner somatic equilibrium, which is fundamental to our immediate well-being and our ultimate survival.

4. Study conditioned and associated responses elicited in our brain by simple design elements.

5. Investigate with ever greater refinement and dependability the interrelations of all responses, their superpositions, configurations, and mutual interferences.

The subjects on which experimentation is undertaken may be both animal and human. Psychologists observe how mice react to mazes, which after all are a complicated sort of architectural interior. An involved stimulation is more appropriate to human subjects, and these should include some of average endowment as well as exceptional and even pathological cases. Aberrations sometimes illuminate by contrast what we appreciate as normalcy

Neutra then classifies the test objects used in such experimentation into three groups:

1. Specific properties of sensory significance: Shapes, colors, textures, consistencies, and the like, considered in their function as singled-out stimuli.

2. Materials: Substances with which our combined senses habitually deal as complex stimuli such as occur in a constructed environment.

3. Arrangements and compositions: Overall stimulus combinations, such as a room designed for a specific use, thus involving, optical, acoustical, chemical, mechanical, thermal and other factors. The play on a sensory and central nervous system as well as on our general physiology may occur for the most part in enlarged and fixed combinations of many ingredients.

Commentary: Our attention to a scene may depend on our task – we may orient to the doorway of a building if we plan to enter it, but are less likely to do so if we are passing by. Much work has been done on the brain mechanisms that allow us to have our attention to attracted to an object (saccades) , and to keep track of a moving object that catches our interest (pursuit movements). These studies have been extended to include the use of audition and touch in attracting our attention.

When discussing the orientation reflex, Neutra says too little about the recognition of objects in relation to each other [apart from his brief mention of “arrangements and compositions”], and the actions that the overall scene supports. Relevant studies evaluate the effect of stimuli that compete for attention. These can be related to the workflow studies in, for example, a kitchen whose findings can guide designing the placement of various features to support a range of tasks.

An adverse emotional tonus can be complemented by positive effects that together are studied in ongoing studies of reinforcement learning that can involve a range of cognitive aspects.

Much progress has been made on Neutra’s overall objectives for the study of physiological data, but the design of experiments that offer a careful study of just a few key variables and yet is relevant to the multitude of variables that affect people in the building remains an ongoing challenge. New methods in machine learning and artificial intelligence that can extract patterns from immense datasets may offer a partial way forward, with the “experiments” moving outside the laboratory and into the built environment. Correlations discovered in this way may then guide more focused studies that can better explore the mechanisms underlying what appears to be crucial.

Not only do “aberrations sometimes illuminate by contrast what we appreciate as normalcy,” architects need more information to design for different populations ranging from young children beginning to learn about their world to those older people who are unfortunately losing there memory or suffer from other disorders. More generally, we have an increasing awareness of how to provide access to buildings for those with disabilities of locomotion or perception.

Theme 11. Community planning and urbanism

46. COMMUNITY PLANNING OF A BIOLOGICAL REALISM (337-380)

Neutra: Community planning is an art, but one in need of a large scientific advisory board, chaired by an expert in biology.

Synopsis: [This is by far the longest chapter in the book and explorers a theme of its own, the extension of Neutra's ideas to the urban scale.]

The design of single buildings must be viewed within the larger context of neighborhoods and cities if it is truly to contribute to human well-being and survival through design. The "natural" is a moving target and cities are now a "natural" habitat for humans. Some observers consider medieval towns in Europe that grew around a pre-existing center such as a monastery or a church to be natural in contrast a city like Washington DC created by rational initiative. Neutra rejects cities based on a rigid planimetric scheme but embraces the development of cities' life processes as a phenomenon within a four-dimensional continuum of space and time. Every city includes not only human and bacterial populations, but also insects, lower mammals, vegetation cover, etcetera. The challenge is to achieve a successful symbiosis – an ecological balance of desirable elements, with marked preference for humans.

Intrigued by studies of embryology, Neutra suggests the interest of altering the "post-natal" environment, the community, in which dwell the infant, the adolescent, and the never quite finished adult. Cities need a more intelligent articulation and sensitive variation on which their continued life will depend. The provision of utilities has provided another impetus for reshaping cities.

A physiologically minded planner may discover useful hints in terms of a biological procedure developed to study systems by seeing how their function is interrupted by various lesions. The traffic system of a city might similarly be blocked here and there for repeated short test durations as part of a well-planned active research. This should give the planner a chance to observe the resulting difficulties (degeneration) as well as tendencies toward rerouting (regeneration) [and here the advent of computerized control systems opens up exciting new possibilities].

Planning should ensure that resources are appropriately deployed to serve different purposes at different times appropriate to individual and communal well-being. Planning must often extend over a long time period, complementing the time periods on which cycles of use occur -- but money is too often the gauge whereas the long term health and well-being of the community should be the priority. Thus, decaying infrastructure is preserved despite the deleterious long term effects of not replacing it.

