UTOPIA COMPUTER

The »New« in Architecture?

Nathalie Bredella, Chris Dähne, Frederike Lausch (Eds.)

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The critical concern of the book "Utopia Computer" is the euphoria, expectation and hope inspired by the introduction of computers within architecture in the early digital age. With the advent of the personal computer and the launch of the Internet in the 1990s, utopian ideals found in architectural discourse from the 1960s were revisited and adjusted to the specific characteristics of digital media. Taking the 1990s discourse on computation as a starting point, the contributions of this book grapple with the utopian promises associated with topics such as participation, self-organization, and non-standard architecture. By placing these topics in a historical framework, the book offers perspectives for the future role computation might play within architecture and society.

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KAMAN LAM

C. H. Waddington's Biological Science of Human Settlements

1963–1978

It is impossible to approach urban development without considering biology—such was biologist C. H. Waddington's provocative gift to ekistics, the endeavour to found a science of human settlements. Despite being historically overlooked, his efforts to rethink urban development through developmental biology (and epigenetics), its reasoning, methods, and models remain further pointers to the alignment of architecture practices with biological sciences and technologies. This paper presents an array of biological premises he posited to help advance hypotheses to which a pluralistic-scientific attitude towards utopianism can contribute.

"It is often said today that… man is passing into a new phase of civilization which will be based on something other than the simple physical science. The candidate usually put forward to take over the dominant role is described sometime as Automation or… Communication Science. There is, however, a case for arguing that the fact of Automation or Communication is less important than what the systems are automated to do… and that the science which will contribute the content of the new civilization, even if not the tools, of the new civilization will, and perhaps should, be biology."
C. H. Waddington[1]

1 C. H. Waddington, ed., Biology and the History of the Future. An IUBS/UNESCO Symposium (Edinburgh: Edinburgh University Press, 1972), 1.

Introduction

Today, in times of bio-medical emergency and climate crisis, biological thoughts on mutation, extinction, population, organization, evolution, control or resilience could not be more influential in the time present, in continuum with a time past and time future. Even when past speculations were far ahead of their time, the prophecies might be fulfilled in the coming generation—what might a biological civilization that encompasses a biological architecture be like?[2]

In the heyday of all-inclusive complexity sciences, "renaissance biologist" C. H. Waddington (1905–1976) was impetuously engaged in a search for answers[3]—in 1963, he became part of an exhaustive effort to reform architecture into a biologically-conscious science of human settlements known as ekistics.[4] Distinguished scientists, such as he, viewed themselves as the conduit to the latest scientific consensus in support of planning practices.[5] Waddington, a prominent geneticist, embryologist, process philosopher, art theorist, futurologist, and one of the most original thinkers in biology in the 20th century, not only devoted himself to this joint effort, but also leveraged the ekistics group as a platform to discuss a pluralistic-scientific attitude towards "utopian" visions. Fellow biologist Ruth Sager put it in a nutshell: "The purpose… is 'to use biology (its principles, and examples; and reasoning and applications) to save the world', in just the same way that Buckminster Fuller's purpose is 'to use

2 Note that architecture, urbanism, city, urban planning, urban design, town planning, human settlements, urban and world development are different derivations of this paper's subject matter. These terms will be used interchangeably to avoid historical jargon and to present a fluid contemporary view.

3 Jonathan M. W. Slack, "Conrad Hal Waddington. The Last Renaissance Biologist?," Nature Reviews Genetics 3, no. 11 (2002): 889–895.

4 "[Foreword]," Ekistics 35, no. 209 (1973): 174–176.

5 Ibid. These scientists include Neo-Darwinist Theodosius Dobzhansky, microbiologist and environmentalist Rene Dubos, physicist Chris Pratt, anthropologist Margaret Mead, immunologist Jonas Salk, and more. Each had commented on the thematic of ekistics with reference to the latest scientific consensus in their fields, notably those influenced by complexity sciences. Their degrees of participation at ekistics' yearly symposia and research projects varied. Waddington was the most diligent symposia attendant among the natural scientists, with only one recorded absence between 1963 and 1972.

architecture (and principles of design) to save the world.' But Fuller's has been written up and organized while Wad[dington]'s idea has not—and could be."[6]

Saving the world may be an exaggeration. Yet, Waddington was certainly a radical—always abreast if not ahead of the latest trends. In life sciences, Waddington is best remembered for his synthesis of genetics, embryology (developmental biology), evolution, and environment into an approach called epigenetics. Still, it is his lesser-known synthesis named "human ecologies" that a transdisciplinary history of urbanism and science should bear his name: *it is impossible to approach urban development without considering biological sciences*.[7] Continual transformation towards mechano-organicism or techno-diversity require a response from architectural disciplines.[8] Waddington's ekistics brings us to the very frontline.

The elusive role of biology in architecture and urbanism

Biology and architecture are traditionally rather disparate fields; even when the relationship between them has been explored, it has dominantly been metaphorical and rarely material or

6 Waddington, Biology and the History of the Future, 5.

7 "Waddington, Conrad Hal, 1905–1975 (embryologist and professor of animal genetics, University of Edinburgh)," The University of Edinburgh Archives Online, last modified 2018. Accessed October 5, 2021. https://archives.collections.ed.ac.uk/agents/people/219?&filter_fields[]=primary_type&filter_values[]=archival_object. Waddington's biology-informed synthesis was first given a general name, "Man Made Future," then "Human Ecology." Both refer to the research institution he founded at Edinburgh University. What connected both initiatives of the biologist with architectural cultures was the point that the world is a man-made artifact, which was in line with media theorist Marshall McLuhan's insight that the end of nature is the birth of ecology.

8 Yuk Hui, Recursivity and Contingency (London: Rowman & Littlefield Publishers, 2019). Mechano-organicism refers to philosopher of technology Yuk Hui's characterization of cybernetics, where the cybernetic machine is capable of absorbing contingency and operating in recursivity; both he concludes to be the key driving forces of an organicist system. Hui argues that cybernetics' agenda to acquire a kind of organicity in machines has been fulfilled in present day's totalizing smartification projects; the task of a philosophy of technology is to fragment totalizing systems, to return them to localities, and to unite moral and cosmic order through technical activities—what Hui calls a techno-diversity of cosmotechnics. Waddington's speculations on future roles of bio-technologies could be seen as a resistance to technological singularity and an argument for techno-diversity.

methodological. While modern art/architecture acquired a considerable part of its material cultures from modern sciences, the pronounced preferences were in mechanicism or reductionism.[9] Reductionist sciences found expressions in the New Objectivity movement in modern art and architecture: pure geometries, glass, concrete, etc., in their search for atomic purity, sterile and static.[10] Biological thoughts appear at the other end of the disciplinary spectrum: cities have been likened to human bodies or organisms throughout history.[11] These metaphors suggest that cities could be interpreted as developing organisms, whose parts belong to a regulatory whole. The actual introduction of biologically-inspired methodologies was bought about by biologist-planner Patrick Geddes: cities were considered akin to a good biological system that animates its uses in all their inter-relatedness, discoverable via civic survey.[12] The biological, human and social (built) world were reciprocal evolutionary forces functioning at a local scale.[13] This notion was picked up by urban critic Lewis Mumford, who extended it into a theory of social organicism in which the biotechnic society shall put technics into the service of organic humanity.[14] Part developmental (city as organism), part evolutionary (the evolution of city and life) and part organizational (interrelated regional order), the possible roles of biology became widely promoted in the golden years of mid-20th century urban planning.[15] Waddington, “a biologist primarily interested in processes in

9 C. H. Waddington, Tools for Thought (New York/NY: Basic Books, 1978), 23.

10 C. H. Waddington, The Scientific Attitude (West Drayton: Penguin Books, 1948), 61–63.

11 Michael Bally and Stephen Marshall, “Centenary Paper: The Evolution of Cities: Geddes, Abercrombie and the New Physicalism,” The Town Planning Review 80, no. 6 (2009): 551–574.

12 C. H. Waddington, The Man-Made Future (New York/NY: St. Martin’s Press, 1978), 152. Volker M. Welter, Biopolis: Patrick Geddes and the City of Life (Cambridge/MA: MIT Press, 2002), 69–71.

