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Ekistics, the Science of Human Settlements

Ekistics starts with the premise that human settlements are susceptible of systematic investigation.

Constantinos A. Doxiadis

We cannot acquire proper knowledge about our villages, towns, and cities unless we manage to see the whole range of the man-made systems within which we live, from the most primitive to the most developed ones—that is, the whole range of human settlements. This is as necessary as an understanding of animals in general is to an understanding of mammals—perhaps even more so. Our subject, the whole range of human settlements, is a very complex system of five elements—nature, man, society, shells (that is, buildings), and networks. It is a system of natural, social, and man-made elements which can be seen in many ways—economic, social, political, technological, and cultural. For this reason only the widest possible view can help us to understand it.

There is a need for a science dealing with human settlements, because otherwise we cannot view these settlements in a reasonable way. Is such a science possible? The answer can be given in two ways. First, by observing that, in some periods of the past, people must have had such a science, which was probably written down only in ancient Greek times (in documents which have since been lost) and in Roman times (perhaps by the architect and engineer Vitruvius). Otherwise, how did people create cities that we still admire? Second, we are now convinced that man, in creating his settlements, obeys general principles and laws whose validity can be demonstrated. These principles and laws are actually an extension of man's biological characteristics, and in this respect we are dealing with a biology of larger systems.

It can be argued perhaps that we are dealing with a phenomenon with a ridiculously short life—some tens of thousands of years, as compared with billions of years for the phenomena of microbiology and even longer periods for the phenomena of chemistry and physics. However, there is no way of proving that a certain period is too short, or long enough, for the development of principles and laws. In this case it is long enough to convince us of certain truths.

To achieve the needed knowledge and develop the science of human settlements we must move from an interdisciplinary to a condisciplinary science; making links between disciplines is not enough. If we have one subject we need one science, and this is what ekistics, the science of human settlements, has tried to achieve. Has it succeeded? The answer is that it is beginning to succeed, and that with every day that passes we learn more and more. How far have we come? How can we answer this question for any road we take if we know only the beginning and not the end?

In this article I try to demonstrate through a few examples the need for, and the existence of, a huge field of knowledge which man is trying to regain and develop in a systematic way. This field is a science, even if in our times it is usually considered a technology and an art, without the foundations of a science—a mistake for which we pay very heavily. As I cannot present the whole case in a short article, I have selected a few points which can illustrate the validity of my statements made at the beginning of this article and the practical importance of this effort to achieve a science of human settlements.

The Principles

In shaping his settlements man has always acted in obedience to five principles. As far as I know this has always been true, and I myself have not found any cases which prove the opposite.

The first principle is maximization of man's potential contacts with the elements of nature (such as water and trees), with other people, and with the works of man (such as buildings and roads). This, after all, amounts to an operational definition of personal human freedom. It is in accordance with this principle that man abandoned the Garden of Eden and is today attempting to conquer the cosmos. It is because of this principle that man considers himself imprisoned, even if given the best type of environment, if he is surrounded by a wall without doors. In this, man differs from animals; we do not know of any species of animals that try to increase their potential contacts with the environment once they have reached the optimum number of contacts. Man alone always seeks to increase his contacts.

The second principle is minimization of the effort required for the achievement of man's actual and potential contacts. He always gives his structures the shape, or selects the route, that requires the minimum effort, no matter whether he is dealing with the floor of a room, which he tends to make horizontal, or with the creation of a highway.

The third principle is optimization of man's protective space, which means

The author is an architect-planner and president of Doxiadis Associates, Athens, Greece, and Washington, D.C.

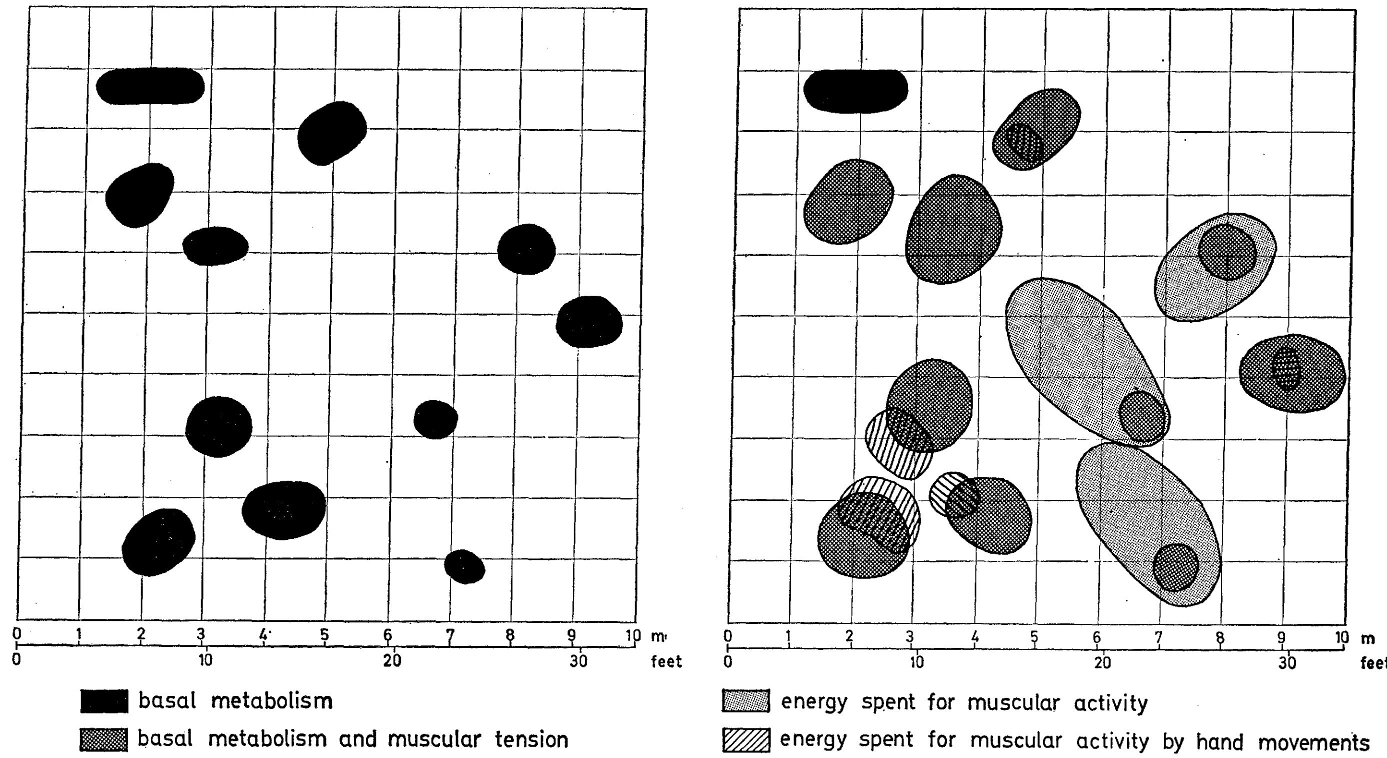


Fig. 1. (Left) Static picture of a group of people as given in plans. (Right) The real picture of the same group as given by energy measurements.

the selection of such a distance from other persons, animals, or objects that he can keep his contacts with them (first principle) without any kind of sensory or psychological discomfort. This has to be true at every moment and in every locality, whether it is temporary or permanent and whether man is alone or part of a group. This has been demonstrated very well, lately, for the single individual, by anthropologists such as E. T. Hall (*1*) and psychiatrists such as Augustus F. Kinzel (*2*), and by the clothes man designs for himself, and it may be explained not only as a psychological but also as a physiological problem if we think of the layers of air that surround us (*3*) or the energy that we represent (Fig. 1). The walls of houses or fortification walls around cities are other expressions of this third principle.

The fourth principle is optimization of the quality of man's relationship with his environment, which consists of nature, society, shells (buildings and houses of all sorts), and networks (ranging from roads to telecommunications) (Fig. 2). This is the principle that leads to order, physiological and esthetic, and that influences architecture and, in many respects, art.

Finally, and this is the fifth principle, man organizes his settlements in an attempt to achieve an optimum synthesis of the other four principles, and this optimization is dependent on time and space, on actual conditions, and on man's ability to create a synthesis. When he has achieved this by creating a system of floors, walls, roofs, doors, and windows which allows him to maximize his potential contacts (first principle) while minimizing the energy expended (second principle) and at the same time makes possible his separation from others (third principle) and the desirable relationship with his environment (fourth principle), we speak of "successful human settlements." What we mean is settlements that have achieved a balance between man and his man-made environment, by complying with all five principles.

The Extent of Human Settlements

Each one of us can understand that he is guided by the same five principles; but we are not aware of their great importance unless this is pointed out to us, and we make great mistakes in our theories about human settlements. This is because we live in a transitional era and become confused about our subject, even about the nature and extent of

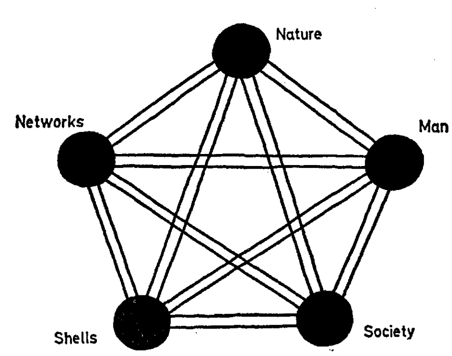


Fig. 2 (above). Fourth principle: optimization of the quality of man's relationship with his environment.