Around 1800, the underground utilities serving vital needs, the newly piped water supply, radiating from pump stations and reservoirs, reconcentrated Philadelphia's already fast-spreading body of dwellings into rows, assembled first around public fountains, then with privately connected taps and tubs. A few years later, gas intensified the communal clustering around the supply of this utility and the process of functional adaptation continued. In due course, the motor age grew and the Fairmont Parkway ran at a sharp slant across the grid. By contrast, the long-established layout of Savannah Georgia with its pattern of many green squares, entirely separated from rolling traffic lanes instead of being painfully permeated by them, is good to this day. It dealt and deals humanely with life, operating in space and time.

The common-use space and communal gathering area of our towns have shrunk disastrously,. Roadways may amount to as much as 35% of total urban ground. In the Middle Ages, people had a different notion of apportioning land to its various uses. Crowded as these places were, they had both a cultural focus as well as a "nature reserve" just beyond the city gate. Attic windows of their houses – and minds as well – could look over the city walls into a landscape of natural functioning.

Neutra notes that in the 1920she developed the series "Rush City Reformed," describing the organism of a living and livable city. He suggested that different categories within a population should be

accommodated differently, with provision for single persons, young couples, and for all people who are no longer raising children. A family is a growing, aging organism and has in each, the first and the second decade of its life, a different makeup, a different set of living needs, different symbiotic requirements.

What can be called a neighborhood has an optimal size that will not change greatly so long as infant development and human stature and gait do not change. Modern traffic may extend settlements, but within a neighborhood, humanly conceived, it should not be allowed to cause significant dimensional changes. The desirable social development that will aid in the survival of the community and the human race under ever changing circumstances depends to a considerable degree upon the neighborhood.

For decades Neutra concerned himself with neighborhoods that muster physical and mental health factors as aids to survival, with a central face-to-face area for recreation, green, clear of disconcerting and dangerous commotion, with elementary school, neighborhood assembly and play space, public health service unit, branch library, and a few scattered day nurseries for toddlers and children of kindergarten age, all accessible over pleasant promenade walks that do not cross lanes of rolling traffic.

The face to face group is too easily disowned in a tendency towards gigantism. Institutions not fully identified with neighbor populations as their communal property never really fuse with human needs.

Young alert people growing up in a small town who have to spend their lives there, frequently show signs of disappointment and restlessness. They seem to feel that they are missing something of the potentialities that the metropolis has to offer. Perhaps there is a certain amplification of the best and brightest of a certain disposition being able to find themselves in a center rather than being a dispersed and with little communication across diverse towns and villages. Thus, even were we to develop a system of ideal neighborhoods, the need for people to move from their original communities to seek appropriate companions and stimulation would cause them to move elsewhere.

Neutra offers at length a proposal for how future cultural gratification might be increased by the design of cities that depend less on dense conurbations of the traditional type and that will provide surroundings that are biologically more bearable. Cities would be articulated into humanly-scaled neighborhoods. A focus of communal living with human scale and grasp may require the city to be designed as a whole array of splendid cores, each elevated over its level of rolling traffic beneath, that can adorn a galaxy of boroughs and neighborhoods with individual life and interest. By coherent and diversified vistas, they may invite frequent visiting between these affiliated part-communities, each with its own refreshing face, pattern, and appeal.

There is an essential urge for locomotor self-expression that is intimately related to our biology. Besides having neural benefits, walking is one of the healthiest forms of general muscular exercise, stimulating to many visceral and glandular processes. Automobile traffic generates thought associations that lead to a secondary but general displeasure with good healthy walk. Neutra thus recommends separation of wheeled traffic from the pedestrian. Slightly sunken roadways, judiciously screened by naturally grouped trees and shrubs, would form the well-segregated, insulated and concealed system connecting individual sectors of the greater community.

Coghill, studying the embryonic development of nervous systems, warns against the expectation that a mere aggregation of locally evolved parts could ever result in a true individual. There is no reason for sheer bigness if there is no cohesion or coordinated function accomplished. A similar view may well apply to city growth. The proper gauge of value lies ultimately in biological returns, i.e., the aids and harms to the survival of a given community and its organic membership. Such aids and detriments are much more relevant for a possible appraisal of specific and vital stability. Diversified slums that prove gold mines for their absentee owners are a bad drain on the community's well-being and an awful biological liability to their occupants. Yet the costly new cannot easily compete financially with the dead and cadaverous which keeps on paying handsomely.

