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Development of Multicellularity: Social/Economic Aspects

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Abstract

This article describes a philosophy of an arising multicellularity on the basis of division of functions between cells. Laws of the division are discussed in elementary multicellularity units, called histions. There is a variety of the histions that have different social structures. Several parameters have been proposed to describe them quantitatively and to systematize them by means of a periodic table. Consideration is given to the rules that govern polymerization of histions as well as the formation of regular cellular networks using them. It is shown that these types of networks could serve as biological tissue models that enable one to predict the tissue development. It has been found that arising multicellularity can result in a drastically decreased metabolites production per cell and thus creates the need in their economically justified unequal distribution.

Keywords: evolution physiology, division of functions, multicellularity, cell sociology, measuring of development, cell network, spatial organization of tissue, cell economic

1. Introduction

It was found long ago that the cell specialization and integration (i.e., the division of "labor" between cells and/or the cells cooperation) form the basis for a multicellular organism development. On that ground, Virchow considered an organism as a cellular state and emphasized its social aspect. Later on, Chandebois [1] and Gass and Hall [2] discussed cellular sociology. Then, with the advances in genomics and proteomics, scientists [3] discussed molecular sociology. The problem of labor division was relegated to the background in subsequent theoretical researches which focused on the ensuing altruism and on its benefits [4–8]. Some experimental studies were devoted to specific mechanisms of the cell specialization/integration [9–12]. Even bioeconomics was suggested for studying economic aspects of development [13, 14].

But both social and economic aspects of the multicellular organism development due to the labor division have been understood rather intuitively and/or qualitatively, remaining unexplored so far. Therefore, many significant development features are still incomprehensible. For example, what laws of the labor division govern the organism development? Why does the development have such characteristic features as cycling, directivity, reiteration, and parallelism? How are potencies gained and realized? What kind of parameters could be used to measure a degree of development and to predict those results? How we could build mathematical models of natural systems in the form of a periodic table? Any answers to these questions are unavailable today. Accordingly, there is not any theory that would be able to measure and to predict development of organisms as well as to construct their non-genealogic natural systems.

We think that a formal description of labor division could be used as the basis for analysis of social/economic aspects of development and for the successful elaboration of their predictive theory, based on an abstract model of the elementary multicellularity unit as an example. It is common knowledge that a major breakthrough in the understanding of the phenomena under study often began from building those abstract models. The simplest cellular groups, which arise as the result of the functional division between cells, could be such kind of models, as applied to multicellular organisms, and these groups will be elementary multicellularity units. In our case, they are called histions [15]. To describe a histion development, we propose a formal language whereby some new encouraging results have been obtained [16, 17]. They are summarized below.

2. Basic concepts

Our work uses the following basic notions:

- list L of functions a, b, c, d,… to be divided;

- list of performers (cells designated as circles);

- potencies to divide functions;

- potency realization conditions; and

- the organism as a performer who executes the entire list L.

The basic concepts are outlined below:

List L of functions are to be divided wherein the functions are lettered a, b, c, d …. An organism can perform a function from the list L in three different regimes, such as:

1. Autonomous survival (AS), which is inherent in single-cell organisms. In this regime, we denote function performers by circles and functions—by small letters above the circles (see **Figure 1**, line *m*, wherein the cell is in column 0). All functions of that sort are fulfilled for themselves only by means of the archaic processing. Thus, they lack any potency to the division of functions.
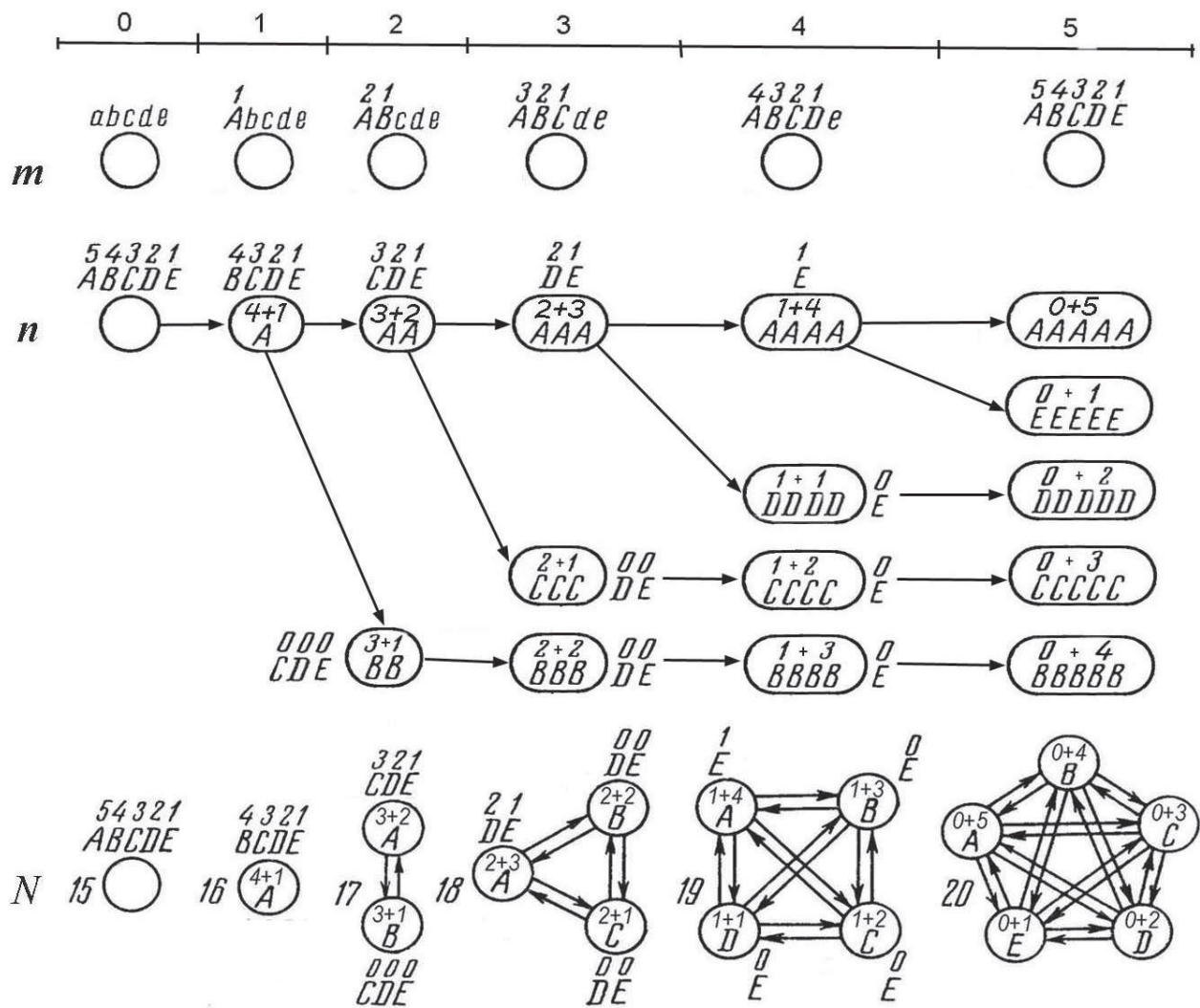
Figure 1. Schematic representation of elementary development acts. The upper line shows a growing number m of the functions that are gaining generative potencies and storing the sequence which is designated by numbers above capital letters. The middle line n illustrates realization of potencies based on the fact that the ancestor of the m = 5 line generates five daughter cells transforming them into more and more specialized ones. An increased number n of specialization acts leads to a rise in the cellular energidity (energeticity) which is denoted by the number of letters inside ovals. The lower line N schematically shows the cell specialization/integration stages and the formation of the simplest histions. The ciphers before histions indicate the total number N of their development acts.

2. Acquisition of potencies (AP): In this regime, some novelties are carried out which impart the division and specialization potencies to the functions, with the improved processing of them. In this case, we denote functions by capital letters above the circles and potencies—by numbers above the letters (**Figure 1** *m*). The number m of functions transferred into the AP regime is a significant parameter of development. A sequence of the transfer is fixed by the number of the gained potencies indicating a phylogenetic age of the function. These numbers represent an arithmetic progression of integers 1, 2, 3, …, *m*. The novelties lead to the appearance of an ancestor with *generative* potencies who is capable of giving a different-type offspring that is suitable to specialize in various functions.

3. Realization of potencies (RP): In this regime, an ancestor produces m daughter cells using a series of asymmetric mitotic cell divisions accompanied by transferring his own potencies to them (**Figure 1** *n*).

The arising daughter cells convert the obtained potencies into structural ones and become committed (or determined). The determined functions as well as those potencies are designated both by capital letters and by numbers within the circles (**Figure 1** *n* wherein the left and the right numbers designate non-realized and realized functions, respectively). The number n of the committed cell functions, that have obtained structural potencies, is the second significant parameter of development. It also defines the cell specialization degree varying within the range $0 \leq n \leq m$. The committed cells can realize their potencies via symmetric mitosis with the similar-to-themselves cells production as well as through specialization and improved processing of the function fulfillment. In this case, the number of function specialization acts corresponds to the number of the function potencies and appears to be variable. The same degree of the achieved specialization is provided for all functions by the fact that young functions get to specialize from a more and more differentiated state and perform the specialization with increasing numbers of partners.

The arising specialized cells integrate into histions by way of the metabolic cooperation and by the service exchange as well (**Figure 1**, *N*). Histions are elementary social units of multicellularity. Each change of function fulfillment conditions is the elementary act of histion development. Transitions AS → AP create generative functional potencies for the production of different-type specialists and well correlate with anagenesis. Transitions AP → RP convert these potencies into the structural ones and realize them *through* the cell specialization to correlate with cladogenesis. The cell integration as well as the composition and structure of histions are conveniently modeled by graphs, as shown in **Figure 1**. Therein, cells and functions are designated by circles and letters, respectively, and intercellular communications by arrows.

