# CHAPTER 1

# BASIC CONCEPTS OF ORGANIZATION

THE INTELLECTUAL MECHANISM used by man to acquire knowledge has led him to recognize the existence of relationships between the various manifestations encountered in nature. He has employed abstraction and integration to build up conceptual individualities which he identified as separate entities in nature. Structural characteristics and dynamic properties have appeared to be the most suitable criteria for defining these entities. However, curiosity has constantly impelled man to attempt to extend his knowledge by explaining and correlating these entities, and an important means has been analyses breaking them down into their component parts.

Out of these analyses has come recognition of the fundamental importance of *organization*. For, as entities have been analyzed one after the other, it has become clear that the seemingly infinite variety of them perceived by our senses is in reality the result of the arrangement of a relatively small number of basic units, the molecules. Moreover, analysis has shown that only a very small number of chemical elements make up even the most complex molecules; that combinations of less than one hundred elements, in different proportions and relationships, account for tens of thousands of compounds and many billions of entities. And further analysis has revealed that elements themselves represent different dynamic arrangements of only a few—according to some hypotheses, only two—fundamental corpuscles.

Upon close analysis, nature, which appears to be so greatly varied, turns out, in fact, to be based upon only a very few fundamental constituents and it is the manner in which these constituents are bound together, their organization into a multitude of combinations, which provides variety.

The study of organization obviously, then, could furnish the most valuable information about nature. And it would not appear to be too much to expect that, if nature's seemingly infinite variety stems from organization of only a few constituents, then organization itself might also be achieved through a few, relatively simple fundamental patterns. If so, seeking out such patterns—systematic analysis of organization comparable to the efforts to systematize constituents—could be of primary importance to better understanding of a host of problems.

### *Homotropy and Heterotropy in Nature*

As man attempted to recognize order in the constant changes seen in nature, he noted certain patterns that appeared to indicate definite "laws of nature." Some of these laws have been observed to operate under such a wide variety of circumstances that they have come to be accepted as "fundamental laws."

In 1824, Sadi Carnot formulated one which is known as the Second Law of Thermodynamics. Carnot observed that, in a given system, work involving the transformation of thermal into mechanical energy is only accomplished as heat drops from high to low temperature. In more general terms, this means that work accomplished in an isolated system results in progressively eliminating differences in temperature. Clausius recognized this as a fundamental principle and postulated that the amount of energy available for work always tends toward a maximum. This condition, called "maximum entropy," corresponds to uniformization of temperature and also to homogeneous disorganization. At first, it appeared that the principle was in conflict with the First Law of Thermodynamics which expresses the rule of conservation of energy. However, Helmholtz soon was able to demonstrate its validity by showing that only the second law could reconcile the first with the impossibility of perpetual motion.

In a more philosophical vein, we considered, in our research, that this Second Law of Thermodynamics in its broadest sense could define a fundamental trend toward annihilation of any existing differences in nature, through the triumph of total uniformity. Since Clausius used the term "entropy" in applying Carnot's original observation to closed mechanical systems, it has seemed preferable to avoid confusion by utilizing another term for this general tendency toward uniformity in its broadest sense. Therefore, we have chosen the term "homotropy."

Despite the theoretically rapid trend in the direction of absolute uniformity, or homotropy, no such final state has yet been achieved. It must be concluded, therefore, that some other factor opposed to that trend exists.

We have chosen the term "heterotropy" for this other factor, which tends to maintain or produce inequality and thus to preserve the order that is evident in nature.

In order to understand the roles of these two opposing fundamental tendencies in the organization of nature in as logical a fashion and with as much ease as possible, it seemed advisable to try to study their operation first in one of the simplest and best known natural organizations, the atom, passing later on to higher and lower levels of organization.

### *The Atom*

The role of the two opposing tendencies in atom organization becomes clear when we study the relationship between the forces that form this entity. Each atom consists of a positively charged nucleus surrounded by negatively charged electrons in adequate number to balance the nuclear charge.