Overall principles and detailed schemes will have to be subtly suited to the needs of human nature, and design principles assimilated to our knowledge of these needs. New knowledge is required and can be bought only at the price of patient and systematic investigation. Scientific statements are neither authoritarian nor, like taboos, pronounced for eternity. As new knowledge evolves, older ideas may well be changed, but for each historical moment their objectivity offers the best available base to build on, with all the moral stamina a human community can muster to be loyal to its potentials and its period.

The chapter closes with the rousing proclamation that the historical moment has dawned when a host of physiologically and sociologically informed and inspired professionals, planners, architects, social workers, all trained in team effort, shall be encouraged to advise developers and development, and reconstruct an environment that will be an aid instead of a handicap to the survival of the human race.

Commentary: Neutra advocates a large scientific advisory board for community planning "chaired by an expert in biology" – but if so, one would need a biologist who understands architecture and environmental psychology. Being an expert on mRNA is great for vaccine development but not for this!

A rectangular grid still has advantages for a city so long as it is varied to making best use of a river or other natural features of the topography, offering the enjoyment of varied views. The houses Neutra designed abutting Silver Lake in Los Angeles are each provided with sightlines to the lake.

The observation that "every city includes not only human and bacterial populations, but also insects, lower mammals, vegetation cover, etc." seems to be the one place where Neutra looks at ecological balance, but his emphasis remained on the well-being of humans as the city changes, rather than on the impact of those changes on the surrounding countryside and the ecosphere more generally.

In discussing the benefit of metaphors drawn from biology and physiology, Neutra suggests that neighborhood boundaries be likened to synapses between nerve cells, which are boundaries but at the same time planes of contact, electrochemical transmission, and subtle but vital energy exchange. This analogy must be updated to include the fact that myriad synapses on a single neuron can be changed through experience in a way that modifies the patterns to which the neuron can respond and thus the overall behavior of circuits containing the neuron. Perhaps the notion of distributed lines of interaction and communication that *cross* boundaries would be a better analogy.

Neutra reports on a visit to the "island of the monkeys," Cayo Santiago, off the East Coast of Puerto Rico, where live several hundred rhesus macaques. He observed the animal community when he was commissioned to plan certain laboratory facilities. He offers a rather idealized view that neglects the issue of dominance – which is different from leadership based on concern for the group as a whole. In any case, there is now a wealth of studies of animal cognition and "culture."

Noting the political situation that results in poor neighborhoods having neither parks nor good schools, we see the need for larger scale organizations to redistribute wealth to ensure a basic level of opportunity for all members of all communities in a city.

Neutra's vision of the future city resembles one put forward by Le Corbusier. Institutions do need to be considered that go beyond the neighborhood level – museums, opera houses, cathedrals and government buildings that seem to demand some special stature. What then is the relation of the various neighborhoods to the various islands or archipelagos of grandeur? A great city would seem to have a need for such buildings that declare the individuality of a city by their nature and their siting, while also maintaining an organic relation with livable neighborhoods.

Neutra argues for multi shift systems in a factory because full usage of an expensive device calls for precisely design that supports multiple operations. Here, however, the study of circadian rhythms is highly relevant. Multishift work may require many people to forsake a natural diurnal cycle, in addition to the problems of coordinating the worker's schedule with the daily cycle of family life.

Neutra nots that it is difficult to compare the individual economic gratification of workers, the civic gratification or the merits of public works programs, and the amounts invested in them. Compare our concern when visiting a church in a poor neighborhood that has many costly artifacts that took funds that might better have served the needs of the poor. And yet often it is the poor who must appreciate that building, seeing it as a place of spiritual and aesthetic uplift in an otherwise drab neighborhood.

Appendix: Two more recent books charting the linkage of neuroscience and architecture

For Neutra, the brain consists of peripheral nerves plus a cortical sheet-as distinct from the way current neuroscience builds on an understanding of the diversity of cortical region sand their continual interplay with a host of subcortical regions. Neutra's ideas remain a source of stimulation for those seeking a rapprochement between architecture and what he calls physiology, but the last 20 years have seen increasing interest in how developments in neuroscience may enter that conversation. This Appendix thus introduces the reader, very briefly, to two books that span this more recent trend.

John Eberhard: *Brain Landscape*

The concern for experiments from neuroscience that inform architecture was developed – Independently of Neutra and much later– by John Paul Eberhard, Founding President of the Academy of Neuroscience for Architecture in his book *Brain Landscape: The Coexistence of Neuroscience and Architecture* (Oxford University Press, 2008). Eberhard shares with Neutra the view that buildings where people spend most of their time can influence the fundamental structure of the brain and thus affect thoughts & behaviors. We see here an echo of Neutra's point (Chapter 8) that the designer must not only innovate but must support a process of learning, of habit transformation, which would contribute to survival through design.