13 Bally and Marshall, “Centenary Paper,” 556.

14 Lewis Mumford and Langdon Winner, Technics and civilization (Chicago/IL: The University of Chicago Press, 2020).

15 Gwen Bell and Jacqueline Tyrwhitt, Human Identity in the Urban Environment (London: Penguin Books, 1972). From the popularization of green belts in post-war Britain, the radical proposals in Japanese Metabolism to Paolo Soleri’s Arcology, a sentiment of the time was that naturalistic thinking might at a minimum thwart urban sprawl through counter-regulatory mechanisms, and, maximally, that it might trigger a reorganization of life through conscious physical planning.

biology of either development or of evolution," would continue to advance the position of biology with the help of an ally.[16]

A science of human settlements of evolutionary origins

For the prolific architect-planner Constantinos A. Doxiadis, evolutionary thinking seemed the primary means to predict the future and to act upon it.[17] In his 1969 Nobel lecture he declared planetary urbanization inevitable.[18] Exponential population growth, the influx of labour to cities and the demand for a roof and a living presented, in his view, a bio-evolutionary problem of unprecedented complexity, and yet, certainty. To prevent urban chaos, he mobilized scientists in a joint effort to establish a multi-disciplinary approach to planning extending from physical aspects to concepts in geography, economics, and the social sciences, to which he gave the name "ekistics," the Greek equivalent to "Raumordnung" and "Landesplanung."[19] Planning was conceived of as the systematic act of balancing elements in the formation of settlements, namely man, shell, society, nature, and networks (fig. 1).[20]

Doxiadis' emphases on evolution were underpinned by the popular science writings of *The Modern Synthesis* proponent Julian Huxley.[21] Huxley was dubbed "the statesman of (biological)

16 C. H. Waddington, "Space for Development," Ekistics 32, no. 191 (1971): 268–269.

17 Doxiadis' lecture was titled "The Future of Human Settlements," in The Place of Value in a World of Facts. Proceedings of the Fourteenth Nobel Symposium, Stockholm, September 15–20, 1969, eds. Arne Tiselius and Sam Nilsson (Stockholm: Almqvist & Wiksell, 1970), 331.

18 Ibid., 309.

19 John G. Papaioannou, "C. A. Doxiadis' early career and the birth of ekistics," Ekistics 72, no. 430/435 (January-December 2005): 13–17.

20 Constantinos A. Doxiadis, Architecture in Transition (New York/NY: Oxford University Press, 1969), 178.

21 Constantinos A. Doxiadis, Ekistics: An Introduction to the Science of Human Settlements (London: Hutchinson, 1968), 42–43. C. Kenneth Waters and Albert Van Helden. Julian Huxley. Biologist and Statesman of Science. Proceedings of a Conference Held at Rice University, 25–27 September 1987 (College Station/TX: Texas A & M University Press, 2010). Huxley's evolutionary theory postulated that the forces driving the slow, devious process of lower-level species' evolution towards higher complexities should be attributed not to orthogenesis (Geddes' interpretation) but a synthesis of natural selection, inheritance theory and genetics, all of which contributes to an evolutionary progress.

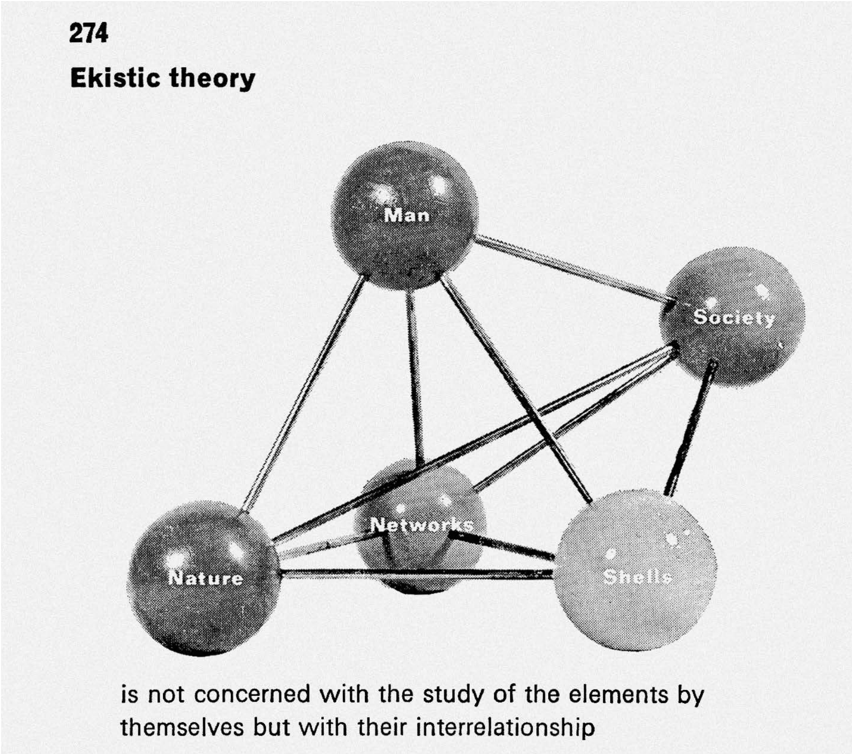


Fig. 1: Ekistics theory claims to study the interrelationship of the five ekistics elements: Man, Nature, Society, Shell and Networks. Source: Doxiadis, *Ekistics*, 285. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

sciences" whose contribution to 20th century biology spanned from cofounding the discipline of evolutionary biology and popularizing science to public politicking for the cause of evolutionary humanism—the quasi-religious call for humankind to seize control of their evolutionary future.[22] The corollary of this was Doxiadis' imperative to control the evolution of physical settlements over future millennia. He also espoused Huxley's rudimentary classification of organisms: cells are first-order biological individuals, bodies second-order ones, and human societies, like

22 Julian Huxley, Evolution in Action (Harmondsworth: Penguin Books, 1968). Julian Huxley, The Uniqueness of Man (London: Readers Union, 1943), 141, 245.

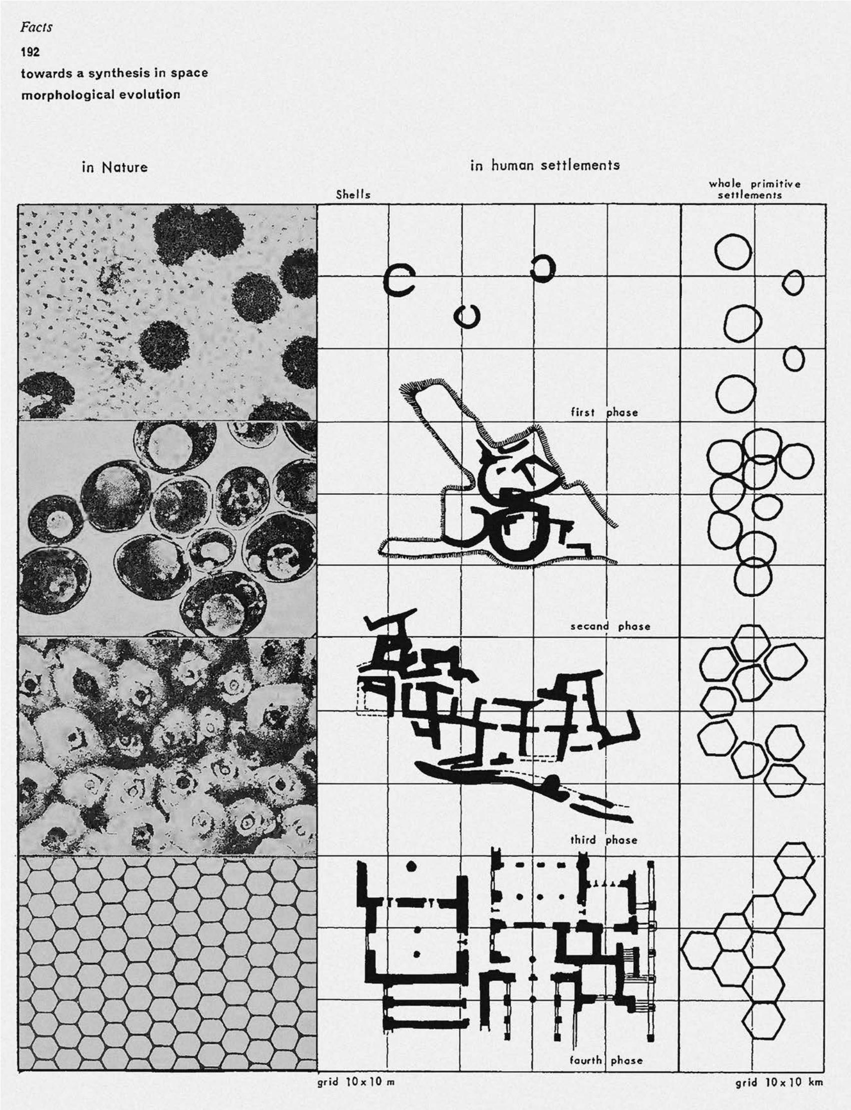


Fig. 2: Organization of settlements in evolution. Source: Doxiadis, *Ekistics*, 206. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

beehives, third-order, which led him to see *human settlements as biological societies* (fig. 2). Similarities between organisms and cities could then be drawn, for example, the digestive system and