The existence of the atom depends upon forces acting between nucleus and electrons. One group is of coulombian nature. These are the electrostatic forces that account for the attraction between oppositely charged electrons and nuclei, and for the repulsion between electrons bearing similar charges. If such forces did not exist, electrons would wander irregularly and would not be retained around the nucleus.

Yet, if electrostatic forces were unopposed, electrons would be drawn closer and closer to the nucleus and would finally fall into it, thereby bringing about complete annihilation of all charges. The fact that electrons are not absorbed by the nucleus indicates the existence of a second, opposing force.

This second force is defined by quantum mechanics and the quantum theory of fields. Quantum mechanics ascribes a series of discrete energy levels to electrons within atoms. Radiation is emitted or absorbed only when electrons pass from one stationary level to another. The energy levels are relatively stable, and a state of minimum energy exists when each of the electrons of the atom is as close as it can be to the nucleus on the ground level.

The energy levels correspond to the orbits described by Bohr's theory which, although not entirely accurate, affords a good basis for understanding atomic properties. Bohr envisaged the electrons revolving around the nucleus in definite orbits, each orbit moving continuously in these states, the atom not emitting radiation. This differs from the older theory according to which the electrons can revolve around the nucleus on any orbit. Such casual orbit motions would lead to loss of energy by radiation. The electrons would come closer and closer to the nucleus and would, as already pointed out, finally be absorbed by it. The quantum theory of fields accounts for the absence of radiation and for electrons remaining in their particular orbits. However, the concept of stationary states fails to explain all the properties of the atom, particularly its chemical reactivity, by virtue of which different atoms combine to form molecules.

According to another tenet of the quantum theory, the Pauli Exclusion Principle, an orbit cannot be occupied by an indefinite number of electrons but, at most, by two electrons that spin in opposite directions. The orbits are arranged in shells, each shell having a definite level of energy. A shell is complete when it contains the maximum number of electrons compatible with the Pauli Principle. Complete shells consist of 2, 8, 18, etc., electrons. When an inner shell has its quota of electrons, additional electrons must occupy an outer shell. Consequently, instead of falling into the nucleus, the electrons in their lowest energy states will continue to revolve at a considerable distance from the nucleus.

As already indicated, if there were only electrostatic forces, the electrons would have long since fallen into their nuclei, neutralizing all electric charges. The universe would be in a state of maximum homotropy. No strong atomic forces would exist and no chemical reactions would take place. The intervention of quantum forces avoids this. It is apparent, then, that the organization of the atom results from the operation of two types of forces, electrostatic and quantum, the electrostatic serving to bring and keep nucleus and electrons together to constitute the atom, the quantum accounting for a motion of electrons which prevents their total annihilation and the neutralization of all electrical charges.

### *Homotropic and Heterotropic Forces in the Atom*

We may now attempt to consider electrostatic and quantum forces in the atom in terms of homotropic and heterotropic trends. Let us hypothesize an atomic system in which only electrostatic forces are active and compare it with a real system which also has active quantum forces. Whereas the fictitious system will rapidly evolve towards a state of maximum homotropy, with annihilation of all charges, this will not occur in the real system. When the two systems have reached final states of equilibrium, the homotropy of the imaginary system will be greater than that of the real system. If the quantum forces that keep the electrons away from the nucleus in the real atom could be withdrawn, the electrostatic forces acting alone would bring about a state of complete annihilation, thus making available a certain amount of energy that had previously been preserved by the quantum forces. In this sense, it is apparent that the electrostatic attraction between nuclei and electrons is of a homotropic character, while quantum forces are heterotropic.

### *Fulfillment * of Quantum and Electrostatic Forces*

There are diverse consequences from the operation of quantum and electrostatic forces in the atom. The partial fulfillment of the electrostatic forces keeps the nucleus and electrons together in the atom, while quantum forces cease to exist with the establishment of complete electron shells, and have, therefore, been called "saturation forces."