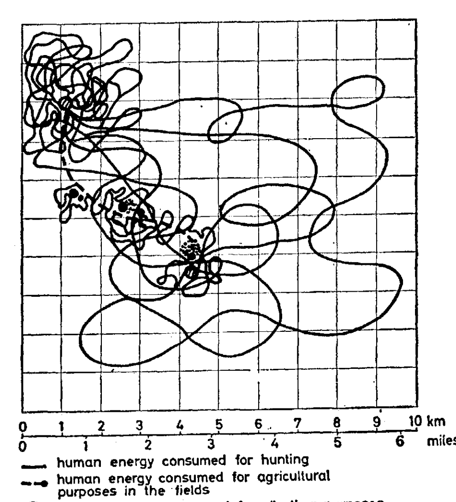
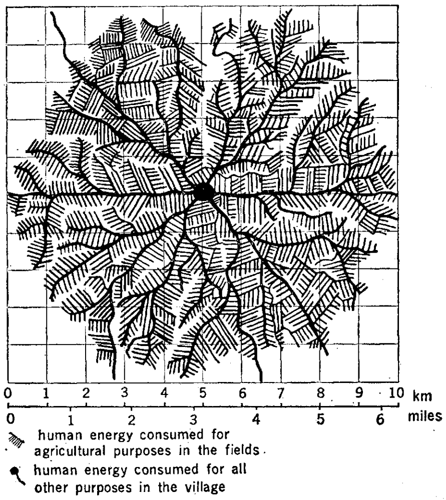


Fig. 3 (right). Energy model for hunters who begin to cultivate the land. Daily per capita energy consumption, 3000 calories.



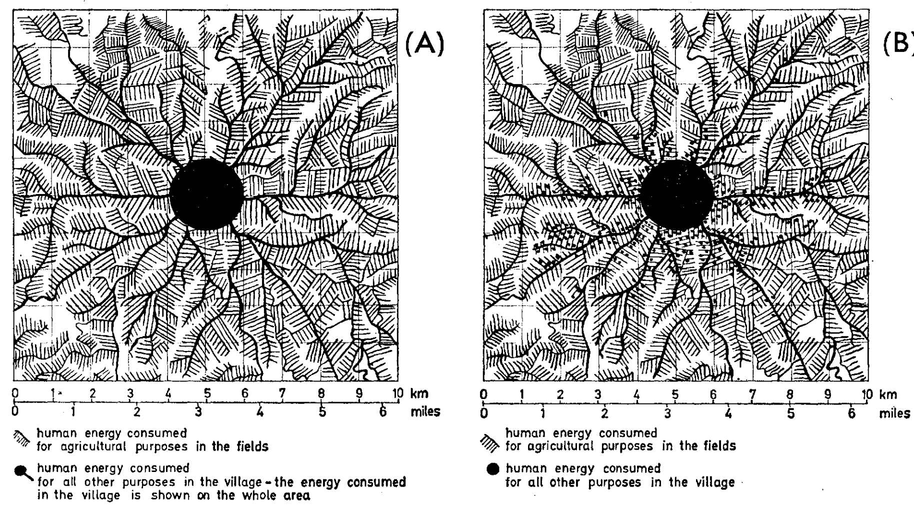


Fig. 4 (left). Energy model of a village. Daily per capita energy consumption, 8000 calories. Fig. 5 (middle and right). (A) Energy model of the central settlement of a system of villages. Daily per capita energy consumption, 12,000 calories. (B) Energy model of the central settlement of a system of villages during the era of the automobile. Daily per capita energy consumption, 25,000 calories.

human settlements, confusing them with their physical structure ("the built-up area is the city") or their institutional frame ("the municipality is the city"). But human settlements have always been created by man's moving in space and defining the boundaries of his territorial interest and therefore of his settlements, for which he later created a physical and institutional structure.

When we view human settlements as systems of energy mobilized by man—either as basal metabolic or as muscular or, recently, as commercial energy systems—we get new insights. We see man spreading his energy thin in the nomadic phase of his history (Fig. 3), then concentrating in one area and using both energy and rational patterns when he organizes his village, where he spends more energy in the built-up part than in the fields (Fig. 4). Later we see him concentrating in the small city and using a wider built-up area, where he expends even more energy, and then, when more people are added, we see him spreading beyond into the fields (Fig. 5). Finally, when he has commercial forms of energy available and can dispose much more energy without properly understanding its impact on his life and therefore without controlling its relationship to his settlement, man becomes completely confused by his desire for more energy. He suffers because, through ignorance, he inserts this additional energy into the system that he creates in a way that causes problems such as air and thermal pollution (Fig. 6).

Throughout this evolution there is only one factor which defines the extent of human settlements: the distance man wants to go or can go in the course of his daily life. The shortest of the two distances defines the extent of the real human settlement, through definition of a "daily urban system" [for a discussion of this process in urban settlements see "Man's movement and his city" (*4*)].

In each specific case, the process starts with the circle whose radius is defined by man's willingness to walk daily up to a certain distance and to spend up to a certain period of time in doing so (the limit for the rural dweller is 1 hour, or 5 kilometers, for horizontal movement; the limit for the urban dweller is 10 minutes, or 1 kilom-

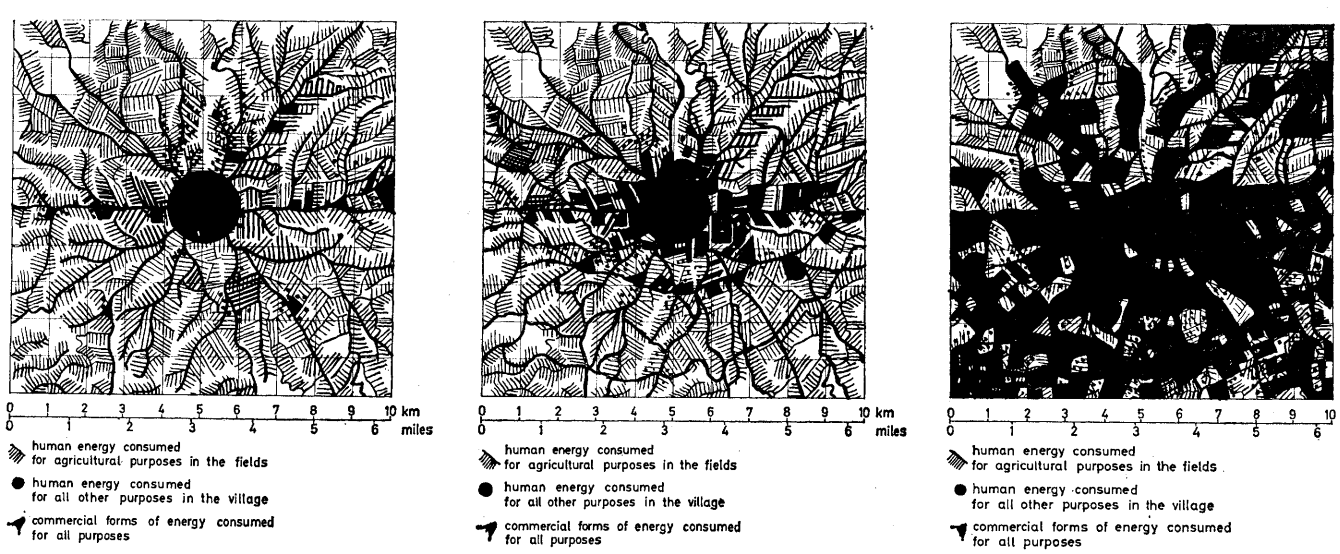


Fig. 6. Energy models of the central settlement of a system of villages during the era of the automobile and of industry. Daily per capita energy consumption, (left) 33,000 calories; (middle) 45,000 calories; (right) 100,000 calories.

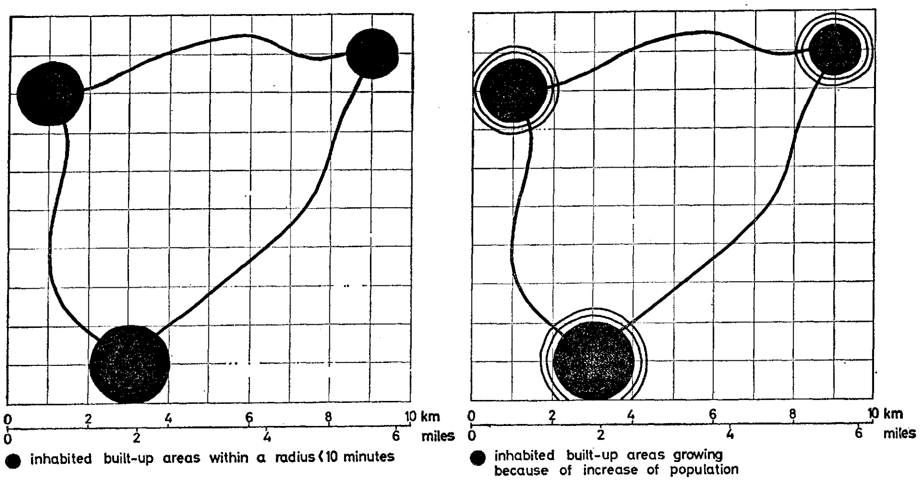


Fig. 7. Growth of a system, pedestrian kinetic fields only. (Left) Phase A; (right) phase B.