3. Quantitative characteristic of histion potencies

The potencies gained can be evaluated quantitatively. In this case, the basic function division parameters *m* and *n* not only permit the whole pool of potencies (the potenciom) to be found but also they make possible the division of these potencies into individual sorts. Besides, we may discuss the pool structure as well as evaluate pool changes in the process of development. The dynamics of potency variations has been analytically treated in [16, 17] and graphically shown in **Figure 2** (here values *m* and *n* were increased to 10 for clearness).

Clear regularities can be traced in tendencies to changing numerical relationships between different potencies for every *m* value. The intersection points of the curves that show the number of potencies divide a histion life cycle into five intervals. So, a projection of the first point of intersection on to abscissa (shown by the left broken line) limits a histion "childhood" period. The next point of intersection (shown by the left solid line) restricts a histion "juvenile" period. The interval between the two solid lines corresponds to the histion "youth" and is characterized by a maximum of non-realized structural potencies and, accordingly, by the best possibility for adaptation. The point of intersection of non-realized generative potencies
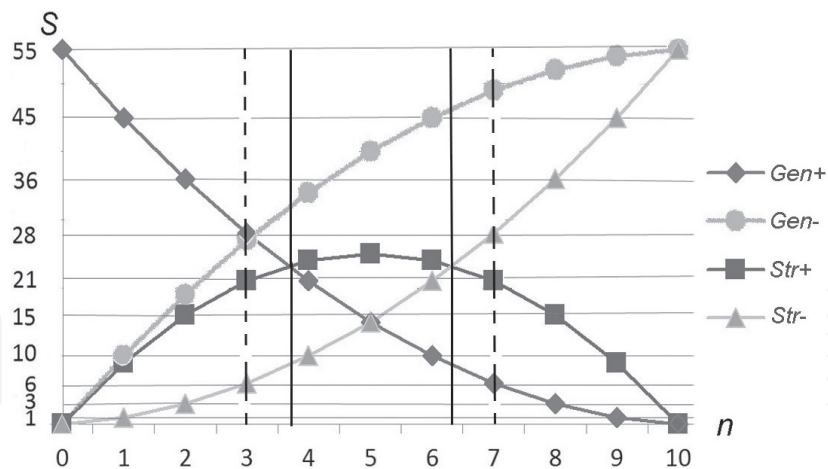
Figure 2. Variation of the number of generative and structural potencies in developing the m = 10 histion. Here the quantity n is laid off as abscissa and the number S of potencies as the ordinate. Gen + and Gen − are the numbers of non-realized and/or realized generative potencies, respectively. Str + and Str − are the numbers of non-realized and/or realized structural potencies. The left broken line is drawn through the first point, thus limiting a "childhood" zone (i.e., a cycle phase, rich of generative potencies and poor of structural ones). The left solid line is drawn through the second point. Both lines restrict a "teen-age or juvenile" zone (a phase with the lesser number of generative potencies but with the increased number of structural ones). The third (central) point bisects the life cycle. The right solid line is drawn through the fourth point. Both solid lines bound a zone of the adaptive maximum or "youth" (a cycle phase with the maximum number of isotopes and nonrealized structural potencies, as well). A cycle zone laying between the right solid line and the broken line corresponds to the phase of the histion "maturity," wherein the number of realized structural potencies is high and a stock of non-realized ones is diminishing but remains therewith pretty high. In addition, there are the rest of non-realized generative potencies. Further to the right, a zone is situated that corresponds to the "old-age" phase when the histions have realized all potencies, thus losing their plasticity and environmental sensitivity, whereas their regeneration capacity and adaptability are minimized.

and realized structural potencies divides the life cycle in two. Spacing between the right solid line and the broken line corresponds to the histion "maturity." The "old age" and the end of the cycle lie farther to the right.

Thus, the explored dynamics of potencies for the first time puts forward quantitative criteria for the life cycle division into the five periods (that had long been understood by intuition only), such as: "the childhood," "juvenile" period, "youth," "maturity," and "old age" and marks those initial and end points.

4. Law of conservation of histion potencies

The above-described dynamics of potencies enables one to come to the following important conclusion: The total number S of all histion potencies is dictated in every histion family by a value of parameter m (or by the number of functions available in the AP state). Hence, S varies only as parameter m changes, remaining unchanged with m constant. This concept is valid as a governing law in application to the "labor division" procedure. We can now state the law as follows: In the development of histions, the total number of potencies remains constant at any value n, but the ratios between generative and structural potencies and/or between realized and non-realized potencies are variable. This law is graphically shown in **Figure 2**.

Two important consequences follow from this law: The first one is that the development is bound to be cyclic because it has its own start (a universal ancestor with non-realized potencies) and its end (when all of the potencies have been realized). The second consequence is that any histion development inevitably involves a division of cells into stem cells and non-stem cells for the following reason.