In the atoms of the noble gases, quantum and electrostatic forces are simultaneously fulfilled. As a result, these atoms are inert. They have no physical or chemical activity and their entry into the formation of molecules is explained by the intervention of van der Waal's cohesion forces. In all other atoms, the electrostatic forces are fulfilled when the number of orbital electrons corresponds to the nuclear charge. However, when this occurs, the electron shells are incomplete and consequently unfulfilled quantum forces are present. When the quantum forces are fulfilled, other electrostatic forces appear.

Under these circumstances, in order to complete its outer electron shell, *i.e.,* to fulfill the quantum forces, an atom may borrow or lose one or more electrons. This is achieved with a second atom which, by the exchange, reduces or increases its orbital electrons to fulfill its quantum forces and is left with a number of electrons consistent with a complete outer shell. The fulfillment of quantum forces requires changes that involve a displacement of electrons outside the atom itself. This exchange of electrons, properly called "electron transfer," fulfills, to be sure, the quantum forces of the atom. However, as a result of the transfer, the relationship between each nucleus and its orbital electrons is changed, resulting in covalent ions. Those atoms that have gained by the transfer and have an excess of electrons now have a negative charge while those that have lost electrons have a positive charge. As a result, new electrostatic forces appear which, although confined to the atoms themselves, influence their external behavior, as evidenced by the interaction between atoms.

An antagonistic relationship can be conceived between electrostatic and quantum forces in the sense that the fulfillment of one usually leads to appearance of the other.

Electron transfer represents only one mechanism for fulfilling the quan-

---

* We have unwillingly resorted to this too anthropomorphic term, the use of which has to be excused as didactic license.

tum forces of the atom. Two atoms which do not have sufficient electrons in their external shells to complete the external shells of both can fulfill their quantum forces by sharing some of their electrons. By achieving a complete external shell for each atom, the sharing process satisfies the quantum forces of both atoms. This method of quantum fulfillment through the sharing of electrons also can lead to the appearance of electrostatic forces. If the two atoms are identical, the shared electrons have an intermediate position and, therefore, do not influence them. As a result, the atoms have their quantum forces fulfilled without inducing new electrostatic forces. This is the so-called "homopolar bond." If, however, two atoms are dissimilar energetically, their shared electrons will be located closer to one atom than to the other, the distance being determined by the competitive influence exerted by the atoms upon the shared electrons. At the same time, other electrons will be influenced by the bond, and, as a result, their orbits will be altered to some extent. Weaker electrostatic forces will result and the bond will be intermediary between the ionic and the homopolar. Both kinds of fulfillment of quantum forces—one achieved by transfer, the other by sharing—thus lead to the appearance of new electrostatic forces in the ions or ionoids.

We must repeat here for emphasis that the fulfillment of quantum forces can take place through various avenues, either by loss or gain of electrons, or by sharing which can range from ionic to homopolar. The plurality of possibilities for fulfillment of quantum forces is very important, making it necessary to consider the results of such fulfillment on a statistical basis.

The electrostatic forces act between charged ions of opposite signs, or between atoms bound by shared electrons. Through the balance of these electrostatic forces, bound atoms appear and correspond to neutral formations, having their electrostatic forces fulfilled. However, it is only with the intervention of suitable quantum forces that the bound atoms can form a new entity, the molecule.

### *Quantum and Electrostatic Forces in Molecules*

Alternate operation of electrostatic and quantum forces leads to the organization of atoms into molecules. The quantum forces in the molecules intervene to permit organization of these entities so that the constituents are maintained at proper distances and positions. The result is electrostatic neutrality. The appearance of new quantum forces that maintain the constituents, through their organized movement, at certain distances and in certain positions, insures not only the establishment but also the stability of the new formations. Besides vibrational movements, other more definite movements can be recognized in the new molecule. When two or more atoms become associated by shared electron bonds, the shared electrons no longer are confined to one atom but are displaced from their own orbits. Under certain conditions, electrons can travel between two or more atoms, or even surround the molecule as a whole. These movements which correspond to the intervention of quantum forces give stability to the molecule.