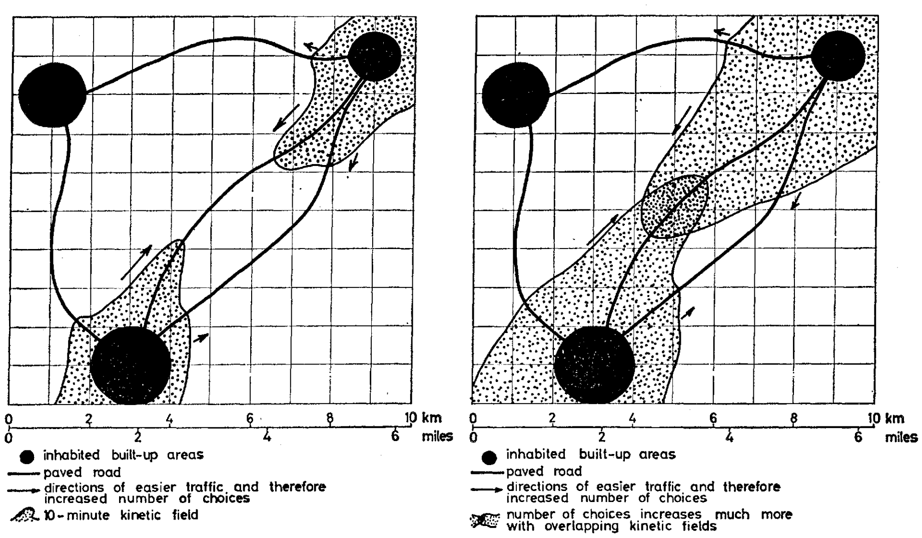


Fig. 8. Growth of a system, pedestrian and mechanical kinetic fields. (Left) Phase C; (right) phase D.

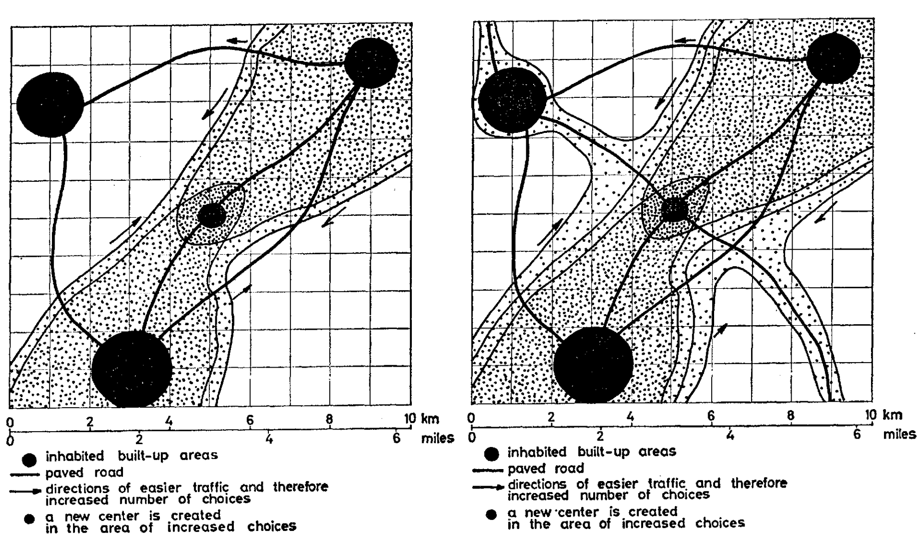


Fig. 9. Growth of a system: pedestrian and mechanical kinetic fields. (Left) Phase E; (right) phase F.

eter). This leads to the conception of a circular city, and of a city growing in concentric circles (Fig. 7). When the machine—for example, the motor vehicle—enters the picture we are gradually led toward a two-speed system (Fig. 8), and then toward interconnected settlements (Fig. 9); then the road toward larger systems and the universal City of Ecumenopolis is inevitable (*5*).

The idea that the small, romantic city of earlier times is appropriate to the era of contemporary man who developed science and technology is therefore a mistaken one. New, dynamic types of settlements interconnecting more and more smaller settlements are the types appropriate to this era. To stop this change from city (polis) to dynapolis (*6*), we would have to reverse the road created by science and technology for man's movement in terrestrial space.

Classification by Size

The changing dimensions of human settlements and the change in their character from static to dynamic, which gives them different aspects with every day that passes, makes the settlements confusing places in which to live, and people, instead of facing this new problem with realism, start trying to escape from the confusion. Some mistakenly support the utopian thought of returning to the system of the small city, but they do not define how this can be achieved without loss of some of the advantages that the great city has given us. Others, feeling that they cannot return to the small-city system, support the big-city concept but do not dare to face the big city's real structure; this is the attitude that leads to dystopia (*7*)—to the big city that lacks quality. But there is another road: to realize that the big city is an inevitable phenomenon, but that the quality of life within it is bad, and to try to improve the quality of that life. This is the only desirable and realistic road.

To discuss quality of life or any other important phenomenon in human settlements without referring to their size is impossible. The confusion caused by the use of terms such as *small* and *big*, *town* and *metropolis*, *city* and *megalopolis* is very great. If we want to avoid it, we must classify all human settlements by size in order to be able to understand them and assign them values. A small neighborhood with cars running through it loses its values, and

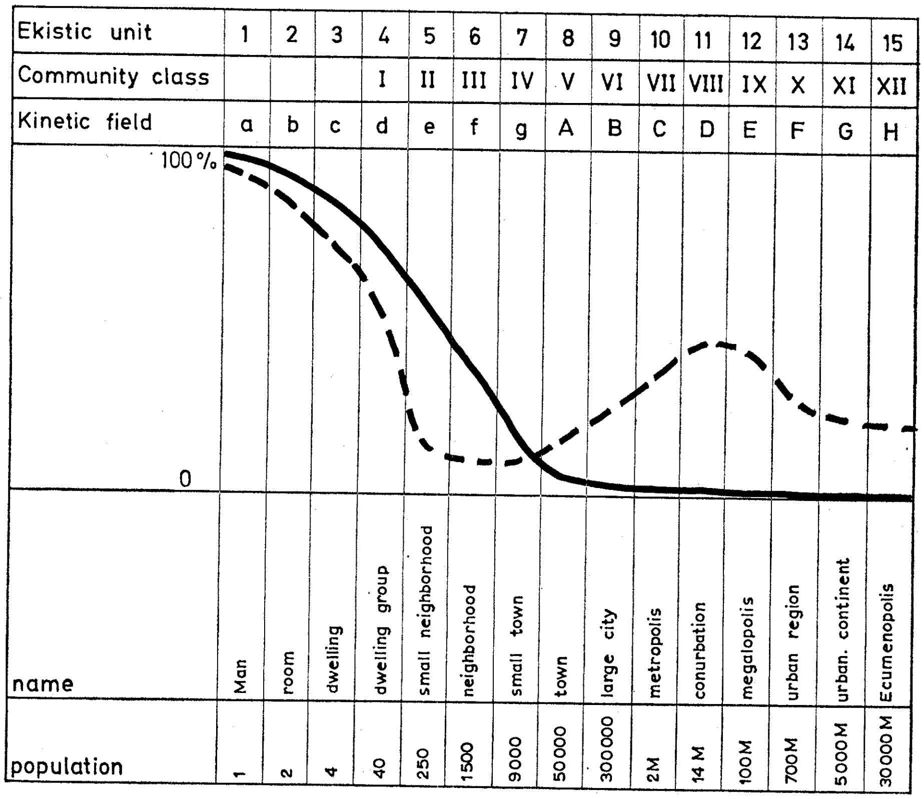


Fig. 10 (left). Contacts in the past and present in every ekistic unit. (Solid line) Past contacts, very much reduced beyond the unit of the town. (Dashed line) Present contacts. The greatest reduction is often in the small units.

a metropolis without means of very fast transportation cannot operate.

To achieve a proper classification, by sizes, of all human settlements, we should start with the smallest units. The smallest one is man himself as an individual. This spatial unit includes the individual, his clothing, and certain furniture, like his chair. The second unit is also very well defined; it is the space which belongs to him alone, or is shared under certain circumstances with a few others—that is, his personal room. The third unit, the family home, is well defined also, as long as we have families. The fourth unit is a group of homes which corresponds to the patriarchal home of earlier days and probably to the unit of the extended family of our day; this is the unit that children need most, mothers need mainly because of the children, and fathers need, if perhaps not directly for themselves, because they are interested in the satisfaction and happiness of both mother and children. I have defined four units; of these the first three are very clearly defined, physically and socially, and the fourth can be conceived of as a social unit.