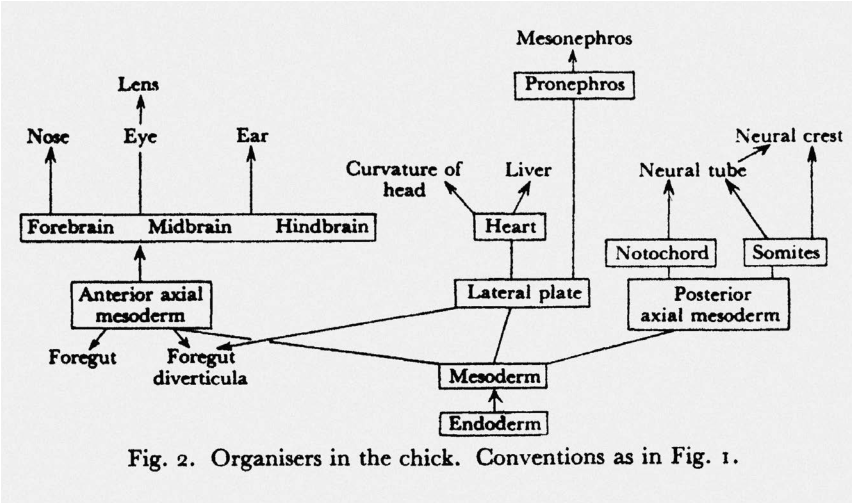


Fig. 3: Organizers, or inducing agents, in the development of the chick from bio-chemical states to body parts. Source: Waddington, *Organisers and Genes*, 12. Reproduced with permission of Cambridge University Press

the sewage system.[23] Along with the five principles of settlement formation and *Central Place Theory*, these concepts became the cornerstones of ekistics, and the basis on which Waddington would intervene.[24]

From developmental biology to epigenetics through the advances of Waddington

While evolution forms the keystone of any grand biological treatise, the developmental and organizational branches of biology may offer a better entry into understanding individual organisms via a threefold inquiry: what does organization mean in biology? What is a developmental system? Implicitly, how does the environment impact life?

23 Doxiadis, Ekistics, 42–43.

24 The five principles of Ekistics are: (1) maximization of potential contacts, (2) minimization of effort in terms of energy, time, and cost, (3) optimization of human's protective space, (4) optimization of the quality of a human's relationship with their environment, and (5) optimization in the synthesis of all principles.

The first answer may be found in Waddington's formative years in developmental biology.[25] The approach of the time, labelled organicism, emphasized the complex inter-relatedness of the developing parts of organisms in *forward* processes.[26] One observed the physico-chemical entities in embryos and their *organizing relationships*—"the nature of the networks of interactions which are involved in the *processes* by which a collection of cells becomes organized into an organ with a unitary character"[27] (fig. 3). Secondly, the notion of a developmental system posits that biological organization can only be profitably discussed in developmental terms, in the process of change.[28] Differing from Huxley's hierarchical classification, Waddington's visions for an evolutionary theory were based on those interactions between developmental processes (fig. 4).[29]

Drawing on the above, Waddington presented an alternative theory of the interrelations between environment and life: epigenetics. It stresses that non-genetic influences such as environment and locality could be causative factors in biological development, specified later as the activation of genomes.[30] A feedback relationship between environment and genes is thus formulated, and is best illustrated by a multi-layered "inscription"[31]: the epigenetic landscape, first pictured as branching creeks and watershed (fig. 5), then as the

25 Waddington was then a junior member of the Theoretical Biology Club at Cambridge.

26 Donna J. Haraway, Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology (New Haven/CT: Yale University Press, 1976), 4–6.

27 Waddington, Tools for Thought, 21. C. H. Waddington, "Chapter 5.5: Whitehead and Modern Science," in Mind in Nature: Essays on the Interface of Science and Philosophy, ed. John B. Cobb and David Ray Griffin (Washington: University Press of America, 1977), 143–146.

28 C. H. Waddington, "Evolution of Developmental Systems," Nature, no. 147 (1941): 108–110.

29 Waddington, "Evolution of Developmental Systems," 109. Huxley, The Uniqueness of Man, 141, 245.

30 C. H. Waddington, "Canalization of development and the inheritance of acquired characters," Nature, no. 150 (1942): 563–565. One of Waddington's most famous experimental findings was bithorax mutation in drosophila (second thorax segment and second set of wings) after ether treatment of the egg.

31 Bruno Latour, "Visualisation and Cognition. Drawing Things Together." Avant, no. 3 (2012): 207–257. Following sociologist of science Bruno Latour, the epigenetic landscape could be considered a mobile inscription device that allows theory to migrate beyond its initial fields.

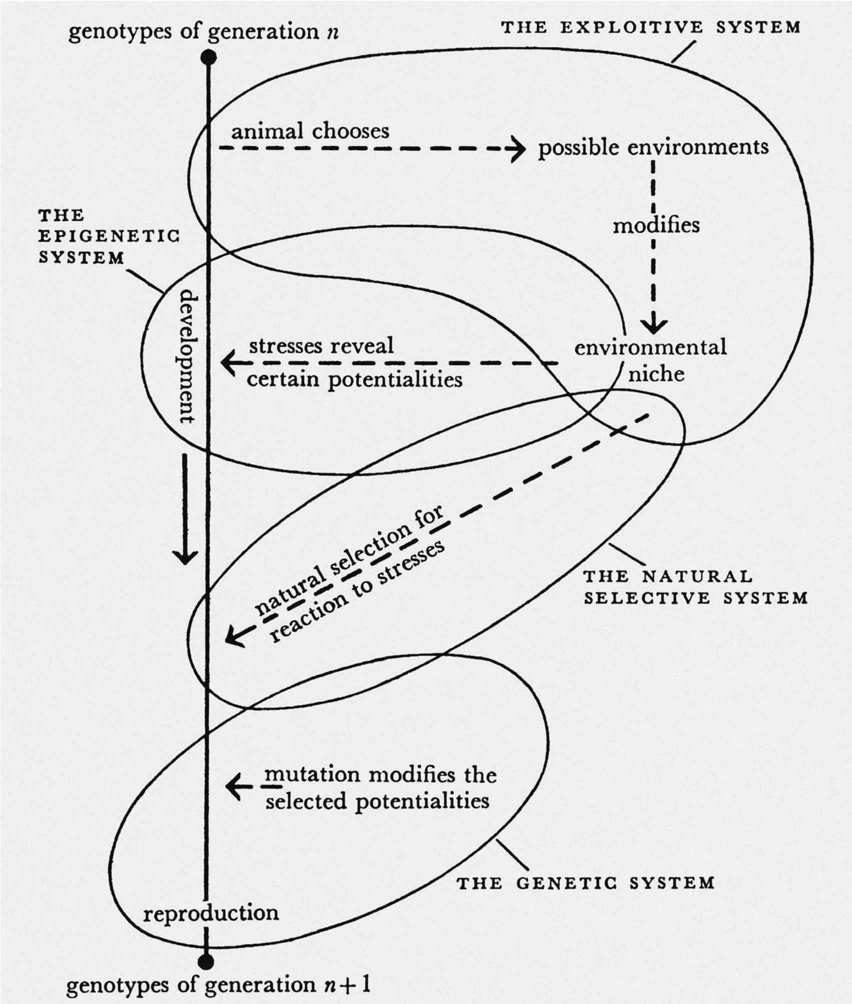


Fig. 4: The logical structure of the evolutionary system: “Changes in gene frequency between successive generations involve the operation of four subsystems: the exploitive, the epigenetic, the natural selective, and the genetic.” Source: C. H. Waddington, *Evolution of an Evolutionist*. Edinburgh: Edinburgh University Press, 1975, 57. Reproduced with permission of the estate of C. H. Waddington: Caroline Humphrey & Dusa McDuff

stenographic landscape and network (figs. 6–7), and finally, as attractor surfaces backed up by the mathematics of topology.[32] The epigenetic landscape has since been applied to simulate various developmental phenomena, from neuro development to social-developmental landscapes in cultural anthropology, while the theory remains a guiding framework for research on genetic-environmental interactions in, for example, environmental toxicology.[33] It also invokes an alternative ecological awareness, in that building and mining activities, or worsening habitation conditions on earth, could potentially impact local population epigenetically—a bodily embodiment of ecological change.