In any development cycle with constant m, the proportion of non-realized generative potencies decreases and the number of specialized histion cells grows. As a result, there comes a time when there appears a shortage of potencies for all cells. This occurs in the point of intersection of two curves: one corresponding to the number of realized potencies and the other to the number of non-realized generative potencies (**Figure 2**, left broken line). Beginning with the moment of the passage through that point, a share of the arising specialized cells (the functions of which will have generative potencies in the AP state) will decrease. In **Figure 1**, such functions are denoted by capital letters with digits above them. Cells having such functions will be the stem cells. Yet, most of the arising cells have functions that remain without generative potencies in the AP state. In **Figure 1**, they are denoted by capital letters with 0 above them. Cells of this sort become the working cells that are capable of generating alike descendants only. Therefore, the law of conservation of histion potencies for the first time offers a simple explanation of the cyclic development as well as of the causes for the division into stem cells and specialized cells.

5. Evaluation of the progressive histion development

An integral measure N of the histion progressive development is to be found using parameters m and n that can be tested experimentally. As such a measure, the total number of development acts, can be taken, whereas N will be composed of two terms, such as: a sum S of all function potencies and the number n of the specialized functions realizing structural potencies, as follows:

$$N = S + n, \text{ or } N = \tfrac{1}{2}(m + 1)m + n \tag{1}$$

For the histions in **Figure 1**, N is shown in front of each of them. This quantity can be easily determined from histion structures. It is also possible to solve the inverse problem, that is, to define both m and n and a structure of a histion from N value [15, 16].

I shall note that up to now, there has been no convenient parameter offered to evaluate the progressive development. We were fortunate to discover it owing to the formal description of the labor division only. It has been suggested to name the offered unit *(N)* of progressive development as *Lamark* [16, 17].

So, *m* and *n* parameters not only make possible a quantitative dynamics description of potencies but also they allow a measure to be found for evaluating their progressive development. However, our description is a theoretical one so far. Testing of the predictable dynamics of potencies shall now become an important challenge for experimental biology of development.

6. Development rules

Division of functions between cells is governed by a set of simple rules or postulates [15, 16]. Several examples of such rules are cited below:

1. Every histion cell is provided with a chance to fulfill any function from set L. Only function fulfillment conditions are variable.

2. Every cell can specialize for fulfillment of any single function only. In this case, n parameter will indicate the number of the cell types involved in the histion.

3. Histion cells are equal in the number of partners.

4. Integration of partners is always mutually beneficial and so on.

These rules may be modified to take into account different environmental conditions and to obtain histion families with varying compositions and social structures [16, 17].

7. Law of periodic histion development

By analyzing the above development rules, we have found that there exists such a combination of rules which can be characterized by a law of periodic histion development stating: The histion composition and structure repeat periodically as the total number N of development acts increases.

Thus, we can classify histions using a periodic table by arranging them in ascending order N and combining the same m-value histions in a row and the same n-value histions in a column, as shown in **Figure 3**. This table gives us an idea of a multitude of directions available for a cell specialization as well as of their relationship variants, that is, of the histion social structure.

The parameters of this table have a biological significance and are suitable for a quantitative analysis of progressive development. Thus, that row number m indicates the number of functions in the GP state while the column number n indicates the number of functions in the RP state. The number N that is cited in the upper left-hand corner of a table cell indicates the total number of histion development acts. In addition, every table cell contains the number H of isotopes which differ in their cell compositions. So, an isotopic coordinate appears and the table becomes three dimensional. The H value is equal to the number of combinations of m elements taken n at a time that is cited in the lower left-hand corner of a table cell. Within each table row, the number of isotopes gradually increases, then it reaches a maximum in the middle of the row (area corresponding to the adaptive maximum zone), and is minimized again at the end. That forms the basis for the divergence in the beginning of the development and for convergence—in the end. The table, which is formally based on the Pascal's triangle, serves as a natural parametric system of histions, demonstrating their megaevolutionary variability. A histion position in the table uniquely determines all the properties of a histion which is also inherent in natural systems [18]. The proposed table offers certain advantages over any options built on other, rather intuitive, grounds [19].

Figure 3. A periodic table of histions with different kinds of the function divisions between cells. Cell 0 of the table contains an independent wide-ranging single-cell organism lacking any potency and performing all functions (denoted by small letters) for himself only. A table row № (m) shows the number of the functions having potencies acquired for specialization. A table column № (n) indicates the number of specialized functions (denoted by capital letters inside a circle) and, correspondingly, of specialized cells. The number of non-realized and realized structural potencies is indicated by left and right numbers cited above letters in circles. The number placed in the upper left-hand corner of the table cell denotes an ordinal number N of a histion. The number in the lower left-hand corner of the table cell is the number H of isotopes varying in the composition of specialized functions but having the same N. The numbers located in the right part of the table cell display from top to bottom the numbers of non-realized and realized generative potencies as well as the numbers of non-realized and realized structural potencies.