Beyond this point we do not have a clear-cut definition of any unit until we reach the largest one possible on this earth—that is, the systems of human settlements of the whole planet. Thus we have five basic units, four at one extreme of our scale and one at the other. No other well-defined unit exists today, except for statistically defined units which are arbitrary, as may be seen from the differences in the official definitions from country to country. If we turn back in history we find, however, that, throughout the long evolution of human settlements, people in all parts of the world tended to build an urban settlement which reached an optimum size of 50,000 people and physical dimensions such that everyone was within a 10-minute distance from the center (*4*). There is no question that, for people who depend on walking as a means of locomotion, this unit is the optimum one from the point of view

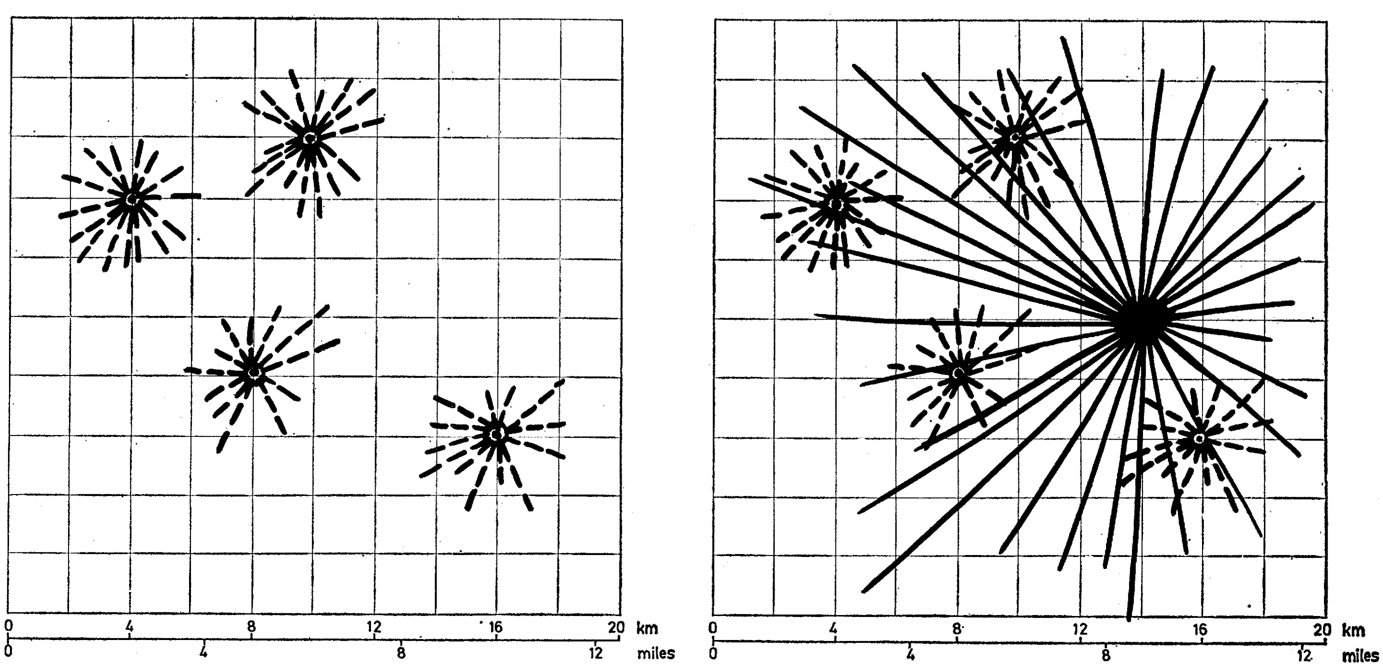
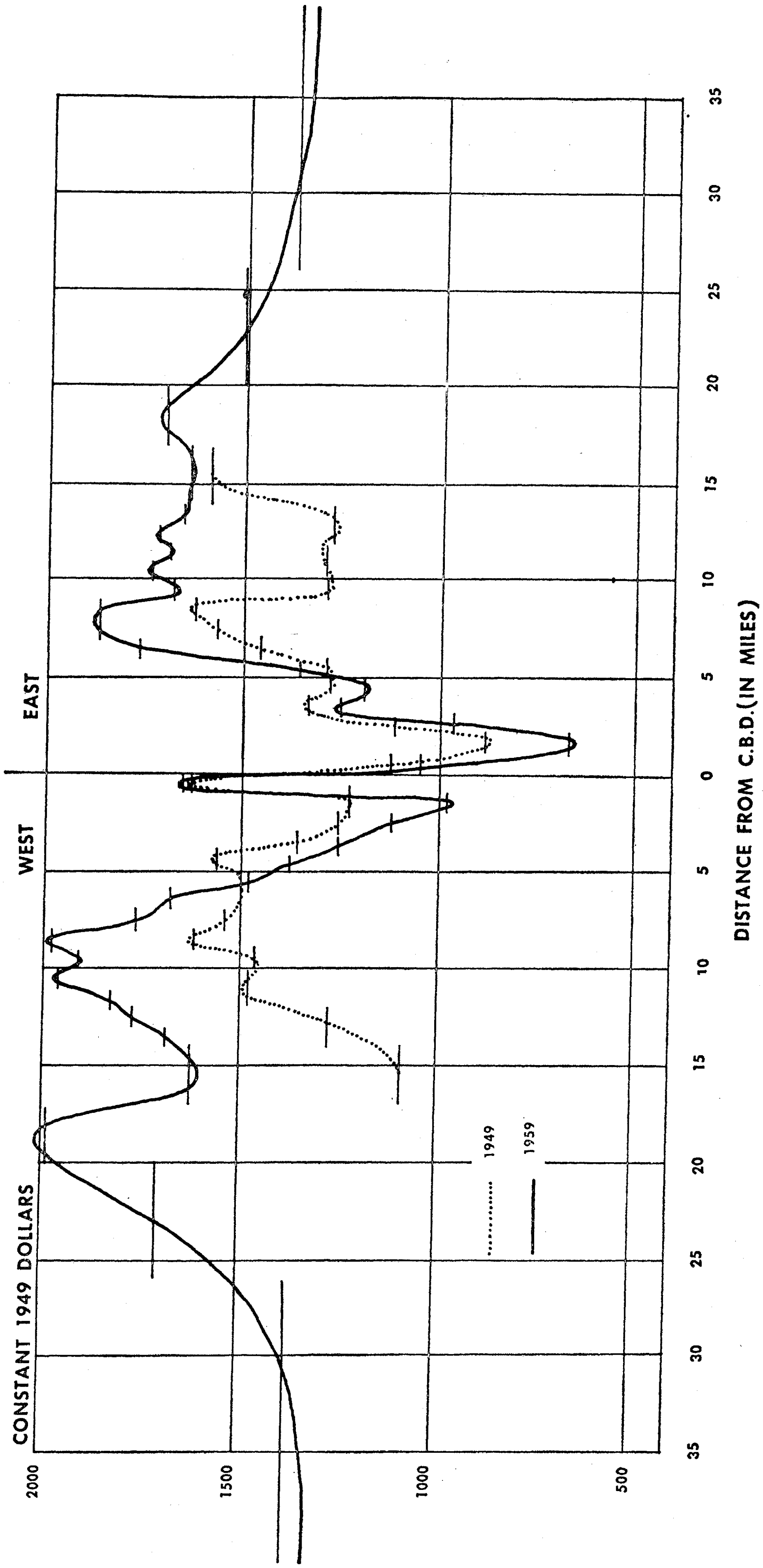


Fig. 11. Freedom for contacts in space. In the past (left) everyone had the same opportunities in his small world; now (right) some people have the choice of all contacts while others have very limited choices.



of movement and social interaction through direct contacts between people. Also, experience has shown that, for people who walk, it is a maximum one from the standpoint of esthetics; for example, creation of the Place de la Concorde in Paris cut from the total 3500-meter length of the Champs Elysées a length of 2100 meters, a distance from which one can reach, and enjoy, the Arc de Triomphe on foot. It is also perhaps an optimum one from the social point of view; for example, Pericles in ancient Athens could get a reasonable sample of public opinion by meeting 100 to 150 people while walking from his home to the Assembly.

Thus we now have four units at the beginning of the scale, one larger one somewhere beyond them, and one at the end—a total of six. How can we complete the scale?

This can be achieved, for example, if we think of units of space measured by their surface and increase their size by multiplying them by 7. Such a coefficient is based on the theory, presented by Walter Christaller (*8*), that we can divide space in a rational way by hexagons—that one hexagon can become the center of seven equal ones. Similar conclusions can be reached if we think of organization of population, movement, transportation, and so on. Such considerations lead to the conclusion that all human settlements—past, present, and future—can be classified into 15 units (*6*). Thus the basic units are defined as units No. 1 (man), No. 2 (room), No. 3 (home), No. 4 (group of homes), No. 8 (traditional town), and No. 15 (Universal City), and a systematic subdivision defines the others. All these units can also be classified in terms of communities (from I to XII), of kinetic fields (for pedestrians, from a to g; for motor vehicles, from A to H; and so on).