Epigenetic systems beyond biology

The question whether urban organization mirrors biological organization or epigenetic development calls for nonliteral thinking, since one cannot discuss genetics, reproduction or heredity in its usual sense in architecture, unless the material context of what we mean by it could be reimagined from scratch.[34] A partial assessment of the significance of Waddington's theories was given by historian of biology and philosopher Donna Haraway, who claimed that Waddington's biggest contribution in developmental biology was in promoting it almost as a Structuralist philosophy.[35] More precisely, epigenetic interactions provided—similar to what homeostatic regulation did in general system theory—a basis for Waddington's theory of progressive systems.[36] Progressive systems preserve stable flows, tend not to have an end-state, and

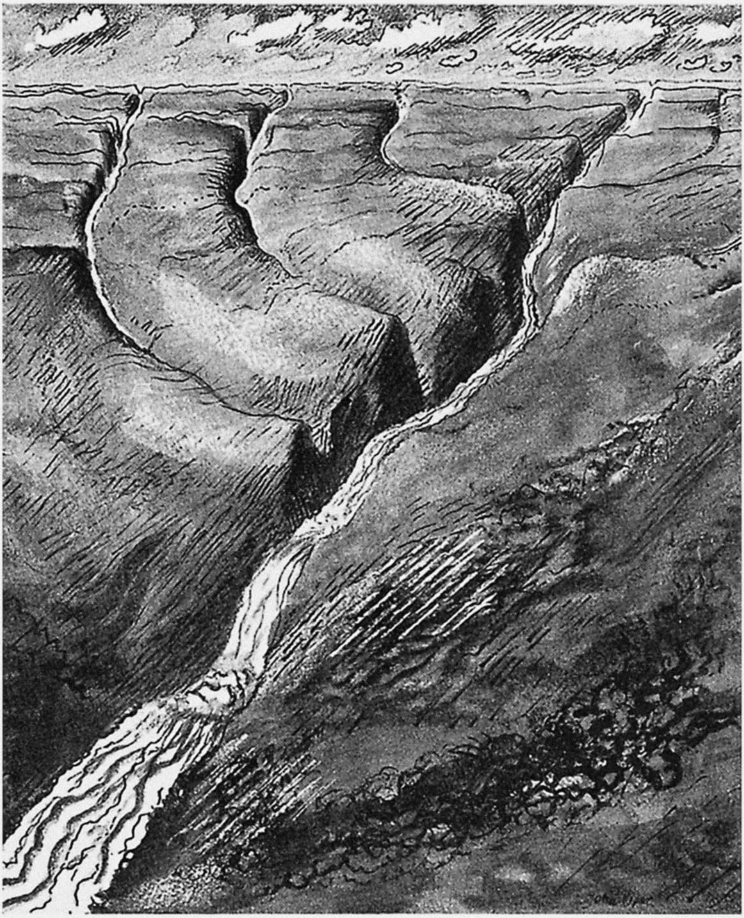
32 C. H. Waddington, Organisers and Genes Cambridge (Cambridge: Cambridge University Press, 1940), frontispiece. C. H. Waddington, The Strategy of the Genes. A Discussion of Some Aspects of Theoretical Biology (London: Routledge, 2014), 29, 45. Waddington, Tool for Thoughts, 105–112.

33 Jan Baedke, "The Epigenetic Landscape in the Course of Time. Conrad Hal Waddington's Methodological Impact on the Life Sciences," Studies in History and Philosophy of Science. Part C, Studies in History and Philosophy of Biological and Biomedical Sciences 44, no. 4 (2013), 756–773. Lok Ming Tam et al., "Arsenite Binds to the Zinc Finger Motif of TIP60 Histone Acetyltransferase and Induces Its Degradation via the 26S Proteasome," Chemical Research in Toxicology 30, no. 9 (2017): 1685–1693. One example of "epigenotoxicity" can be found in how arsenic exposure in drinking water affects epigenetics through degrading TIP60 proteins (DNA repair proteins).

34 Present-day biofabrication endeavours to recharter architectural materials, construction methods and standards from the bottom up. The historical milieu to which ekistics belonged was not ready for such disruption. The broad applicability of existing standards in the developing world had higher priority.

35 Haraway, Crystals, Fabrics, and Fields, 16.

36 Ludwig von Bertalanffy, General System Theory: Foundations, Development, Applications (New York/NY: George Braziller, 1969),160–163.



THE EPIGENETIC LANDSCAPE
From a drawing by JOHN PIPER

Looking down the main valley towards the sea. As the river flows away into the mountains it passes a hanging valley, and then two branch valleys, on its left bank. In the distance the sides of the valleys are steeper and more canyon-like. (See p. 91.)

Fig. 5: The initial conception of the Epigenetic Landscape as depicted by artist and friend John Piper. Source: Waddington, *Organisers and Genes*, frontispiece. Reproduced with permission of Cambridge University Press

exhibit two main behaviours: diversification/branching and stabilization (fig. 8).[37] For Waddington, the growth of towns into cities

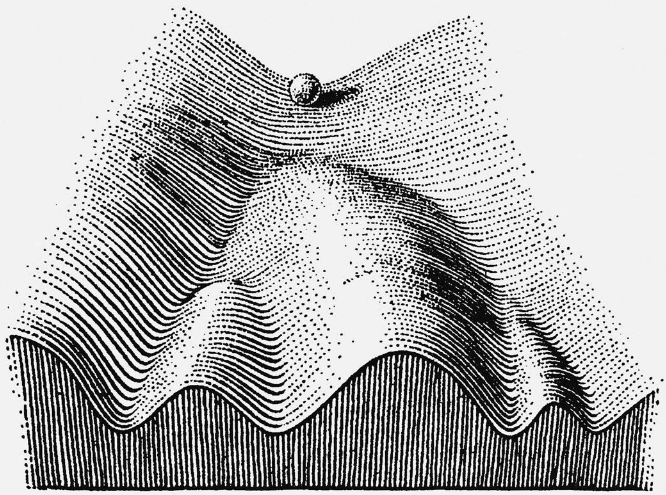


FIGURE 4

Part of an Epigenetic Landscape. The path followed by the ball, as it rolls down towards the spectator, corresponds to the developmental history of a particular part of the egg. There is first an alternative, towards the right or the left. Along the former path, a second alternative is offered; along the path to the left, the main channel continues leftwards, but there is an alternative path which, however, can only be reached over a threshold.

Fig. 6: Epigenetic Landscape from above. Environmental stimulus drives alteration in the landscape. Alternative pathways are formed in correlated push-pull efforts in the underlying, mutating genetic system (Fig. 7). The sphere poised at the top, which could represent part of the cell, limbs, organs or that of generations of the same species, slope down to the *canalized/stabilized* developmental pathway (chreod) natural selection favours. Source: Waddington. *The Strategy of the Genes*, 29. Reproduced with permission of Taylor & Francis through PLSclear

fits the definition, in that multiple sub-centres and subsidiary paths will be developed after some form of stability is challenged, but haphazard sprawl will be stabilized via a natural selection of pathways and an eventual deceleration.[38] Today, seeing urbanization as progressive systems may help us picture those otherwise mostly invisible sociological questions: how does different activities create trajectories for altering the characters of cities,