The periodic table includes all histions that are possible in the framework of the adopted rules of development. The development itself can be represented as the histion's advance on table columns and rows and along the isotopic coordinate, as well. For example, when moving down the columns, the acquisition of generative potencies occurs, while in moving on the
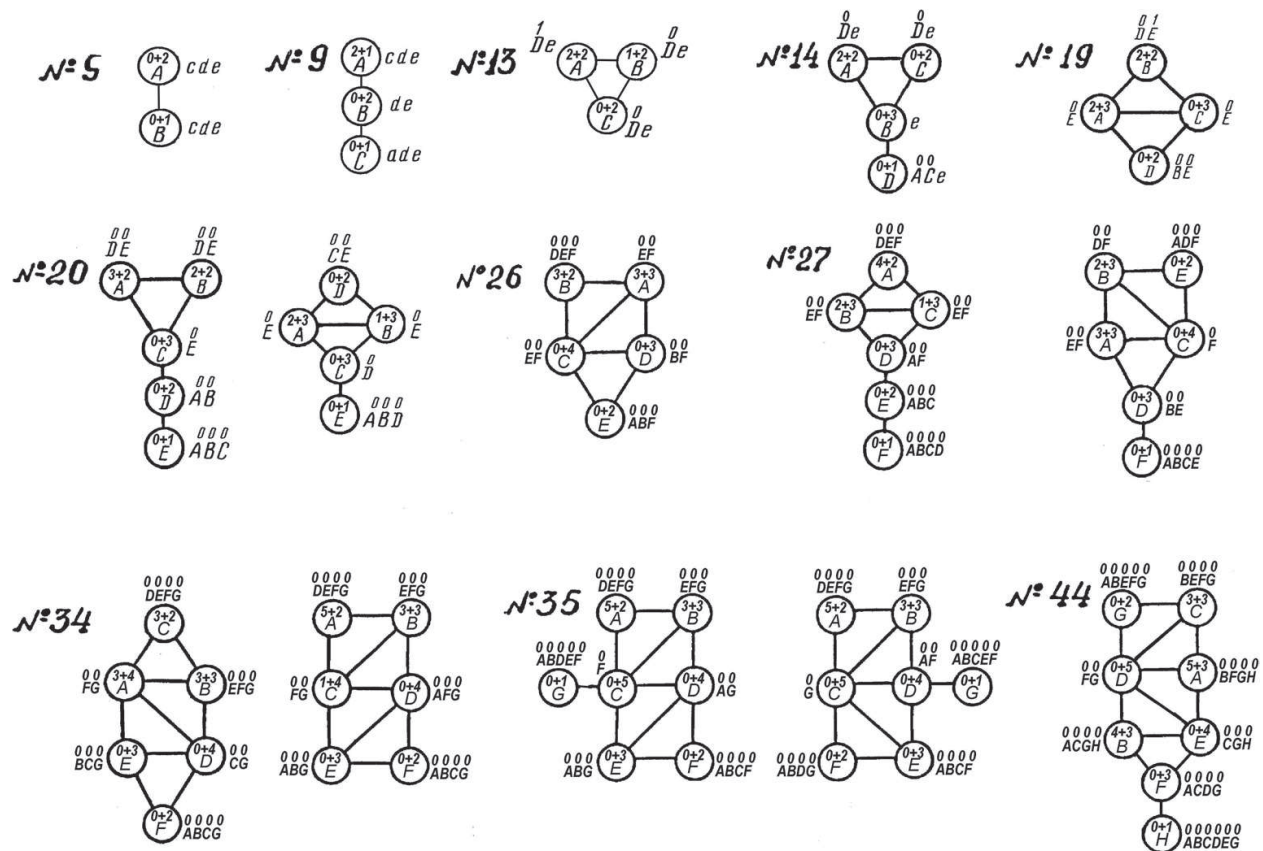
Figure 4. Some examples of coincidence of monomeric histion structures with the spatial organization of cleavage of *C. elegans* in the development. Here, histions are simplified, their numbers agree with those shown in **Figure 4**. Real photographs of the cleavage have been taken from the internet resource http://Wormatlas.org. A—Founder cell; P—Stem cell.

rows to the right, their realization occurs in the progressive development, just representing the histion's macroevolutionary variability. When moving along the isotopic coordinate, a search of isotopes is carried out in the deviant development.

The above-described ideas accord well with the existing knowledge of the basic laws of multicellular organism phylogenesis. Versatile, full of potencies, single-celled ancestors of all subsequent histions are placed in the zero column of the table. When moving along the rows to the right of the table, these potencies are being realized by way of increasing the number of specialized histion cells at the expense of asymmetrical mitosis of the cells' ancestor. Within each line, the depletion of potencies leads first to the isolation of stem cells and then to the completion of the histion development cycle. To ensure the histions' survival, their positions in the middle of line (i.e., within the zone of adaptive maximum) and approaches to it via microevolution shall be the most advantageous ones.

Any continuation of further development as well as the approach to the right end of the line leads to the loss of all specialized members of the histion. Thereby, it causes reverting into the single-cellular state, an additive increase of the number of generative potencies, and the transition to the beginning of the next line. Then everything is repeated again. Thus, the histion development is characterized by such features as: finiteness, directivity, attainment and loss

of diversity, parallelism, and repeatability. The same properties are typical for the development of real biological organisms in different taxonomic categories. Therefore, the proposed table serves as a model for building natural systems of real organisms.