The Quality of Human Settlements

We can now face the important question of quality in human settlements since we can refer to a specific unit by first defining its size. A small town, especially in older civilizations, can satisfy many of our esthetic needs

Fig. 12. Outward movement of the higher-income groups in the Detroit Standard Metropolitan Statistical Area. The curves show the per capita income of people residing at several distances from the central business district (C.B.D.).

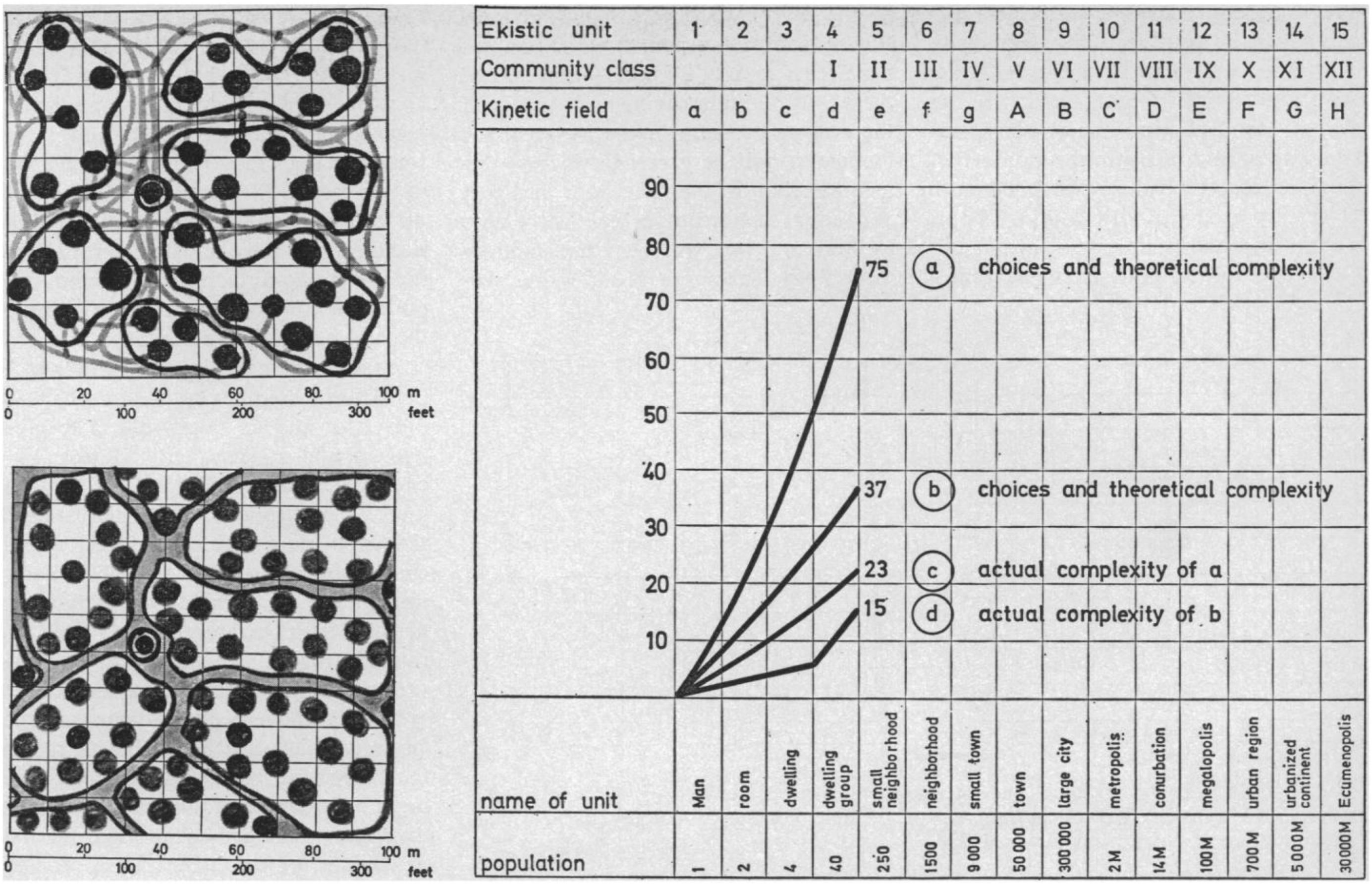


Fig. 13. (Top left) Toward organization of a dwelling group unit, showing first phase of organization: formation of dwelling groups, connections in certain areas, economy in use of space and time. (Bottom left) Toward organization of a dwelling group unit, showing third phase of organization: order in function and structure, maximum economy in use of space and time. (Right) Complexity and simplicity.

for picturesque streets and squares, and this is why we like it. But most people want to visit it, not to become its permanent inhabitants, as they are guided by the first of the five principles discussed above and try to maximize their potential contacts in the big cities, in order to have more choices for a job, for education and health facilities, and for social contacts and entertainment.

In our era, which begins with London at the time it was approaching a population of 1 million, about two centuries ago, and in other areas later, we lost the ability to satisfy all five principles. Guided by principles 1 and 2 we reached the stage of the big city, but in these cities we do not satisfy the other principles, especially principles 4 and 5, and we are not happy. We say that our settlements have no quality, and this is true in many respects, but we have to define what we mean. We need such a definition because we must remember that we now have much more water, of better quality, in our homes than man has had at any previous time, and we have much more energy available for conditioning our environment and for making contacts. A statement closer to the truth would be that our cities are better than the small cities of the past in many respects and worse in others.

Judgment about quality can be made in several ways in terms of the relation of every individual to his environment—that is, his relation to nature, society, shells, and networks—and the benefit that he gets from these contacts. We can measure his relations to air and to its quality; to water in his home, in the river or lake, and at sea (its quality and his access to it); and to land resources (their beauty and accessibility) and the recreational and functional facilities provided by them; and we can express judgments based on measurements of many physical and social aspects of the cities. Out of the great number of cases that I might cite I have selected three of the most complex ones.

We often talk about the greater contacts that the big city offers us, but we do not measure these contacts at every unit of the ekistic scale. If we do so we will discover that in units 2 and 3 (room and home) we have fewer person-to-person contacts than we had before, because of smaller families and new sources of information (radio and television); that in units 4, 5, and 6 (that is, in the dwelling group and neighborhoods) we have far fewer contacts because of the multistory building and the intrusion of automobiles in the human locomotion scale (*9*); and that in the larger units we have increased contacts because of the news transmitted to us by telecommunications media, the press, and so on (Fig. 10). In this way we see that we increase our one-way and, by telephone, two-way potential contacts with people and objects far away from our living area and decrease potential contacts with those close by. Is this reasonable for any of us, and especially for the children who cannot cross the street? This is a problem of quality of life seen in human terms. The answer to this problem is, I think, a city designed for human development (*10*).

As a second case I have selected one which refers, not to the relation of man to his environment, but to the relation between two persons as they are related to their environment. If we take the case of the Urban Detroit Area, which has been defined by a 5-year study (*11*) and covers 37 counties (25 in Michigan, 9 in Ohio, and 3 in Ontario), and rate the value of all its parts, taking as an example the esthetic value of its natural landscapes, and measure the number of units of esthetic value associated with places a person can visit within 1 hour, we find that the person who owns a car has access to 582 units from the centre of the city and to 622 from the outskirts. However, a person without a car has access to only 27 units—that is, less than 1/20 the number of units to which the other person has access, even if his income is half as great. If we now remember that, in the past, poor and rich had equal opportunities to visit places by walking, we will see that modern technology has increased the gap between people relative to the choices they have for making contacts in their settlements (Fig. 11). If the Urban Detroit Area grows in a way which takes people farther apart, and if the wealthier ones move outward at a speed of 1.8 meters (2 yards) a day (Fig. 12), we can understand how critical is the situation we have created through the use of modern technology without an understanding of the whole system of the city and how we serve it.

As a third case I have selected the problem of complexity, about which we talk a lot and do very little. The great size of the modern city is not what causes the bad quality of our environment. Corporations have increased in size even more without any loss in efficiency, and the armies of World War II were able to operate very efficiently despite their unprecedented size and rate of growth. The quality of our city, expressed, for example, in terms of a system of movement, is decreasing because we have not been able to reduce the increasing complexity by introducing a high degree of simplicity, as primitive man managed to do. The number of choices for primitive man in a space having no pattern of organization is the same as the number of persons in the space—let us say 37. Since there is no structure in the system, the complexity equals the number of choices—37. When a structure—social (family) or physical (wall of a compound)—is built into the system (Fig. 13, top left and right), the number of choices remains 37 but the actual complexity is 15 [6 (compounds) + 9 (maximum number of persons within one compound)], and this means a coefficient of simplicity of 2.5. If this happens, then people learn to come together in larger numbers and the same area may contain 75 people; that is, there are 75 choices (Fig. 13, bottom left) and a theoretical complexity of 75 but an actual complexity of 23 (9 + 14), or a coefficient of simplicity of 3.4.