The fulfillment of intramolecular quantum forces will affect molecules in a similar way as fulfillment of atomic quantum forces affects atoms. By a process similar to that governing motion of electrons in atoms, motion of entities that enter into the structure of molecules is also controlled. The fulfillment of quantum forces is achieved in various ways. For example, there may be localization of the movement of electrons in the molecule. As the result of relative immobilization of these electrons, electrostatic forces appear in the molecule as a whole.

The relatively immobilized electrons can be considered as being related to the molecule as an entity, since they cannot definitely be attributed to any of the constituent atoms. As a result, the molecule becomes electrostatically active.

The positions of electrons and even of atoms in molecules can be understood easily by considering events at the molecular level in the same way we considered those at the atom level. The molecule whose electrostatic forces are balanced is neutral. However, it has active quantum forces which govern the position and mobility of the constituents and the relative positions of bound atoms or of certain electrons in the entity. Fulfillment of molecular quantum forces is realized through changes in movement of electrons which lead to loss or gain of one or more electrons, protons, ions or even groups of atoms. This leads to appearance of electrostatic forces and the molecule becomes an active entity. In the molecule, as in the atom, quantum forces can be fulfilled in more ways than one—although one may represent a preferred situation. For this reason, activation of molecules, through changes in mobility of molecular electrons, has to be considered on a statistical basis.

The electrostatic coulombian character of an activated molecule is the result of the changes in mobility of the electrons. Positive or negative areas in the molecule develop according to the abundance or dearth of electrons, at these positions. The new electronic arrangements in a molecule can be seen as representing a preparatory step for the molecule to become an active entity in the same way that atoms are activated and become ions. The molecule loses or gains one or more electrons, (or protons, ions or groups of atoms) and becomes electrostatically active, with positive or negative charge, depending upon the nature of the lost or gained entity, and this is the outcome of the fulfillment of the molecular quantum forces. This is illustrated by the following examples concerning the benzene molecule, and the carboxyl and hydroxonium radicals, in which we shall limit ourselves to changes produced by quantum and electrostatic forces.

In the benzene molecule, which is electrostatically neutral, the electrostatic positive and negative forces of the constituent atoms are balanced. However, all the electrons are not in fixed positions. The $\pi$ electrons of the double bonds move around in the molecule. Because the molecule is closed, this movement is circular, thus accounting for the stability of the molecule, recognized in part by the equal reactivity of all its carbon atoms which is encountered under certain conditions and results in the Kekulian forms.

The fulfillment of the quantum forces accounts for a kind of relative fixation of these wandering $\pi$ electrons which is responsible for the other structures of the benzene molecule different from the Kekulian ones. It is this localization of electrons with the capacity to enter into further reactions which results in the activation of the molecule as seen in the resulting Dewar structures which in turn accounts for active centers such as ortho, meta, and para positions. These excited molecules, electrostatically active, can readily take part in chemical reactions. Study of the mobile $\pi$ electrons in many other molecules allows us to understand their role in providing molecular stability, while their relative localization favors the appearance of electrostatically active centers in the molecule and resulting reactivity. Here again, localization of electrons opens up many possible avenues to activation.

The carboxyl and hydroxonium ions represent typical examples of another kind of activation. Inactive carboxyl occurs when the quantum forces cause the electrons to wander continously between the two oxygens of carboxyl. Because of this electronic condition, the H atom seems no longer to be bound to either of the O atoms, but is situated between both; this form corresponds to the electrostatically fulfilled condition. With fulfillment of quantum forces, the wandering electron takes a more fixed position at one or the other oxygen. When this occurs, the $H^+$ ion leaves the carboxyl group, and the carboxyl acquires a negative electrostatic equilibrium, leading to further combining activity. This fulfillment of the quantum forces is responsible not only for the appearance of an activated group of electrostatic character, but also for the existence of two structures, each one with another active oxygen.

A similar activation takes place when a molecule acquires an ion, as seen for the hydroxonium ion. Water can, under certain circumstances, bind a proton resulting from a hydrogen atom which has lost its electron. This bond is achieved through a valency bridge, and can be regarded as the fulfillment of molecular quantum forces. Different structures can be considered as resulting from the fixation of the hydrogen bridge in different positions in relation to the tetrahedral constitution of the oxygen atom. They help to give this bridge bond its high resistance.