37 Waddington, Tools for Thoughts, 103–116.

38 Ibid., 109–110.

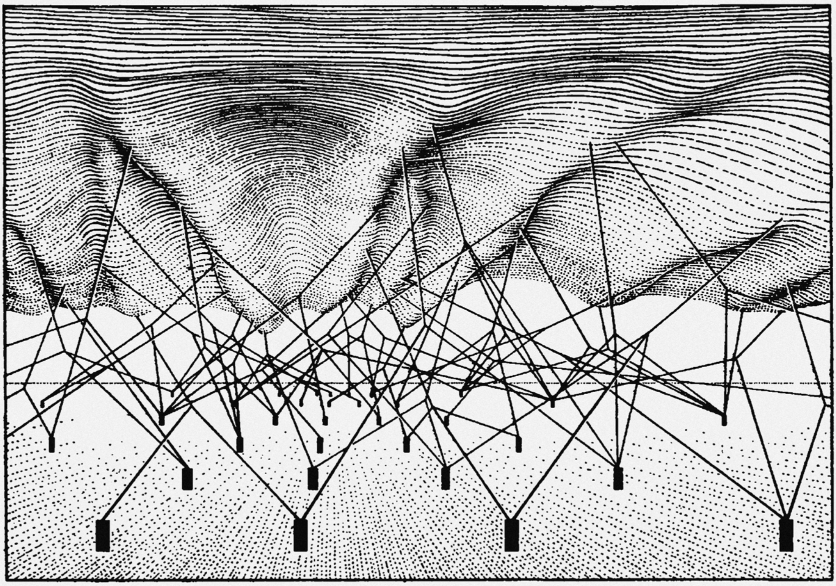


FIGURE 5

The complex system of interactions underlying the epigenetic landscape. The pegs in the ground represent genes; the strings leading from them the chemical tendencies which the genes produce. The modelling of the epigenetic landscape, which slopes down from above one's head towards the distance, is controlled by the pull of these numerous guy-ropes which are ultimately anchored to the genes.

Fig. 7: Epigenetic Landscape from below. The pegs represent genes and the guy-ropes the chemical tendencies that the genes produce. Source: Waddington, *The Strategy of the Genes*, 45. Reproduced with permission of Taylor & Francis through PLSclear

e.g. from xenophobic to cosmopolitan? Architects may as well wonder: along the developmental process, could a new architectural *plasticity* that which responds to both environmental stress and loops of changes in population be defined?[39]

39 Humphrey, Caroline, "A Nomadic Diagram: Waddington's Epigenetic Landscape and Anthropology," Social Analysis 63, no. 4 (2019): 118. The word "plasticity" is borrowed from anthropologist Caroline Humphrey's interpretation.

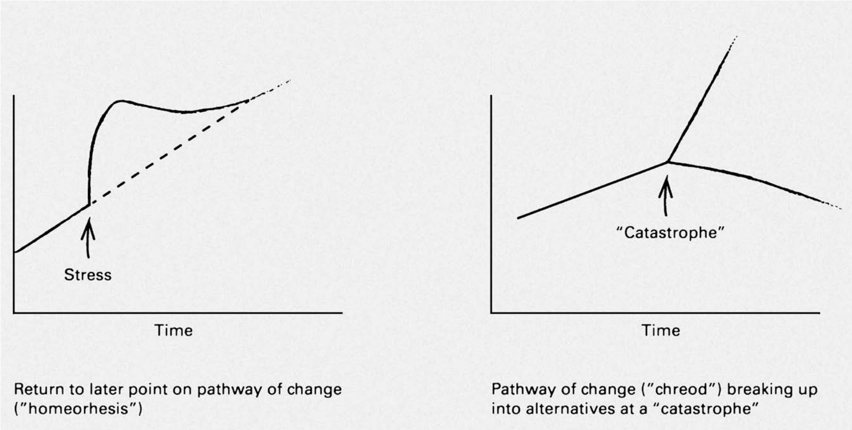


Fig. 8: To control the developmental pathway of a progressive system concerns diverting or differentiating the course of ongoing activities. Waddington's concept of "homeorhesis" (a word which means preserving a flow) suggests change tends to be buffered or absorbed. However, when stability is at risk or at a "catastrophe," developmental pathway is likely to break up into canalized alternatives. Source: C. H. Waddington, "Thinking about Complex Systems." Ekistics 32, no. 193 (1971): 412

Biologically-inspired methodologies of ekistics in practice

As a testbed, the masterplan of Islamabad presents an exemplar of ekistics' biologically-inspired ideas, although it is unclear whether Waddington actually had any impact on the project.[40] Doxiadis attempted to plan the new capital of Pakistan multi-dimensionally by establishing a branching methodology to guide him through decisions (fig. 9).[41] In terms of growth, by building a new centre approximate to the existing one, a symbiotic relationship was created where the new city could absorb infrastructure from the old, eventually forming a two-nucleus capital. In comparison to star-shaped or concentric forms, a directional grid was considered the most advantageous for future expansion. As for the construction process, priority was given to housing lower-income groups—the builders—rather than to governmental

40 Constantinos A. Doxiadis, "Islamabad: The Creation of a New Capital," The Town Planning Review 36, no. 1 (1965): 1–28.

41 Ibid.

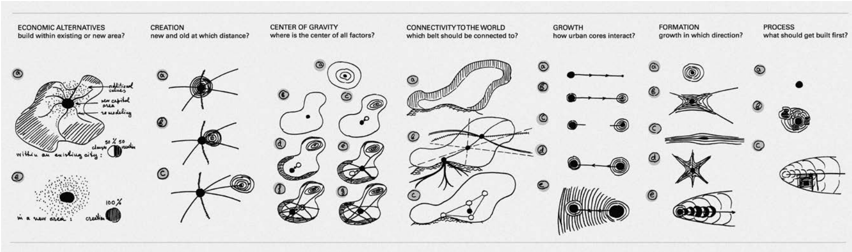


Fig. 9: The branching methodology underlying the design of Islamabad. Source: collage made by author. Diagrams: Doxiadis, "Islamabad," 1–28. Reproduced with permission of Constantinos A. Doxiadis Archives. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

headquarters, since Doxiadis considered builders to be better developmental agents for the city. Reversing the order might have risked the emergence of slums.

By branching out options and following the most sensible stream, an inclusive design came into being: the multi-core dynapolis on a directional city grid, its growth symbiotic with the existing city of Rawalpindi and a national park (fig. 10). These interrelationships were pivotal to the capital's development.[42] It should be noted, however, that these design alternatives are essentially adaptations from Doxiadis' principles, *the evolutionary urban cores*, rather than from unique findings via surveys or experiments.[43]

A biological science of human settlements through Waddington's perspectives

The promise of approaching the subject of human settlements as a *science* evinced a preoccupation beyond the design of city forms, but with establishing a firm justification system, "the organized attempt… to discover how things work as casual system."[44] A clear objective of Doxiadis was to mirror the achievements

42 When compared to equally top-down plans of Brasília or Chandigarh, the ecological and economic sensibility in Islamabad's is an apparent attribute to the capital's prosperity today.

43 Doxiadis' lifelong biology-inspired principles included seeing the cohabitation of humans and machine as unhealthy (for example, open sewers or exposed wires), and the idea of a directional "Dynapolis." Doxiadis, Architecture in Transition, 99–107.

44 Waddington, The Scientific Attitude, x.

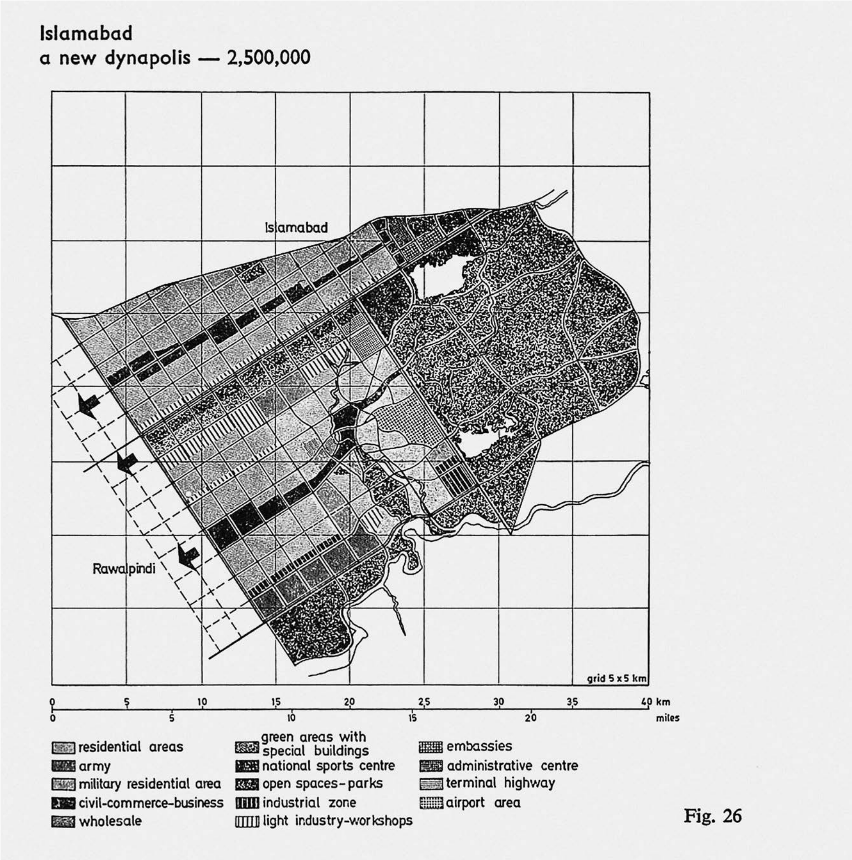


Fig. 10: Doxiadis Associates' masterplan of Islamabad, consisting of a national park, a central green corridor and two uni-directional urban cores. Source: Doxiadis, "The Future of Human Settlements," in *The Place of Value in a World of Facts*, 330. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