In a similar way we find that the actual choices given an individual belonging to a group of 50,000 people, or living in a city of 50,000 population, theoretically number 50,000 (Fig. 14). These choices are reduced to 20,000 if 10,000 of the people live in the city and 40,000 live in the surrounding country (Fig. 15), and they are reduced to 5000 for a farmer living far out in the countryside (Fig. 16), as only a certain fraction of a man's time can be devoted to making contacts. What about the quality of contacts in the small village?

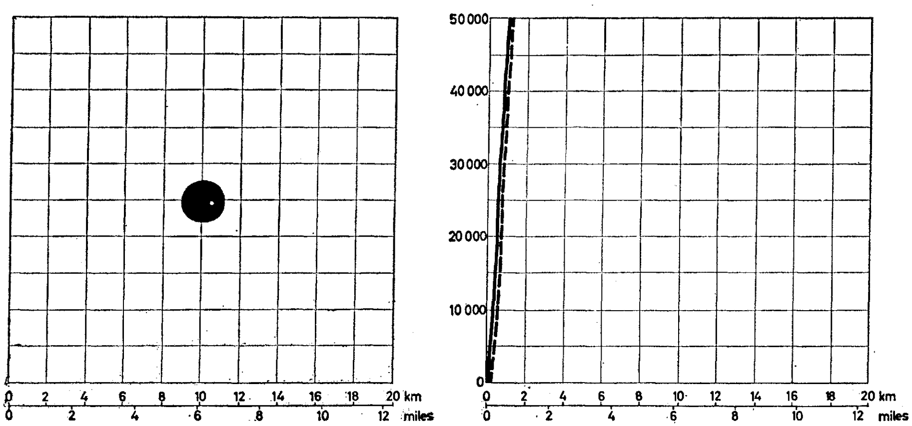


Fig. 14. (Left) A city of 50,000 people. (Right) Case of a citizen in a city of 50,000 people. (Solid line) Theoretical number of possible contacts: 50,000; (dashed line) actual number of possible contacts: 50,000.

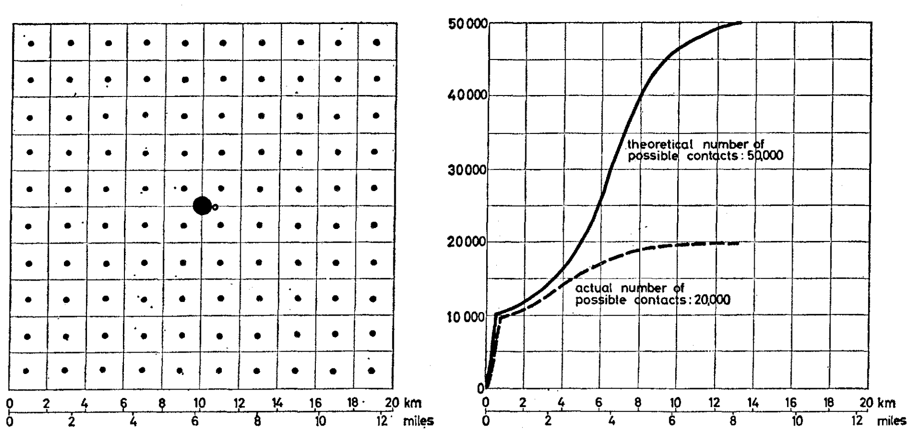


Fig. 15. (Left) A city of 10,000 people in a region of 50,000 people. (Right) Case of a citizen in a city of 10,000 people in a region of 50,000 people.

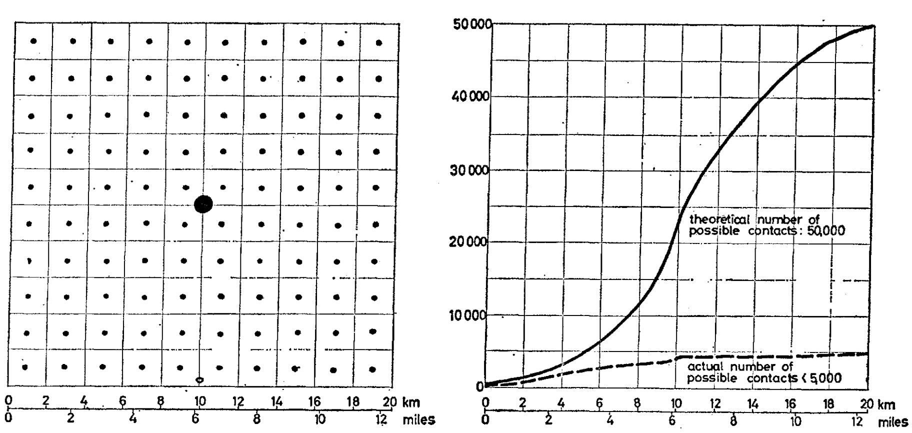


Fig. 16. (Left) A city of 10,000 people in a region of 50,000 people. (Right) Case of a "peasant" in an outlying village of a region of 50,000 people.

Morphogenesis

The question now arises, if we know how to analyze and define quality, can we do anything to ameliorate conditions in cities whose quality is not high? The answer is that man has often faced many of these problems (not all) by giving his static settlements proper structure. By this I mean the settlements which were created up until the 17th century and which ranged in size from No. 2 units—that is, from rooms which, once created, did not grow—to No. 9 and 10 units—large cities, very often surrounded by walls, that seldom grew. Peking is probably the only No. 10 settlement created before the 17th century. This is the structure which led to the shape and forms of the cities we admire today. It is time we tried to see how the changes came about; it is time we examined the morphogenesis of human settlements.

Morphogenesis in human settlements varies with the type of unit we are dealing with. From the many types of units I will select the room, the No. 2 unit, and will follow its formation. We do not know how and when the formation of a room started. It probably started in many parts of the world, and probably the rooms had many forms and sizes. We have reason to believe that the first rooms were of moderate size (according to today's standards), but they may have been very small one-man, one-night huts similar, in a way, to those built and used by the apes (*12*). In any case the moment came when some primitive people had round huts and others had orthogonal ones, and when there were different types of roofs or, in some cases, no roofs at all. In at least one modern instance—that of the Bushmen of the Kalahari Desert in southwest Africa—there is no door to the hut; the Bushmen jump into it over the wall (*13*).

Of great interest for us is the fact that, no matter how the first room started or how it was developed, the room always ends up, given enough time for the development of a composite settlement, with a flat floor, a flat roof, and vertical orthogonal walls. We can see the reasons for this. Man probably first builds the horizontal floor, so that he can lie down and rest, and walk without great effort or pain (the second principle). He then tends to build vertical orthogonal walls. The reasons for making the walls vertical and orthogonal are many: when he is in the room he feels at ease with, and likes to see, surfaces that are vertical relative to his line of sight (Fig. 17); he makes the walls vertical in conformity with the law of gravity; and by making them vertical and orthogonal he accommodates his furniture best (Fig. 18) and saves space when he builds two rooms side by side (Fig. 19). For similar reasons he needs a flat roof: a horizontal surface above his head makes him feel at ease when he is inside the room, and this construction enables him to use larger pieces of natural building materials and to fit one room on top of another without any waste of space, materials, and energy. In this way the form of the room is an extension of man in space (in terms of his physical dimensions and senses) and follows biological and structural laws.

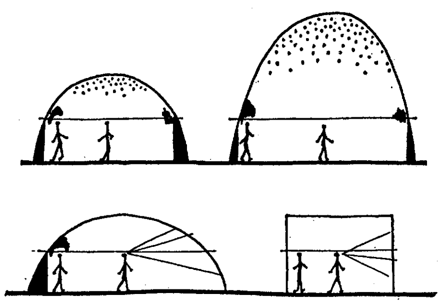
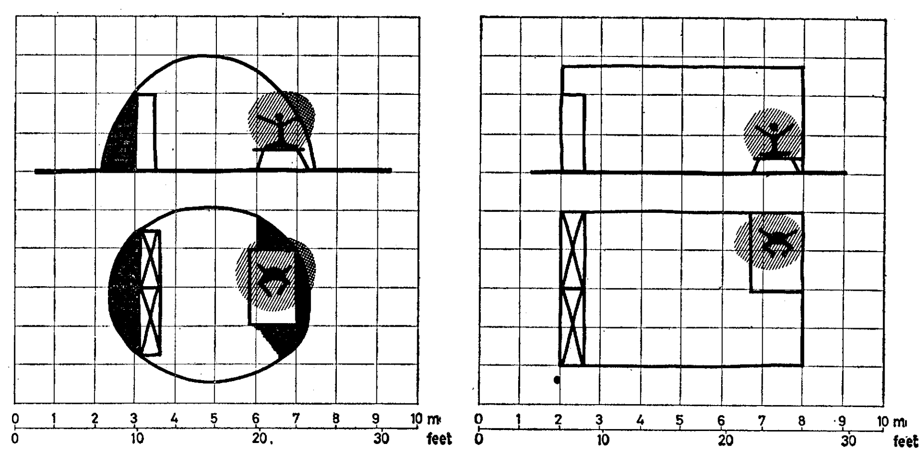


Fig. 17 (above). Formation of the walls. Walls have to fit the body and the senses of man. Fig. 18 (right). Formation of the walls. Curved walls (left) lead to waste in the synthesis of furniture and room; straight walls (right) allow the most economic synthesis of furniture and room.