### *Bonding of Molecules*

Electrostatic forces in radicals or activated molecules may be further balanced when new bonds are realized between entities with opposite electrostatic forces. Bonding of molecules having electrostatically excited centers may or may not be of chemical nature which is considered to correspond to changes in the structure of the molecules. More often, only a physical bond between molecules takes place, in which case there are no changes in molecular structure. Both types of bonding result in fulfillment of the electrostatic forces through a balanced neutralization, but bonding alone is not sufficient to establish a new entity. A new entity, with structural and functional individuality, apparently is realized only when quantum forces appear and establish definite relationships between the bonded constituents' molecules, placing them in certain positions and organizing their movements. The holistic concept emphasizes the difference between molecules or radicals bound only by the fulfillment of their electrostatic forces of general coulombian character, and the new entities resulting from the appearance of specific quantum forces proper to them. Here again, then, at the molecular as at the atomic level, progress in organization is achieved by alternate operation of electrostatic and quantum forces.

### *Polymolecular Formations* *

When an electrostatically active molecule or radical binds an electron, ion or even a small radical, the resulting entity is still considered a simple molecule. The group resulting from the bonding of several polyatomic radicals is a complex molecule. Like simple molecules, complex molecules also can group together and the bonding of several leads to still more complex formations, the macromolecules. In turn, macromolecules also can be grouped and the bonding of two or more produces polymolecular formation. Thus, organization progresses from simple molecules to polymolecular formations, first through the grouping together of similar entities. A

---

* All three terms—macromolecules, polymolecules and complex molecules—are chosen only for didactic convenience.

new entity appears when one of these groups binds a respective secondary part.

*Micelles*

A distinctive type of new entity results from the bonding of molecular formations with simpler constituents, such as ions or ionized molecules. To this type of entity we have applied the name of "micelle." * Polymolecules, macromolecules, complex molecules or even simple molecules can form the principal part of these micellar entities.

According to the above definition, micelles are entities formed by the binding of molecules, as principal units, to ionized molecules or ions, as secondary units. The latter originally were considered to be "impurities" until Duclay showed their important role in establishing specific entities. According to our concept, micelles are produced when grouped molecules and active impurities become bonded as the result of reciprocal balance of electrostatic forces and the alternate operation of electrostatic and quantum forces, seen for atoms and molecules, applies again. Fulfillment of electrostatic forces leads to appearance of quantum forces, this time proper to the micelles. The quantum forces maintain the micelle constituents in proper positions and govern their movements, described as vibratory for these entities. The operation of the quantum forces, together with fulfillment of the electrostatic forces, accounts for the stability of micelles.

The micellar quantum forces also can be fulfilled, leading to the appearance of unequal distributions of micelle constituents. The micelle then passes from relatively neutral to an electrostatically active form which can enter into further bonds, and it is primarily in further bondage that micelles appear in a reticular aspect.

In an overall view of the development of organization, from atoms to micelles, the relatively simple pattern of alternating operation of electrostatic and quantum forces can be recognized. The regularity of the pattern allows us to consider it as fundamental to the progress of organization. We have tried to go further and to recognize the existence of this same simple organizational system for formations below the atom and above the micelles. We tentatively conceived of subatomic formations being organized in the same manner, *i.e.*, by alternate operation of electrostatic and quantum forces. We will not go into this study here as it would lead us too far from

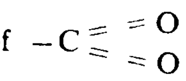
---

* It is to this type of structure that we apply the term micelle, as distinguished from various other meanings found in the literature.

the subject of this presentation. An outline of this subject is presented in Note 1.

### *Organization of Motion as Heterotropic Achievement*

An interesting aspect of the concept presented above is the influence of homotropic and heterotropic forces upon the motion of particles within the organizational framework. At-random mobility must be considered to be an attribute of entities free of any constraint, and thus corresponding to a homotropic state. Any change toward constraint, leading to a degree of immobilization, must be considered a heterotropic effect. The systematized mobility produced by quantum forces, which appears to prevent annihilation of opposing charges, accounts for the relative immobilization. While mobility itself is an homotropic attribute, its systematization is heterotropic.