As mentioned above, a set of rules may be modified so as to allow the development of histions in variable conditions. For example, when canceling the rule of the equal number of partners for each histion cell, the existence becomes possible of such a set in which the number of cell partners depends on the number of their structural potencies. The reality of such histions is verifiable. Since a direct observation of histions is possible but early in the development (at the cleavage stage, when they exist in the monomeric form), a correlation has been studied between histion models and spatial organization versions in the development of blastomeres (**Figure 4**, such a correlation shows a good agreement of models with the reality).

Other examples were reported earlier [15]. These results confirm the validity of the histion theory. Thus, histions are a new object of developmental biology. They represent an independent and the so-far overlooked level of the biological organization between cells and tissues.

8. The formation of cellular networks

In organism development, a monomeric state of histions is quickly replaced by their polymerized state. This view gives a clue to the elaboration of a predictive theory of biological tissue structures. The basis for this theory is the proposition that it is histions, and not the cells, as such, that are the elementary morphofunctional units of tissues. This understanding is justified by the fact that most of the tissues consist of several, rather than of one, types of cells. We can assume that tissues are the result of polymerizing histions and represent one-, two-, or three-dimensional cellular networks. The regularity of networks can be considered as a manifestation of the histion structure of tissues. Such networks reflect sociology of tissues and characterize tissue properties. Network structures give us information on variants of three-dimensional organization of tissues. However, modern experimental histology does not have any effective methods for studying the three-dimensional structure organization and remains two-dimensional histology. Unfortunately, the existing mathematical theory of the structure of biological tissues [20, 21] fails to put forward the needed set of models. This is why tissue engineering lacks any scientific basis up to the present.

A notion of histions has given insight into a theory of spatial organization of tissues providing a new effective approach to the study of tissue structures [15]. So, based on the known histion composition/structure and using histion polymerization rules, it is possible to calculate a variety of cellular network structures. The cellular networks may be conceived as geometric and topological models of the spatial tissue organization. A set of such models allows one to predict a tissue development and then to experimentally find its histoarchitecture unknown earlier.

So, it has been shown that for a two-dimensional case (single-layer epithelium), the existence of 11 regular models is possible for the cellular networks known as regular parquets of Kepler. We have already found nine of the models in real tissues and predict the detectability of two more [15].

For a three-dimensional case (multilayered tissues), a family of regular models has been constructed too. Using such models in computer simulation by means of special programs, Gistoarkh and Gistored give the chance to animate and visualize cell shapes and their interrelation in the layer space. With the help of the constructed models, any reconstruction of three-dimensional structures of multilayered tissues is reduced to comparison of their cuts with the sections of the models followed by the choice of that from them which well corresponds to reality.

Reconstructing cell shapes and cellular network topologies has been carried out by this method for a number of integumentary and sensory epithelia [15, 22, 23]. At the same time, the reconstruction requires less cuts while the accuracy attainable allows us for the first-time determination of tissue topologies and those variations in development. Regular structures, translational symmetry, and stoichiometric composition are typical for all cellular networks. Also, it has been shown that changes of cellular networks in development are comparable with phase transitions. At the same time, various defects giving some additional properties to tissues are also typical of such networks [24]. By way of illustration, let us compare three tissue models (such as cellular mosaics, a network, and a histion) with the real tissue structure in order to see how the tissue models correlate with it (**Figure 5**).