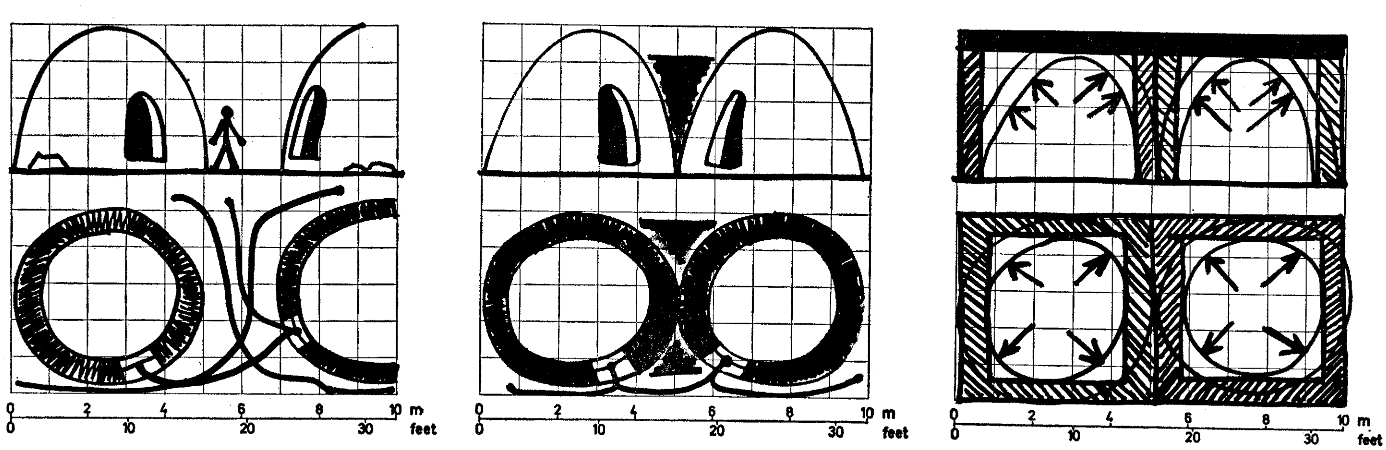


Fig. 19. Formation of the walls. Two separate nonconnected rooms (left) can remain independent units, but people tend to bring them together. Two separate, connected rooms (middle) cannot remain independent units; they create many problem surfaces. Two connected rooms (right) tend to eliminate the problem surfaces; they tend to occupy a minimum total area.

Thinking in these terms, we reach the conclusion that the morphogenesis of the room is due to several forces derived either from man or directly from nature. When we move on to the house, the neighborhood, the city, and the metropolis we discover that several forces enter into the game, but their relationships change from case to case (*14*). The unit of the metropolis, for example, is too large to be influenced directly by the unit man (again, in terms of his physical dimensions and senses) whereas it *is* influenced by the natural forces of gravity and geographic formation, by modes of transportation, and by organization and growth of the system.

Thinking in this way for all 15 ekistic units, we reach the following conclusion. The changing forces of synthesis which cause morphogenesis within every type of ekistic unit follow a certain pattern which, in terms of percentages, shows a decline of the forces derived from man's physical dimensions and personal energy and a growth of those derived directly from nature itself as a developing and operating system (Fig. 20).

Figure 20 can be understood, and will not be misinterpreted, if we keep in mind the following considerations.

First, it does not represent any specific case (a room in a desert house can be different from one in a mountain dwelling), but represents the average for all cases in each ekistic unit.

Second, the ratio between the different forces given for each ekistic unit in Fig. 20 is based only on personal experience which cannot be expressed by measurements at this stage. It is based on the assumption that all forces can be assigned equal importance. We have no way of proving that this is the case, but several trials prove simply that, by proceeding in this completely empirical way, we make the smallest number of mistakes. For this reason the shape of the surface representing the validity of each force (Fig. 20) can be considered to correspond to reality, while the ratio of one force to another is arbitrary.

What I can state here is that many years of experience as a builder of human settlements has proved for me the general validity of these diagrams in everyday practice for small-scale units and for several large-scale units, as shown in recent studies made in France (*15*) and in the Urban Detroit Area study (*11, 16*). I can also say that the same diagram of synthesis is reasonably valid beyond the limits of the ekistic

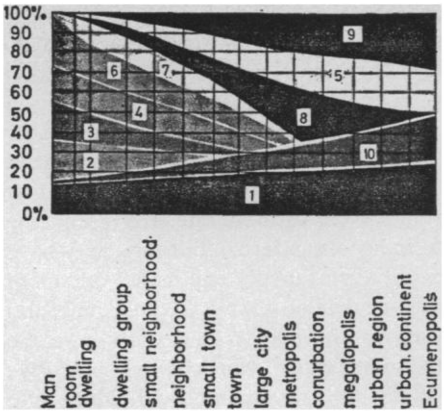


Fig. 20. Probable validity of the forces of ekistic synthesis: 1, gravity; 2, biological; 3, physiological; 4, social; 5, movement; 6, inner structure; 7, external structure; 8, growth; 9, organization; 10, geographical.

logarithmic scale, for units smaller or larger than the ekistic ones. Thus the ekistic logarithmic scale can be considered a basic tool for the study of synthesis in space, which is a basic characteristic of morphogenesis of human settlements. In nature, gravity, for example, plays an increasing role in larger units—this is why large birds do little flying—and a decreasing one in smaller units (Fig. 21). In this way we can understand the changing relationships between several types of forces which influence the formation of several types of organic and nonorganic systems in space.

Two Myths

Another question now arises: If we can analyze the problem of quality and understand the morphogenetic process which should enable people to build properly and improve an undesirable situation, why are conditions so bad in our cities? The answer, apart from the fact that some problems are not related to the physical structure of the city, can run along the following lines.

1) Man, who understood the morphogenetic process for the small units, thought that the forces and laws valid for the small units were valid for the big ones that we build today, and this is not true.

2) New forces—like motor vehicles —have entered the game, and their impact on the city has not been understood.

3) Man did not seem able to learn about the new problems, and did not even seem interested in them, before the crisis came. He became confused, to the point of mistaking poverty for an urban problem, whereas it is simply a huge human problem which becomes more apparent in the urban areas because of the proximity of the rich, who have not been previously exposed to poverty, to the poor.

We can prove the foregoing three points in many ways, by considering some myths which still prevail in the minds of many people. I have selected two characteristic ones. I will start with the myth of the city of optimum size.

The city of optimum size. A long discussion is taking place throughout the world about the need to build new cities of optimum size, and proposals have been made by many experts and adopted in government policies, but no one can prove his case in a convincing way.

Some define optimum size as being related to the income of the people; but in a developing world, where the average per capita income increases by 2 percent a year (and by more in urban areas), what is the meaning of this optimum over a long period?

Others argue in terms of optimum numbers of people and of organizational and, more specifically, municipal efficiency, but they are not able to produce any convincing proof (*17*). Even if they could, comparisons of one city with another city have no meaning in a world where people no longer live in isolated cities but live in urban systems. But if I could prove that one city of 200,000 people had greater municipal efficiency than a city of 1 million, I must also prove that the people in the two cities were equally satisfied (otherwise what is the meaning of efficiency for them?) or that a system of five cities of 200,000 was as efficient as the city of 1 million, which is not the case.