The correlation of mobility with homotropy, and of fixation with heterotropy, appears basic. The process of uniformization which corresponds to homotropy appears to be possible only in the presence of a maximum of free mobility. The heterotropic systematization of movement can be seen at various levels of organization. Electrons in movement in the atom differ from electrons in movement in the environment through a systematization of their mobility, as they are constrained to follow definite patterns. The relative fixation of certain electrons—for instance, shared electrons—following the fulfillment of quantum forces also marks a further heterotropic influence. This also applies to radicals such as the carboxyl. In the formation of  $-\mathrm{C}\begin{matrix}\leqq\;=\mathrm{O}\\ \leqq\;=\mathrm{O}\end{matrix}$ the movement of electrons, in itself, is homotropic, while the limitation of movement between the two oxygens is an heterotropic effect. With the electron fixed in one position, bound to only one oxygen, a further step in immobilization is achieved and represents a heterotropic factor. In more complex molecules, such as unsaturated fatty acids, for example, the tendency of the electrons to wander is related to homotropy, while their restriction to the molecule or even to certain areas of the molecule represents an heterotropic effect. This also applies to micelles, where the water molecules and impurities have a certain degree of mobility. This mobility must be considered to be a vestige of the movement of free water molecules, with a high mobility considered as a homopolar effect at this level. The retention of water or other molecules in the micelle may be considered as a heterotropic effect. And their further fixation, as in the activated micelle, is a further heterotropic effect.

Organization, which results from the alternate operation of electrostatic coulombian homotropic and organizational heterotropic tendencies, leads to the realization not merely of stable configurations but, more significantly, to entities capable of reactivity, and consequently able to respond actively to the various changes of the environment. The fact that fulfillment of quantum forces causes appearance of new electrostatic forces, which will be further neutralized, leads to the progress of organization to ever-higher levels.

At each step of organization, however, another characteristic can be recognized. It results, in part, from the fact that progress toward higher entities is accomplished by an increase in complexity rather than only in size. The increase in the positive charge of nuclei in atoms, for instance, brings about a parallel increase in the number of surrounding electrons, but this goes on only up to a certain point. Actually, the size of the atoms is limited by the size of the nucleus which, in turn, is limited by the quantum forces able to insure stability for the nucleus. Nuclei become unstable when they contain too many protons.

### *Levels, Entities and Constituent Parts*

As already noted, we defined an entity through its structural and functional individuality. We used the term "level" to indicate a conceptual grouping of entities having the same basic constitution, such as, respectively, nuclei, atoms, molecules, micelles, etc.

We have used the term "part" to define an entity when it contributes to the formation of another entity. Nuclei and electrons are parts that form an atom. Molecules are parts when they are bound through electrostatic and quantum forces to form micellar entities. In progressive organization, each new entity thus is composed of parts which are entities from the level immediately below, and the new entity itself serves as a part for the immediately superior entity. We call this relationship "hierarchic," one entity being inferior to that which it forms and superior to those which have formed it. So conceived, each new organizational entity can be identified not only through the nature of the parts forming it and the manner in which they are bound, but also through its level in the hierarchic succession.

We have seen that most of the entities are made up of dissimilar parts. Analysis of what happens when an entity is formed has shown that the process is complex. In order for an entity to act as a part in a higher level, it must first pass through an activated stage. Activation opens up many opportunities, a plurality of possible formations. So does another process, an immediate consequence of activation. Almost continuously, several similar entities are seen to join together in a kind of "common grouping," adding further to the multiple possibilities of new entities. The multiplicity of possiblities at each step in organization explains the exponential increase in the number and complexity of the entities, resulting from the hierarchic pattern of their formation.

According to the holistic approach, an entity exists only through its own qualities. It must have characteristics other than those of its constituents. It is the relationship between the constituents, in the new entity, largely resulting from the operation of quantum forces, that characterize the entity.