From this analysis, it can be concluded that further studies into tissue structures should be focused on the elucidation of the composition and structure of their cellular networks and of
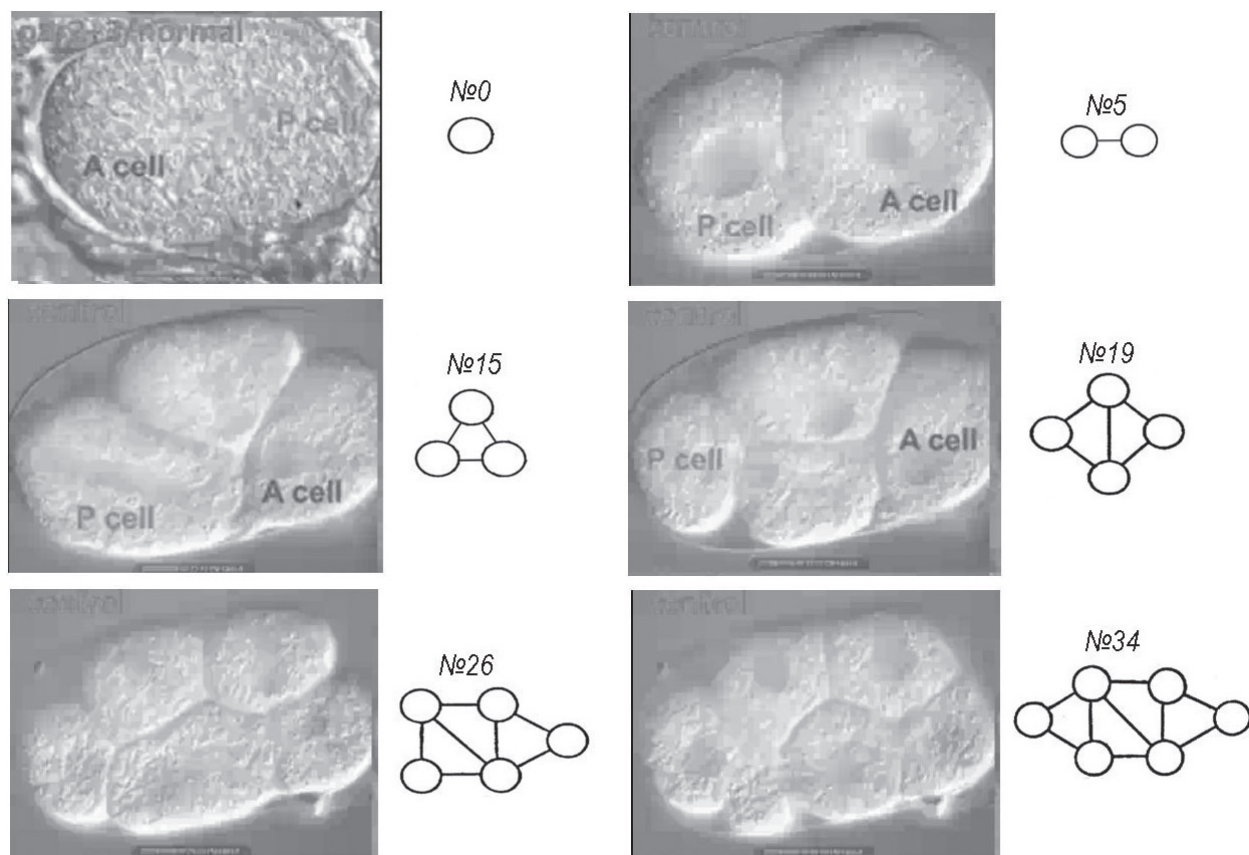

Figure 5. An example of coincidence between the real AB_2 tissue structure (the auditory epithelium of the cochlea of birds) and its model as cellular mosaics, a network, and its histion. Hair cells are dark, supporting cells are light.

histions, as well. The use of such models drastically improves the performance of exploring the spatial organization of the real cell layers. The analysis of networks opens a new line of investigation into the structure of biological tissues. It is of interest to study predictability of their changes both in development and in disease. Moreover, such an approach would become particularly important and promising for tissue engineering. Parameters of cellular networks could serve for these purposes as new diagnostic signs.

9. Economic results of the multicellularity development

The division of labor and the technological progress can lead to ever-increasing productivity and consumption of goods per head. From the times of Adam Smith, just the same result of development was considered normal and preferable in the human community. However, this is not true of the development of multicellular organisms. Despite the fact that the division of functions between cells can, in principle, cause the consumption and production of metabolites per cell to increase, that idea could be implemented in the early stages of development only. So it failed to be widely used later on because a limited number of niches and the biosphere as a whole as well as the unlimited ability of organisms and cells to reproduce themselves ultimately lead to the permanent deficiency of available resources. As it was noted by Malthus, the permanently improved economy of the multicellular organism vitality has become one of the major trends in the organism development. This is one of the fundamental laws of development [25]. In this case, the number of metabolites produced per cell materially decreases. For example, compared with the original single-cell organism, the specific (per cell) production and consumption of metabolites in animals with a body weight of about 100 kg goes down to 10 times and even to 100 times less—in large animals, even more.

And how did the cell need change therewith? To evaluate them, the following should be emphasized: the versatility of the basic molecular mechanisms, such as: cellular bioenergetics, reduplication, transcription, and translation, enables the single-cell organism to spend for synthesizing 1 g of DNA, RNA, or protein as many macroergs of nitrous bases and of amino acids as the higher organism cells spend. Thus, reproductive needs of developing cells remain practically unchanged. In contrast, the needs of cells for performing specialized functions decrease regularly in development. Growing specialization and the accompanying bioengineering progress have made possible the economy's improvement of many processes associated with environmental adaptation, searching for food, and the production of metabolites.

If we compare the metabolites' productivity decline with the constancy of reproductive needs, we shall see that the quantity of metabolites produced in an organism is insufficient to provide reproduction of all cells. This means that the percentage of the cells capable to reproduce themselves is bound to decline. This can be accomplished by a number of measures. Firstly, this is ensured by the very structure of the periodic table because the law of conservation of potencies as well as the depletion of potencies sets a limit to the number of cells involved in the development. Secondly, this is provided by the function order in the development. So a resource-consuming reproduction function is among the first involved in the development. Such a measure causes division of an organism into the reproductive system (constituting the least part by weight) and the soma that is the largest part of the organism. Therewith, the reproductive system is supplied according to a high reproductive norm, whereas the soma

switches over to a more economical regime of the specialized vital activity. Thirdly, the soma also generates two different size populations of cells. The smaller one consists of the stem cells and of the fissioning committed cells that are relevant to the beginning of table rows. These populations make up cambia (the local reproductive "incubator" zones) and they are supplied according to the high reproductive norms. The majority of cells are non-reproducible (or working) cells and they are related to the ends of table rows, say much like keratocytes or nucleus-free red blood cells. The supply norms for these kinds of cells are substantially lower. In response to the above-described measures, a share of reproduced cells regularly decreases in the organism development (from 100% at early stages down to less than 1% in the grown-up individual). Obviously, the realization of these measures was accompanied by changing development rules. For example, rule number 1 is no longer applicable to all the cells of the body.