Others base optimum size on organizational aspects such as one school or one hospital for so many children or people. But, in a world of changing ratios between age groups and of changing technical and managerial abilities, this line of thinking cannot lead anywhere. Such considerations are very useful for calculating needs which have to be satisfied in certain areas and periods, but not for calculating the optimum size of the city. Technological calculations based on the means of transportation cannot be helpful either. Since speeds change continuously, how can we speak of an optimum distance? We can have an optimum distance expressed in terms of time, but this means a continually changing physical dis-

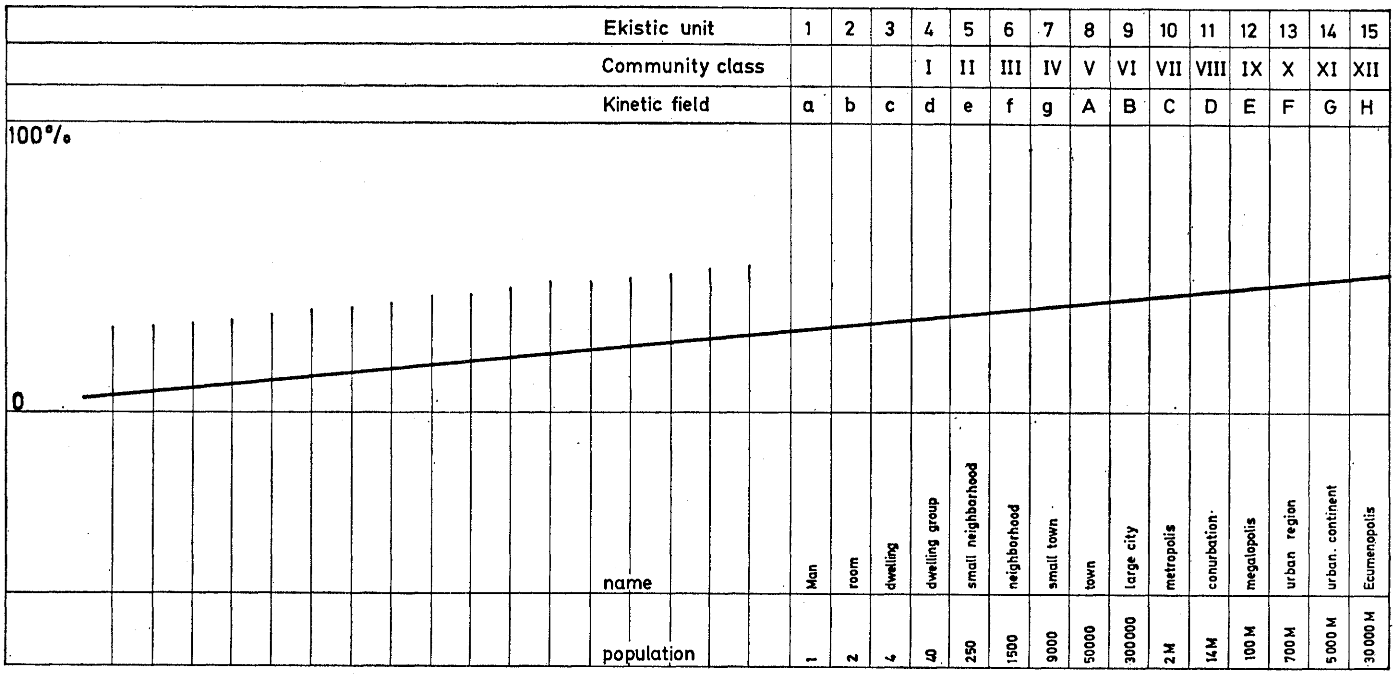


Fig. 21. Influence of the force of gravity in morphogenesis.

tance. Are we going to stop the development of technology?

In this changing world there is no optimum size for a city. The dynamic cities have no optimum size, but only an optimum speed of growth. And what this optimum speed of growth is, is a very complex question, the answer to which depends on many factors concerning the city itself and its relationship to the total space around it. For example, the answer for two dynamic cities, one 10 and one 30 kilometers from a metropolis, are completely different.

Is there no optimum size with which we can deal? The answer is that there is, because there is one relatively constant element, and this is man, insofar as his body and senses are concerned. I think that, for the foreseeable future, we can reckon with a man whose body and senses will not change. If this is so, we are led to the conclusion that there is a unit of space which will continue to serve his needs as it has done in the past; this unit is the circle that can be inscribed in a square 2 kilometers on a side (*4*). The importance of this unit is demonstrated by the growth of actual traditional cities and by the diagram of synthesis in space (Fig. 20), which shows that direct human forces do not go beyond the circumference of this circle. With traditional population, this unit contains 50,000 people.

The conclusion is that the optimum-size city is a myth. But any city can be divided into physical units of optimum size, and these may be used as a basis for planning that envisions an optimum number of people in a community. However, this latter goal is much more difficult to attain. I do not believe that we are ready for it, although we have the necessary arguments and data.

The static plan. Another myth which still prevails is that we can solve the problems of our cities through the conception, and official recognition, of a physical plan expressed by a two- or three-dimensional drawing. But our cities are growing organisms. They need a development policy leading to a development program which is expressed, in space, by physical development plans, but they also need economic, social, political, administrative, technological, and esthetic programs.

This does not mean that there are no areas where a physical plan can be final; if there were none, we would all be mentally ill. We need a room with constant dimensions, a home that gives us a feeling of permanency, a street and a square which do not change and which are esthetically satisfying. Such considerations lead to the question, to what extent can our environment be a constant one? The answer is that, if there is a unit of optimum size such as a room, a home, a community (up to the one of 1-kilometer radius), this can and should be constant. In this way we can face a world of changing dynamic cities by building them with constant physical units within which we can create quality—units meant for a certain purpose and containing a certain desirable mixture of residences, cultural facilities, industry, and commerce. These would be designed on the basis of the long human experience which led to the natural growth of cities, such as Athens and Florence, or to the building of planned cities such as Miletus and parts of Paris, which we admire today.

We can design these small units if we understand the processes of synthesis and morphogenesis of the past and if we do not try to discover new patterns of life expressing nonexistent principles, just for the sake of changing the traditional ones. On the other hand, for the larger units and for the dynamically changing ones with which man has had no experience or a very bitter one, we must proceed in a different way. Not knowing what is going to be good or bad, we must use a completely different approach. We must build all possible alternatives and compare them in terms of the quality of life they offer their citizens. This approach is impossible in practice (we cannot play with the happiness and the incomes of millions) and would have been impossible in the laboratory even 20 years ago. But now we can build simulation models and compare them by means of computers.

To do this we have developed the IDEA method (the acronym stands for Isolation of Dimensions and Elimination of Alternatives). We first build all alternatives for the future of an urban system (this is possible if, through experience, we concentrate on the most important dimensions for every type of unit and every phase) and then eliminate the weakest ones. It is only in this way that we can avoid errors based on the mistaken belief that "I know," and can avoid the long period required for learning by trial and error, as primitive man learned.

This method certainly does not eliminate mistakes, but it reduces them to a minimum. Its application to the very difficult problem of the Urban Detroit Area (*11, 16*) has demonstrated how useful it can be for large-scale areas for which there is no human experience at all.

Experience has convinced me that, if we can develop a science of human settlements and, through it, recognize the guiding principles, laws, and procedures of man's action regarding terrestrial space, we can build much better human settlements in the future. This will be, not through the repetition of past solutions, but through their synthesis within the new frame formed on the basis of the new forces that have entered the game. The physical features of future cities can be at least as impressive as those of the famous cities of history or of today. At the same time, the guiding principle of real freedom of choice for everyone, not for certain classes only, can be implemented for the benefit of every person, and thus man's cities of the future can be better and far more important for all their inhabitants than the famous cities of the past.

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Cell Communication, Calcium Ion, and Cyclic Adenosine Monophosphate

Howard Rasmussen

Intercellular communication in higher animals takes place in one of two ways, either by direct communication from cell to cell by way of nerves or by indirect communication by way of chemical messengers within the circulatory systems. Traditionally, these two modes have been thought to differ. However, from the beginning of a serious consideration of the mechanisms underlying each, important similarities have been obvious. An immensely important similarity was discovered by Dale, Loeb, Gaddum, Elliott, Von Euler, and others (*1–5*): Transmission of signals from one cell to the next across synapses in the nervous system is generally by chemical rather than electrical means. It is recognized that synaptic transmission is a highly specialized function which is carried out by a very limited number of unique, low-molecular-weight neurotransmitters, whereas hormonal control in the endocrine system represents an amazingly complex and diversified set of functions carried out by a considerably greater number of different chemical messengers of varying size, structure, and chemical complexity. It had been assumed that the study of the action of a specific hormone and the release of neurotransmitter at a synaptic junction had little in common. However, recent experimental evidence indicates that neural transmission and the operation of many parts of the endocrine system, although differing in physiological function, may share a common biochemical mechanism at the cellular level. The basic elements in this widespread biochemical control mechanism are: calcium ions, adenosine 3′,5′-monophosphate (cyclic AMP), intracellular microtubules, microfilaments, secretory vesicles, and a class of enzymes known as protein kinases which phosphorylate specific proteins with adenosine triphosphate (ATP) as substrate.

The author is professor of biochemistry at the University of Pennsylvania School of Medicine, Philadelphia 19104.

Intracellular Calcium

Ever since the early studies of Loeb, calcium ion has received the attention of cell biologists, physiologists, and biochemists because of the profound effects this ion has on cellular and enzyme function (*6, 7*). The most important and widely accepted role of calcium is that of serving as the coupling factor between excitation and contraction in all forms of muscle (*8, 9*), between excitation-secretion coupling at nerve endings (*2*), and in both exocrine and endocrine glands (*10–14*). Calcium ions are also involved in the regulation of glycogenolysis in muscle and ascites cells (*15–17*) and gluconeogenesis in kidney and possibly liver (*18–21*). It has been implicated as an intermediate in the action of melanocyte-stimulating hormone (*22*), in the action of vasopressin on the toad bladder (*23*), and in the action of parathyroid hormone on the function of bone cells (*20, 24, 25*).

In animal cells the concentration of calcium ion in the cytosol or free cytoplasm is in the range of 10^{-5} to