### *Principal and Secondary Parts*

As noted, entities at progressive levels of organization are formed of dissimilar parts. These parts do not have equally important roles. There is a "principal" part which is characteristic for a given level. There are "secondary" parts that are nonspecific for the level, the same ones can serve at different levels. The secondary part for a hierarchic entity often is an entity of a far lower level. *(Fig. 1)*

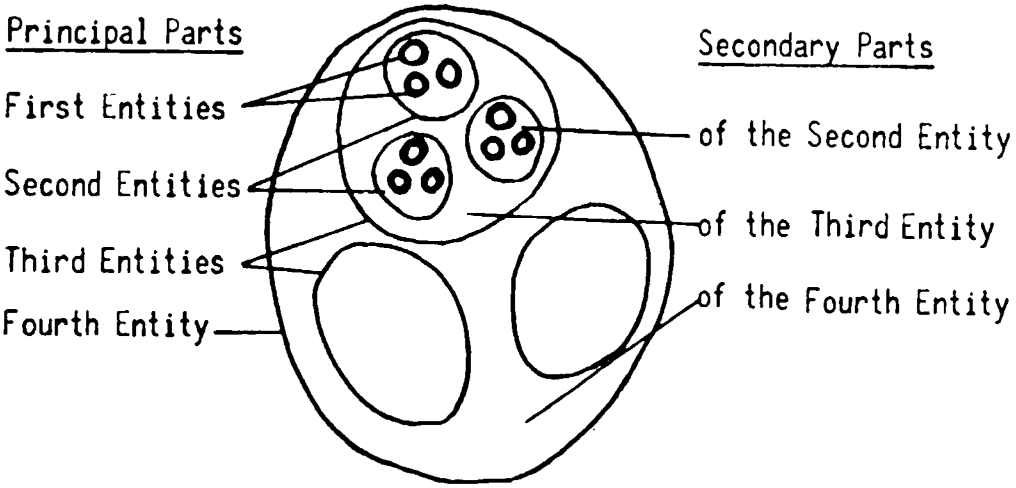


FIG. 1. *The hierarchic organization.* In the organization in general, the different entities appear interrelated according to a characteristic hierarchic pattern. Each entity is formed by a principal and a secondary part. An entity is hierarchically "superior" to the entities which form its principal part and "inferior" to those in the formation of which principal part it enters.

Secondary parts have important characteristics in common. These become especially evident when lower level entities are examined. At levels below the atom, secondary parts for all entities are electrons. It is of interest to observe that in higher entities as well, such as molecules or micelles, all secondary parts have a negative electrical charge.

Also characteristic of secondary parts is their derivation directly from the environment in which the entities of which they are components, appear. This is clear for many crystals, where water molecules represent the added secondary part. This water of crystallization is not free between the ions but bound to them. Water appears indispensable to crystal formation, since its loss results in disintegration. Water can be considered to play a secondary part. Similarly, in some crystals such as gold, some electrons wander between the atoms while others are concentrated in certain regions. (Brillouin) These electrons represent a secondary part in these crystals as do water molecules in others. Water and electrons can be related to the environment from which they derive.

Derivation of the secondary part from the environment appears to be even clearer at the micellar level. In the case of the gelatinous precipitate obtained by coagulating a colloidal solution, a part of the environment in which the gel is precipitated enters into the formation of the new micelle. For example, the micelle of colloidal copper ferrocyanate contains potassium ferrocyanate as a secondary part for each principal part of copper ferrocyanate. Micelles of ferric hydrate, obtained by the hydrolysis of a boiling iron perchloride solution, provide another example. Besides the $Fe_2O_3$, molecules from the $Fe_6Cl_6$ solution used in the preparation enter into the formation of this hydrosol. The role of the negatively charged constituents becomes apparent when a part of the cation of this secondary part is removed from the intermicellar fluid and the hydrosol still persists. It is only when the chloride content becomes too low that coagulation results. The molecules of potassium ferrocyanate or iron perchloride, once considered to be impurities, must be looked upon as secondary parts of these micelle entities. Derived from the environment, they enter into the formation of the micelles, especially through their negative electrostatic character.