In order to separate various systems and populations according to their blood supply levels, the organism had to work out different physiological compartments in the form of various anatomical organs. Further, to provide uneven blood supply to different compartments, the organism has formed a system for providing both a separated blood supply and a selective uneven distribution of metabolites as the saying is "Some feast, and some fast." The non-uniformity is graphically shown in **Figure 6** using the Lorentz's diagram where the hatched area can be a quantitative measure of divergence between the uniform and the real blood supply to different organs [15].

Therewith, the organism imposes a ban on the free migration of most working cells between compartments. The above-discussed complex of measures enabled the organism to essentially decrease productive consumption expenses per cell and thereby to increase the organism's economical efficiency.

Thus, a non-uniform distribution of metabolites is vitally important for the existence of a developed multicellular organism. From the Lorentz diagram, a trend becomes clear of a spontaneously proceeding process caused by various damaging factors. Such processes are focused on leveling a distribution of metabolites (**Figure 6**, the arrow and the dotted line). That is, the rich
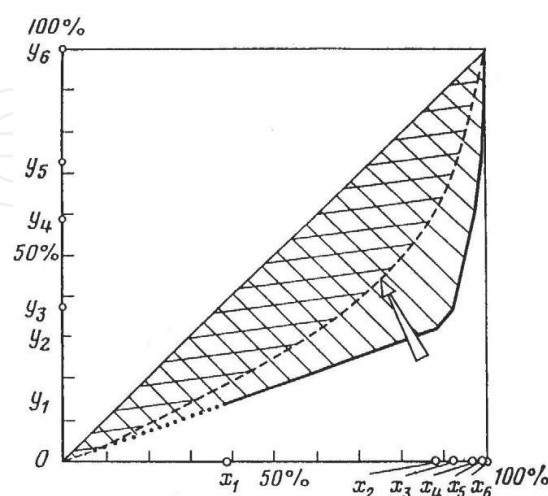

Figure 6. Unequal blood supply of different organs and tissues represented as a Lorentz diagram that is built using the data obtained by Folkov and Nil, after [15]. OX: Percentage of the total weight; OY: Percentage of the total volume per minute. x_1 and y_1—Bone, adipose and/or connective tissues; x_2 and y_2—Skeletal muscles; x_3 and y_3—Skin; x_4 and y_4—Digestive apparatus; x_5 and y_5—Brain; and x_6 and y_6—Heart. The arrow indicates a development trend of spontaneous processes which decrease inequality of distribution.

will grow poorer, while the poor will grow slightly rich. The redistribution of metabolites can be revealed in various kinds of pathologies, such as atrophies and/or inflammations. But if such redistribution is carried out in combination with the redistribution of potencies, it can reveal itself as an uncontrollable increase of some kinds of cells followed by their arbitrary settling down in different compartments (organs). This effect takes place in the malignant tumor growth with metastasis. Full equalization of metabolites distribution corresponds to the death of the organism.

So, to be able to survive at scarce resources, multicellular organisms had to take a number of measures, such as:

- the caste division of cell populations into those having potencies for developing and those lacking them, when the reproduction is not allowed for most cells;

- non-uniform distribution of metabolites;

- forming of special "incubators" for carrying out a controllable centralized production of just as many specialized cells as it is required to conform to the vacancies available;

- regulated choice of a profession; and

- a strict ban on the free migration of most working cells.

And these measures have made it possible to get the overall result of the progressive development including technological progress and improving of the vital activity economy.

10. Conclusion

Division of functions between cells generates a multicellular organism with its inherent sociology and economy, wherein there is no room for the equality of cells. These developmental aspects have their own mechanisms and are regulated according to their own laws, unknown so far. They should become the subject of a special study. Within the framework of the study, it is necessary to tackle such problems as:

1. determination of L, m, and n parameters which are inherent in multicellular organisms;

2. elucidation of mechanisms and of the sequence of obtaining both generative and structural potencies and of their realization, as well as the determination of the number of the potencies and of those dynamic changes in development;

3. investigation into monomeric histion compositions/structures and construction of their parametric systems;

4. investigation of cellular networks and elaboration of three-dimensional histology;

5. quantitative analysis of metabolites' distribution in a real organism.

The resolution of these issues will become a step forward to the development of a nomogenetic theory that would allow not only modeling but also measuring of the multicellularity development (both in norm and in disease). Also, this would enable development to be controllable thus providing the scientific basis for tissue engineering and regenerative medicine.

Acknowledgements

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