made by modern sciences, in particular medicine, which meant that universal urban problems could be cured by tested solutions, and that the outcome of a top-down masterplan could be predicted. This led to an obsessive practice of diagrammatic explanation based on inductive generalization.[45]

45 For a comprehensive account of ekistics' merits and limitations in architectural and urban design see, Panayiota I. Pyla, "Ekistics, Architecture and Environmental Politics, 1945–1976. A Prehistory of Sustainable Development." (PhD diss., Massachusetts Institute of Technology, 2008).

Waddington, although respectful of the architect's practical work, thought artists/architects ought to embrace the sophistication and contemporaneity of a newer scientific paradigm, where *chance* and *indeterminacy* are among the fundamentals of reality.[46] He had earlier conceived that good town planning is, like gardening, "the art of making things grow healthily in the right places."[47] The analogy implies that good planners assign agencies, maintain growth, intervene only occasionally, and embrace unforeseen disturbances; from the viewpoint of a developmental biologist even, a new potentiality would arise after every mutation.[48] Waddington had hoped that the "scientific architects," in their quest for data or other justifications, would not overlook scientists' capacity to seize on new aspects of reality[49]—for example, much more imaginative forms of nature-culture in relation to the process of urbanization.[50] The capacity of ekistics became limited as it rarely questioned its self-generated certainties, nor seized the *chance* to design feedback-generating experiments out of profitable discussion; for example, Waddington's suggestion to synchronize planning with biological phases of human communities (fig. 11).[51]

To reveal those overlooked potentials in his collaboration with Doxiadis, Waddington would dedicate his last years to writing about complex systems, under which the matter of human settlements belongs.[52] For Waddington, the collaboration between biology and the science of human settlements necessitated not a

46 C. H. Waddington, Behind Appearance. A Study of the Relations Between Painting and the Natural Sciences in this Century (Cambridge/MA: MIT Press, 1970), 3–4.

47 Waddington, The Scientific Attitude, x, 69.

48 Waddington, Behind Appearance, 106–107.

49 Ibid., 100.

50 Waddington, The Man-Made Future, 165.

51 Waddington, "Man Is a 'Multi-Shellular' Organism," Ekistics 32, no. 191 (1971): 278. The lack of experimentation in ekistics was hugely dissimilar from the group's contemporaries, like architect Frei Otto's collaboration with biologist Johann Gerhard Helmcke or architect Paolo Soleri's collectively designed and built colossal structure in the name of arcology. Frei Otto and Berthold Burkhardt, Occupying and Connecting: Thoughts on Territories and Spheres of Influence with Particular Reference to Human Settlement (Stuttgart: Edition Axel Menges, 2009). Paolo Soleri, Arcology: The City in the Image of Man (Cambridge/MA: MIT Press, 1969).

52 The two textbooks on complex systems are *Tools of Thoughts* and *The Man-Made Future*.

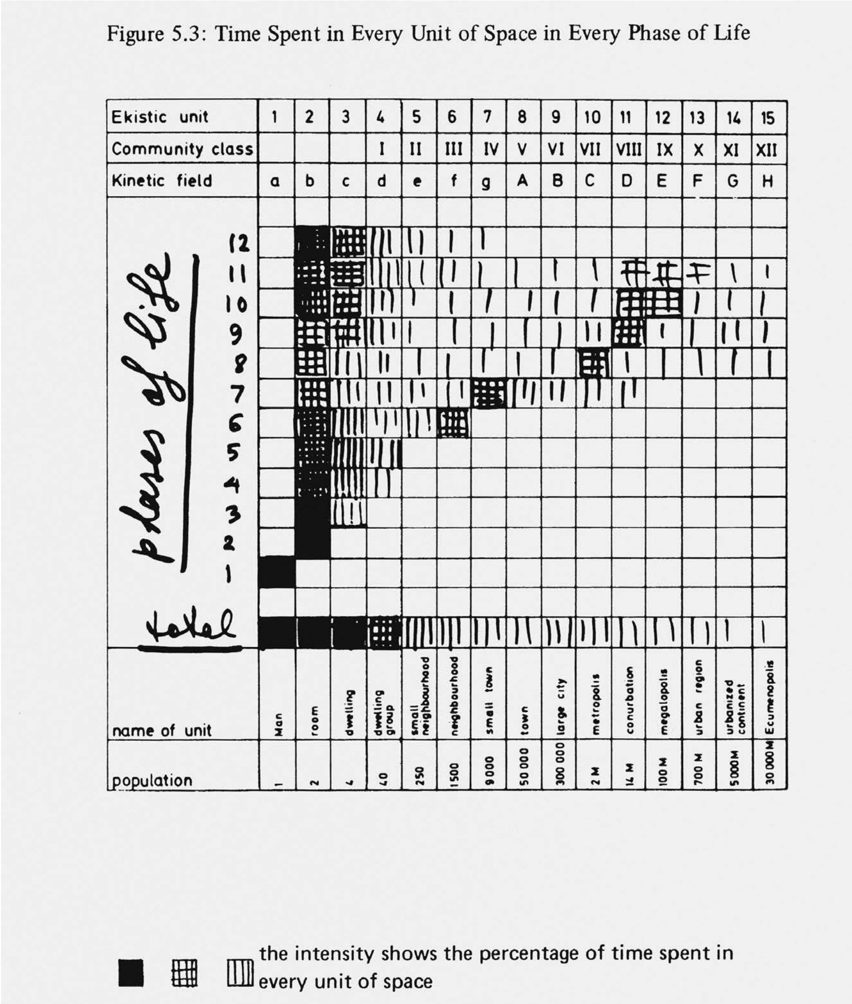


Fig. 11: Intended to apply the botanical or zoological method of taxonomy on the subject of human settlements, Doxiadis proposed a classification grid, known as the Ekistics Grid, divided into the five ekistics elements on a y-axis, matched by a logarithmic scale of population size, on the x-axis. This basic method of classification was used in every analysis or project. Demonstrated is the ekistics grid adapted to Waddington's suggestion to synchronize spatial needs with different phases of life. Source: Constantinos A. Doxiadis, *Anthropopolis. City for Human Development*. New York/NY: Norton, 1975, 107. Dt. UrhR: Constantinos and Emma Doxiadis Foundation

question of how to plan better, but *how to connect planning with the developmental assets of all the world's biological systems*—a set of postulates which will be detailed as follows.[53]

Urban development is mutational: reassessing Central Place Theory

A radical picture of urban development cannot omit the perspective of architect Justin Blanco White, Waddington's wife, and her exposure to some of Doxiadis' dogmas.[54]
As network-technology-impinged decentralization portends death for traditional urban centres, the validity of ekistics' Central Place Theory immediately comes into question. Envisioned by geographer Walter Christaller, Central Place Theory overlays equations and geometrical figures above a large region, and helps evenly distribute the most economically favourable central places, commodity hubs, and urban services. Doxiadis adhered to this model throughout his career, while Blanco White thought its validity had a lifespan.[55] A discussion she had with Christaller would lead to the notion of a centre as a transient concept; one regional pattern superseded by another in successful regional development (fig. 12).[56] By extension, this points to the need to evaluate spaces in terms of their evolutionary values in different configurations.