This concept becomes of even greater importance when entities are considered in relation to the constantly changing environment. The electrostatic balance between entity and environment realized at any given time cannot be considered to be permanent because of the changes which occur in the environment as it travels toward ultimate total homotropy. As a working hypothesis, it can be assumed that the relationship between entity and environment would change as the latter moves toward total homotropy. It can be assumed, too, that as hierarchic organization develops in time, secondary parts from the environment would differ for different entities. Changes in environment would provide evidence that these secondary parts are related more closely to the environment as it existed in the past when these entities are assumed to have appeared. We will see below how important this is for the more complex entities of higher levels.

In the role played by secondary parts in progressive organization, the changes in their mobility are of special significance. We have already seen that in hierarchic entities the secondary parts are simpler units than the principal parts, a factor which facilitates their mobility. The mobility can be related to the fact that these secondary parts are derived from the environment where they are mobile, with their motion not systematized. The intervention of quantum and quantum-like forces, which help to create new entities, can be seen as a kind of organization of the relative mobility of the secondary parts. It is the systematization of their movement which prevents complete annihilation of electrostatic forces present. The relationship between secondary parts and environment thus explains the character of the mobility encountered throughout hierarchic organization.

It must be emphasized here that, because of the electrostatic nature of the bond between principal part and secondary parts, a principal part is capable of entering into the formation of more than one specific type of entity. Similarly, fulfillment of quantum forces can lead to more than one type of structure. However, of the many possible new entities, or structures, only a few will fulfill the requirements for developing a still higher organization, *i.e.* will be capable of acting as principal part in a new entity. Some remain at their original level without progressing, even after being bound to other entities. Even many of those which have some capability for higher organization can go only one or two steps. Only a very few will continue all the way up. In other terms, only a few will be able to utilize new quantum forces in order to realize new entities. While various bonds and structures offer a large variety of possible new entities, it is the entity with a capacity to adequately resist the effects of the changing environment which will take part in progressive organization.

In considering the forces which intervene in progressive hierarchic organization, one has to consider the free energy available in the environment. The immense amount of energy received from the sun represents a type of heterotropic energy which can intervene in organization. We will see that this is easily recognized for higher entities. The ability of certain entities to develop may be related to their peculiar ability to utilize heterotropic forces, most of them of solar origin. The less successful disappear or remain at lower levels.

### *The Organized Boundary*

We have seen that an entity achieved through systematization of the movements of its components acquires a boundary between itself and the environment as a result of this restricted movement. The boundary does much more than delimit the entity and constitute a barrier between it and the environment. The electrons of the outermost shell form the boundary of the atom, for example. It is through them that the atom realizes its relationship with the environment. Chemical reaction is largely limited to this boundary. In the atom, where the nucleus is the principal part, and the electrons are the secondary part, it is evident that it is the organized movement of the electrons that provides the boundary. The form and organization of electronic shells, and specifically of the boundary shell of an atom, are results of quantum forces. The environmental nature of the secondary parts and their buffering role make them of great importance in complex boundary formation. Theoretically, hierarchic progress may be considered to depend upon the development of secondary parts which allow increasingly complex boundary formations. This explains the importance we attach to the study of boundary formation in higher entities.

To summarize the above concept of organization, the different entities can be integrated into a hierarchic organizational pattern which depends upon alternate operation of the two fundamental forces, electrostatic of coulombian nature, and quantum of organizational nature. Entities can be identified by the nature of the inferior entities that act as constituent parts and the relationship between constituents as principal and secondary parts. While the principal part is formed by an hierarchically developed entity, the secondary part is a second entity from the environment. The incorporation of a part of the environment into a new entity corresponds to a systematization of its motion. And it is through the organized motion that appears a boundary formation which marks the realization of a new hierarchic entity.

This concept of organization has made it possible to understand the relationship of the series of entities that compose the biological realm.