Eberhard proposed that we use neuroscience to establish a framework for design decision-making in architecture in order to enhance the quality of life through reduction of stress, increased cognition, prolonged productivity, enhanced spiritual and emotional response. Eberhard's work adds several additions to Neutra's vision:

- Insights from 50 years of neuroscience, of course. In particular, he addresses the roles of a range of specific brain regions.
- An attention to the different issues that arise when we take *typology* into account – the different needs of people in different types of building.
- A plethora of suggested experiments. Few would interest the neuroscientist, but perhaps we will see a new profession of those with the relevant motivation to design and conduct studies with possible significance for both fields.

As a precedent, we may note the role of the structural engineer in assuring the stability of a building, including in the event of an earthquake or strong winds. There are already pertinent efforts in environmental psychology, human factors, and ergonomics, and the issue here is to assess the future benefits of extending their reach by factoring in the insights of neuroscience and the related disciplines of cognitive science and artificial intelligence. Here, the suggested experiments must extend from "plug in known science in assessing a problem in architecture" to developments within the disciplines that can support new questions for the architect to consider.

Eberhard emphasizes the different needs of people in different types of building. Rather than talking about survival of the whole human race, the emphasis shifts to creating well-being for people going as they use different types of buildings. Among his *consideration of various typologies*, Eberhard proposes that neuroscience will change architects' understanding of:

- how classroom design affects the cognitive processes of children
- how the design of hospital rooms could impact the recovery rate of patients
- how working environments impact workers' productivity
- how sacred spaces instill a sense of awe in those who worship there

and much more.

Neutra's comment on embryology stressed the importance of looking at human development and considering the impact of the environment on people at different stages of their lives. To this we would now add an assessment of the varying conditions in health and disease, and in wealth or poverty, to mention just a few, recalling the importance of the EvoDevoSocio framework. We may add here the attempts advanced by Eberhard, John Zeisel, and others to relate architectural forms to the needs of different populations, such as young children learning in a kindergarten, or people in with Alzheimer's disease in a home designed to supplement their failing memory.

Eberhard proposes that a *new knowledge base* developed from neuroscience will enable architects to respond to cognitive experiences of spaces and places and to combine these design concepts with adaptive technology for the fabric of cities and buildings. This will yield a major shift in the paradigms of architectural education and practice.

Michael Arbib: When Brains Meet Buildings

My own book, *When Brains Meet Buildings: A Conversation Between Neuroscience and Architecture* (Oxford University Press, 2021) builds upon my work in neuroscience and conversations with many architects to, hopefully, make clear to the architect some key ideas about the brain and how they are relevant architecture. The human brain has hundreds of anatomically distinct regions, and at least 10 billion neurons, and each neurons may be influenced by anything from four to 10,000 connection points or synapses. To help the architect gain a basic understanding of such complexity the book does not try to tackle every detail at once but seek to explain different *systems of systems* relevant to perception, action, learning, imagination, language and more – with a continuing concern for the back and forth between the experience of architecture and the work of the architect who must imagine how to design a building to support a varied range of experiences and behaviors.

Here are just a few of the key ideas:

- The importance, mentioned above, of the *action-perception cycle* that places perception within the cycle of ongoing behavior rather than grounding behavior in reflex responses to stimuli. The action-perception cycle is a learning cycle too. Each time we go around the action-perception cycle, there is a possibility of learning something new. Heraclitus said you cannot step in the same river twice; here the slogan becomes "you can't think with the same brain twice."
- An exploration of how imitation as well as empathy have been linked to mirror neurons, though my own work has emphasized that mirror neurons can only be effective though their integration into larger neural systems "Beyond the Mirror."
- The increasing attention paid by architects to the notion of the atmosphere of a space that in some sense sets a mood – such as the serenity of a Japanese garden in Kyoto. In particular, *atmospheres* extend the notion of *affordances* from their original meaning of perceptual "invitations for behavior" practical action to the realm of mood and emotion.
- The book introduces a variety of kinds of learning – both different mechanisms such as Hebbian learning, reinforcement learning and supervised learning; and different psychological factors such as episodic memory, procedural memory, and working memory – Hand give some sense both of the brain mechanisms involved and of the relevance of these different forms to the challenges of architecture. In particular, the notions of cognitive map and episodic memory seemed to come together in a brain region called the brain called the hippocampus, and the

book explores at length the way in which the hippocampus may work with other diverse brain regions during the extended process of the design of a building.

Michael A. Arbib is an Adjunct Professor of Psychology, University of California at San Diego; Former and Founding Coordinator, Advisory Council, Academy of Neuroscience for Architecture; and Emeritus at the University of Southern California as University Professor, Fletcher Jones Professor of Computer Science, and a Professor of Biological Sciences, Biomedical Engineering, Electrical Engineering, Neuroscience, & Psychology.

His latest book, *When Brains Meet Buildings: A Conversation Between Neuroscience and Architecture,* was published by Oxford University Press in August 2021.

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