53 Waddington believed that countless facets of ekistics' concerns demanded biological reasoning and applications beyond the self-restricted realm of physical planning. This view has been referenced by urban theorists as a critique of physicalism: "a perspective that assumed social problems might be solved by manipulating the physical built environment." Erik H. Erikson et al., "Discussion." Ekistics 35, no. 209 (1973): 197. Bally and Marshall, "Centenary Paper," 551.

54 Waddington's knowledge of the architectural profession should be attributed to his wife, architect Justin Blanco White, later the Super-intending Architect of the Scottish Development Department, who occasionally accompanied him to ekistics' Delos meetings. Blanco White was a significant architect-intellectual: she was the daughter of feminist writer Amber Reeves (1887–1981), part of the first generation of female architects and at the centre of student activism at the Architectural Association (AA) where she studied from 1929 to 1934. After AA, Blanco White belonged to a group of practicing feminist architects who "were determined to use their skills as architects for the public good, joining with social reformers in other disciplines (health, housing, welfare) to develop prototypical solutions to the pressing social problems of their day." To this end, she took a post with the Civil Service in Edinburgh where "she played a significant role in the research, design and development of policy for statutory development plans for Scottish cities and boroughs during the 1950s." Elizabeth Darling, "Introduction to the Lives of Women in the Architectural Profession: Justin Blanco White," in Oxford Dictionary of National Biography, last modified July 11, 2019. Accessed October 5, 2021. https://www.oxforddnb.com/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-112261.

55 Walter Christaller, R. I. Wolfe and M. J. Blanco White, "Regional Location of Settlements," Ekistics 20, no. 119 (1965): 223–233.

56 Ibid., 233.

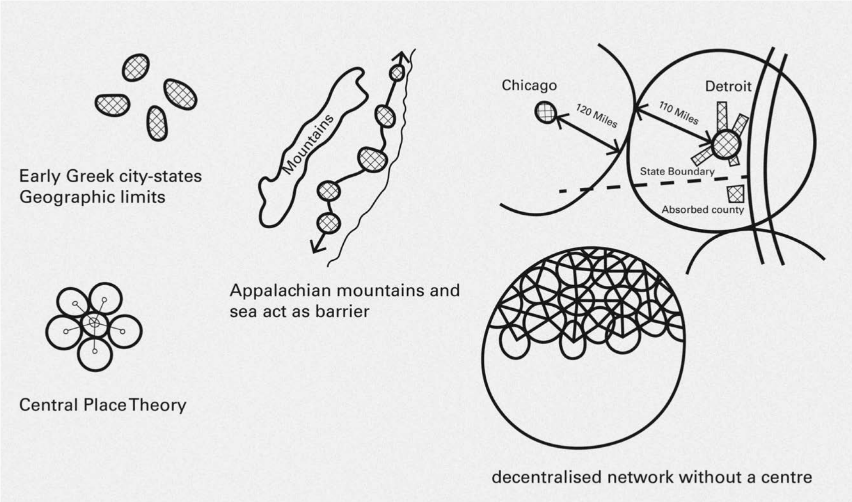


Fig. 12: Diagrams of Central Place Theory and alternative regional patterns in discussion, from city-states towards a connected world where absolute centres are absent. Source: Walter Christaller, R. I. Wolfe and M. J. Blanco White, "Regional Location Of Settlements," in *Ekistics* 20, no. 119 (1965), 233

The emphasis on transience echoes Waddington's question about urban mutation: is the construction of new centres, replacing old ones, a natural selection and hence evolution?[57] He answered in the negative, based on his knowledge that new towns are usually built on the experience of the old, not rebuilt from scratch according to a different pattern, or a set of alternatives to be naturally selected as a biological organism does. He concluded that the replacement of old towns with new ones could function like bone growth, where tissues are removed and added simultaneously in a coordinated way.[58]

Development concerns biological population and organization without compulsion

Waddington made clear within ekistics that a scientific approach to planning almost without exception deals with statistics and

57 C. H. Waddington, "Space for Development," Ekistics 32, no. 191 (1971): 268.

58 Ibid., 269.

population; one must know what the valid conclusions one can draw are, and what are not.[59] Further, since thinking on the level of population rather than the individual was one of the biggest advances in developmental biology, architects ought to adopt this viewpoint by mobilizing the populace in their design: "a population has got to have internal variability to provide resources that can respond to changing circumstances (by utilizing one or another of the many diversities)."[60] He hinted at self-help in housing or, in the case of the Tennessee Valley Authority's watershed resource management, a collective method of long-term investment of a magnitude comparable to money.[61]

Questions of population cannot evade socio-political implications: being or gangs? Pet or pests? On one occasion, Waddington proffered a suggestion for tackling population explosion in postwar India (fig. 13)—adding reversible contraceptives to salt to temporarily sterilize the whole population, and make exceptions only by application.[62] The involuntary measure would have violated every freedom. One is compelled to ask: does biopower in a Foucauldian sense draw a too-fine line between managing a population statistically and managing human societies *zoologically* and dictatorially.[63] A significant number of today's problems lie in the biosphere, where regional control might be hoped for, but no conventional model of democracy can easily adapt to the radicality of benevolent biocontrol.

Speaking of benevolent control, Waddington questioned whether organization without compulsion is possible.[64] He argued strongly in the affirmative for the biological world, saying: "There is no compulsion with an embryo which organizes it. There is a human idea of organization, drawn from the model of the army

59 Ibid.

60 Ibid., 213.

61 R. C. Quinn et al., "Points Made in Discussions," Ekistics 32, no. 191 (1971): 301. Waddington, The Scientific Attitude, 151.

62 Waddington, The Man-Made Future, 30.

63 Michel Foucault, Michel Senellart and Graham Burchell, The Birth of Biopolitics. Lectures at the Collège de France, 1978–79 (New York(NY: Palgrave Macmillan, 2011).

64 Discussion at Delos, "Biological and Psychological Considerations Of Groupings," Ekistics 28, no. 167 (1969): 241–243.

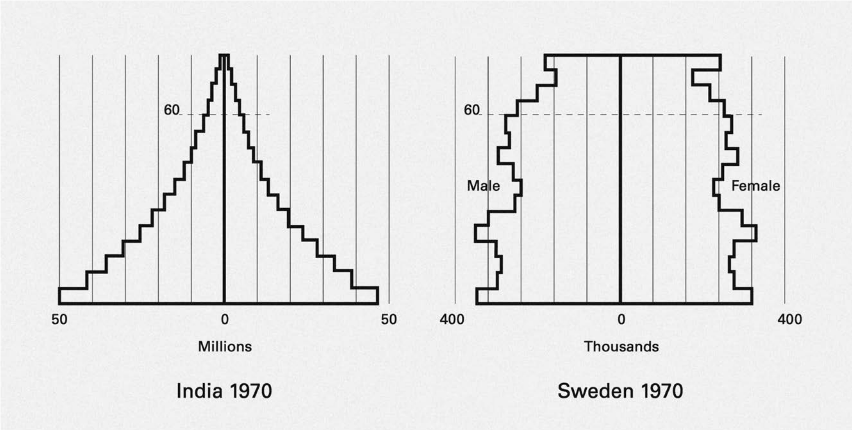


Fig. 13: Age distribution diagram of Indian and Swedish population in 1970. In comparison, note the fertility rate and shorter lifespan in the former. Population base could serve as good indication of structures of needs as well as labour in particular societies. Source: Waddington, *The Man-Made Future*, 23. Figure adapted from the original source by author

or the church. It is a totally non-biological type of organization. Biological organization… depends on participation between the components, which interact with one another in a very intimate way, so that you can't really separate them."[65]

As a precursor to the idea of the "hive mind" in cyberculture of the 1990s—today widely applied in silicon valley's corporate culture, the notion of biological organization still holds untapped potentials for architectural practices.[66]

65 Waddington et al., Biology and the History of the Future, 55–56.

66 Kevin Kelly, Out of Control. The New Biology of Machines, Social Systems, and the Economic World (Reading/MA: Perseus Books, 1995), 9–25. Decades after Waddington's speculations, the 1990s witnessed a new form of cyberculture that converged the communal counterculture of the 1970s with the latest scientific technologies into a biologically inspired techno-utopianism. After the first Artificial Life Conference at the Santa Fe Institute, which sat at the intersection of biology and informatics, Whole Earth Review's and Co-Evolution Quarterly's editor Kelvin Kelly summarized the circle's calls to rethink the natural and socio-economic worlds as connected information networks in his acclaimed book Out of Control. Kelly hailed the phenomenon of "hive mind" as an emblem of a new form of social organization; it refers to swarm intelligence of bees or ants, where rules applied on individuals can generate distributed, decentralized, collaborative and adaptive behaviors of a powerful social whole. An opinion of Kelly and his contemporaries was that a new socio-economic order (or corporate culture) modeled on hive systems computationally could bring about unprecedented socio-technical progress.

Development is instructional

Another thesis of Waddington's was that instruction (or algorithm) is a far more appropriate formulation than information to use in connection with developmental or evolving systems.[67] He explained, "one gets a better idea of the real nature of complex systems we actually come across if one thinks of them, not in static terms of the amount of information they contain, but by asking the more dynamic question, how much instruction was necessary to produce them, or what instructions do they tend to impose on their surroundings?"[68]
In genetics or epigenetics, the capabilities of organisms or living systems could be enhanced through bio-computing.[69] In planning, bio-computational thinking may connote outlining those *vernacular* as well as interventional technologies that serve as instruction about the generation of design, whose systemic capacity is "grown" and belongs to the entire developmental system.

Industrial development through microbiology

The possible application of microscopic biotechnologies in urban or rural development was seriously considered by Waddington and his circle. A discussion on energy and technological development at Delos 10, for example, offered an approach for transforming industrial landscapes through molecular biology.[70] Removed from the rest of the discussion on expanding energy availability through renewable sources, Waddington attempted to disrupt typical mindsets by asserting that we may want to take a new look at those energies uninteresting to anthropocentric economic

67 Waddington, Tools for Thoughts, 140–145. Erich Jantsch and C. H Waddington, Evolution and Consciousness. Human Systems in Transition (Reading/MA: Addison-Wesley, 1976): 247–250. Waddington et al., Biology and the History of the Future, 37.

68 Waddington, Tools for Thoughts, 145.

69 Jantsch and Waddington, Evolution and Consciousness, 247–250. "Understanding Biological Computation," Microsoft Innovation. Accessed October 5, 2021. https://innovation.microsoft.com/en-us/biological-computation.

70 Robert Anderson et al., "Energy resources for development," Ekistics 34, no. 203 (1972): 240.

development, but of value to organisms. Waste heat produced by physics-based industrial models but below an economical threshold could be absorbed into biological systems and diverted to bio-chemical produce, see for instance the growth of algae, rubber, penicillin, hydrochloric acid, yeast, and many other types of protein. Pervasive applications of molecular biology could penetrate into sterile industrial landscapes and turn them into shared production sites of biological life, human and machine, and "when the world's chemical productive industries progress from the Paleo-technic stage of high-temperature energy input to the Neo-technic stage of applied molecular biology, the world's industrial energy balance sheet will look very different."[71] In development and for everything in general, Waddington argued that biology offers a rationale of participation and organization over maximization.[72]

Other radical proposals by Waddington and his network to transform urban and rural development included solid-state enzyme reactors for agricultural nitrogen fixation or edible protein production, microbial techniques in industrial gel filtration, even carbon-to-protein conversion through pervasive cultivation of *spirulina platensis.*[73] These ideas were well-received among some planners, since discoveries in microbiology likely affect not just humankind's survival, but may very well affect the location, size, and distribution of urban and rural settlements too.[74] A study of the inter-relationship between discoveries in one field and activities in others may help ekistics or architecture cultures in general redefine their goals and go further.[75]

71 Ibid.

72 Waddington et al., Biology and the History of the Future, 35–36.

73 The proposals mentioned above were made by industrial microbiologist Carl-Göran Hedén. Ibid., 12–21.

74 Dix, Gerald, "Some Ecological Aspects of Coastal Development," Ekistics 49, no. 293 (1982): 102–107.

75 Ibid.

Utopian visions as evolutionary functions in the pluralistic-scientific attitude and socio-genetic system

Our revisiting of the latent connections between biology and architecture is directed towards a central objective: what are our best chances towards realizing socio-political ideals, or urban utopia, via biological thinking? In answering this, Waddington's predilection for Whitehead's philosophy would likely lead him to prefer process-oriented approaches over superstructural notions:[76] the profound function of a scientific attitude of mind, and the evolutionary-ethical function of a socio-genetic system. In *The Scientific Attitude*—his eponymous view that sciences contribute to social reorganization in its most creative tasks—Waddington argued that an increase in scientific control over human's surroundings is an inevitable evolution of sciences, "whose final standard of value is an observed process of evolutionary advance, it judges things not for themselves, but only for which they produce on the rate of advance."[77] Specifically, he gave the examples of a large-scale but regionally coordinated organization, a decentralization of technology, and compromised privacy for the sake of control, as technical extensions of the scientific attitude.[78] The other thesis, derived from *The Ethical Animal*, is the notion of an interconnected "socio-genetic system" (the mechanism of social teaching and learning) which passes on ethical codes (biological wisdom) that constitute a secondary mechanism by which evolutionary advances can be bought about, perhaps in the form of an epigenetic landscape.[79] Combined, one function of sciences and socio-genetic ethics is to create flexible criteria for assigning higher values to those

76 Waddington would likely identify superstructural notions such as "ideals" or "discourse" as "fallacies of misplaced concreteness" in A. N. Whitehead's philosophy of science. Waddington, Tools for Thoughts, 24–25. Alfred North Whitehead, Science and the Modern World. Lowell Lectures 1925 (Cambridge: Cambridge University Press, 1929), 64–72.

77 Waddington, The Scientific Attitude, vii, 171, 172.

78 Ibid., 23, 152–154.

79 C. H. Waddington, The Ethical Animal (London: Routledge, 2016), 29.

activities that encourage forward progress, both of the socio-genetic system (below), and of the changes in the grade of human organization which that system causes (above).[80] Architecture—if understood to be about the control and organization of the physical environment a pluralistic-scientific attitude could create, in addition to its ethical function in the socio-genetic evolution of humans, the ethical animal—was precisely Waddington's example of one of the highest-value activities where coordinated evolutionary advances were and are still called for.[81]

Conclusion

Restructuring architectural practices as a biologically-conscious science remains an enormously challenging undertaking by today's standards. In the heyday of the complexity sciences and their claims of applicability across subject matter, ekistics' and Waddington's historical endeavours demonstrated the very ideal of systemic control, and the political will to divert a discipline as self-absorbed but responsibility-laden as architecture, to the openness of science where dogmas can be and were debated. The reasoning and techniques of biology offer at the very least a chance for modern art and architecture to break away from the fixated material cultures the modernists acquired from the physical sciences. In the better cases of Geddes and Mumford, the evolution of cities and life were considered reciprocal, thus forming the evolutionary, developmental, and organizational bases of an organicist approach to planning. These lines were pursued by Doxiadis on a universal scale with reference to Huxley's evolutionary theory and were exemplified in Islamabad where processes, interrelations, or evolutionary pathways were incorporated in the design process. Despite the practical success of this project, Waddington's interest was in a genuine conceptualization of a possible science via insights from developmental biology and epigenetics, which would illuminate the potentials of identifying urban development processes as biological developmental ones,

80 Ibid., 204.

81 Ibid., 217.

whose organization, course, and interactive dynamics could be described and prescribed though the kind of experimentation ekistics lacked. As a result, many of Waddington's ideas on ekistics are fragmentary—but advanced— speculations, for example, that regional patterns are transient in mutation; that seeing architectural development from the perspective of biological population and organization gives biopolitics a design function; that algorithm-environment interaction begins with formulating instructions; that microbiology offers a radically different rationale to the design of industrial landscapes; and that ultimately, to get in closer proximity to utopian visions, we need to install sets of earthy, process-oriented and sciences-embodied functions in our practices, those that will control and facilitate the inherent evolutionary mechanism of (post-)humanity, namely, the socio-genetic system of the ethical animals, whose ways of life are still to be architected.

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The critical concern of the book "Utopia Computer" is the euphoria, expectation and hope inspired by the introduction of computers within architecture in the early digital age. With the advent of the personal computer and the launch of the Internet in the 1990s, utopian ideals found in architectural discourse from the 1960s were revisited and adjusted to the specific characteristics of digital media. Taking the 1990s discourse on computation as a starting point, the contributions of this book grapple with the utopian promises associated with topics such as participation, self-organization, and non-standard architecture. By placing these topics in a historical framework, the book offers perspectives for the future role computation might play within architecture and society.

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