

Instytut Biologii UMCS
Zakład Ochrony Przyrody

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On Some Terms and Concepts Proposed by the Author in the Field of Phenology

O niektórych, proponowanych przez autora, pojęciach i terminach w dziedzinie fenologii

О некоторых, предлагаемых автором, понятиях и терминах из области фенологии

*In Memory of N. P. Smirnov,
phenologist and philosopher.*

Listing some of the terms and concepts in the field of phenology that the author has worked out seems purposeful for the following reasons:

- 1) they are distinctive contributions to the theory of phenology which has not yet been adequately elaborated;
- 2) they contribute to the theory of ecology, physical and regional geography and environmental protection;
- 3) they border on the concerns of an entire complex of biosphere sciences;
- 4) they are a personal summary of the author's many years of phenological research.

The materials presented are excerpts, usually in a near verbatim manner, of my previous publications. In many cases the contents of particular concepts and terms "overlap", mutually tie in. Introducing precise boundaries between them would be impossible for meritorial reasons. This fact would seem justified if we take into account a fundamental truth: on the one hand the unity of life processes and the artificiality of all attempts to pigeon-hole them on the other.

Below are given the names of the concepts, terms and formulations to be discussed with the notation (in brackets) of the number of the position in the literature from which it has been taken:

1. The definition of phenology (3, 4, 4a).
2. "Phenological clocks of the biosphere" (10).
3. "Phenological accords" (1, 8, 9) and "Leading notes" (1, 2, 8, 9).
4. "Isophenotopes" (11).
5. "Phenological cross-sections" (5, 6) and "Complex isophenes" (8, 9).
6. "Phenological whorls" (7, 8, 9).
7. "The phenological fan" (8, 9).
8. "Phenological beats of the biosphere" (8, 9).
9. "The phenological maturity of the environment" (7).

THE DEFINITION OF PHENOLOGY
(PROPOSALS FOR A NEW UNDERSTANDING)

Phenology is a science about seasonal changes affecting the material unity of phenomena in organic and nonorganic nature in the yearly cycle (4, 4a).

What kind of attributes does the definition have? — 1) it relies on relations in nature as they actually are, where live plant and animal matter, as well as all the factors from the nonorganic environment intertwine and interpenetrate each other; 2) it eliminates a certain dualism that encroaches on the understanding of natural phenomena, when we speak e.g. of the “dependence of the organism on the habitat”. This expression suggests that the organism exists somehow separately as does the habitat, and that the latter influences the former from the outside in some way. In reality the habitat penetrates the organism in various ways, penetrates it, due to which the organism is “saturated” by the environment like a sponge is by water. It seems we can speak of the environment as of veins, arteries and capillaries in the body of the organism, which along with the actual blood vessel and other organs create one “joint-vessel” system of a given geographical-natural habitat. Upon examining the biology, ecology and etiology of organisms, we realize it is impossible to separate the “veins and capillaries” of the habitat from the actual veins and capillaries. It suffices as an example to mention the effect of increasing light and the lengthening day on the activity of the pituitary gland in birds, the influence of temperature on the maturing of their reproductive organs, as well as the effect of these factors on the whole of the above-mentioned organism.

Phenology is a science of the seasonal rhythmicity of nature (3). Commentaries on the above (accepted by some phenologists) definition: The “condensed” in the progenitive elements, primary rhythm, afterwards developing and externalizing itself in certain phenological phenomena is the concave and convex sides of the same phenomena. The primary rhythm causes and shapes the secondary rhythms; conversely, secondary rhythms cause and shape the primary rhythm. Thus it is like the wave motion of the incoming and outgoing tide, the process of the winding and unwinding of the same spring. Since organisms in nature are not made up of unconstructed communities but of highly organized living communities (biocenosis, physiocenosis), the unwinding and winding of the springs (organisms) is the result and reflection not only of the present individual qualities of the species, but is also the reflection of its historical adaptations in a particular complex on a given surface.

Attention: In the above definition the word “rhythmicity” of nature could be replaced by the word “pulse”; it is correct in the sense that it suggests the necessity of dealing with all phenomena in nature in a more biological manner: examining nature as the great organism with individual organs and tissues (7).

“PHENOLOGICAL CLOCKS OF THE BIOSPHERE”

The concept “phenological clocks of the biosphere” was borrowed from the concept of “physiological clocks” (Erwin Bünning 1958¹). It has already been accepted by science in reference to the daily rhythmicity of physiological processes in plants and animals. It seemed natural to the author to adapt and transpose the “clock” concept to the group of sciences dealing with environmental biology and name it “phenological clocks of the biosphere”. The theoretical signals for this concept would be as follows:

1. All natural phenomena are related to each other with all sorts of dependencies in time and space; that is to say, not only historical time but also actual, daily and yearly. They are thus a function of the chrono-spacial systems of the biosphere, rhythmically changing among other things also in the yearly cycle.

2. Since the process of consecutive changes coming about in the yearly cycle of nature can be empirical with the functioning of a clock, it is also possible to speak of “phenological clocks of the biosphere” indicating its phenophases in certain systems. The role of indicators in such clocks would be played by certain leading phenomena.

The strengths of the discussed concept:

1. The concept shows the biosphere, especially the landscape, as one live organism, marked by a pulsating rhythm. It would suggest research directed in such a way.

2. It is a simplified concept, but it manages, however, to give in a synthetic way, a whole range of problems entailed in it and concerned primarily with the seasonal rhythm of the ecosystem.

3. It is a concept that integrates the interests of a whole complex of biological and geographical disciplines.

The significance of research on “phenological clocks” (only the most important aspects shall be presented here):

1. One of the characteristic features of the geographical habitat is its seasonal rhythm; thus, learning its “phenological clocks” ties in directly with researching the landscape biology.

2. Studying the “phenological clocks of the biosphere” could play a prominent role in biogeography, diverting it from its currently predominant interest in researching the rules governing the location of plants and animals on the face of the earth towards the study of the life of geographical-natural habitats in their yearly pulsations.

3. Such research would also play a significant role in bioclimatology when we take into account the basic fact that phenological phenomena are an excellent indicator of the bioclimate.

¹ E. Bünning: Die physiologische Uhr. Springer Verlag, Berlin-Göttingen-Heidelberg 1958.

4. "Phenological clocks" show live nature in a particularly suggestive manner as a mysterious web of mutual conditioning. As we know, destroying this web leads to disturbances in the homeostatic systems, which in turn is the source of one or another ecological catastrophe. As such, studying these "clocks" can give us much valuable material for the theoretical principles of environmental protection as a science.

Nor should we omit the role of this concept in shaping a broad wholistic view on life and nature, which is especially important in teaching biology and geography today, endangered by advancing specialization with ever greater particularization and atomization.

"PHENOLOGICAL ACCORDS" AND "LEADING NOTES"

Not one of nature's phenomena exists "of itself", but always in a complex particular to itself. This complex conditions and shapes the phenomenon on the one hand; on the other is itself conditioned and shaped by particular factors making up the phenomenon. Thus in nature we have no "unisons", only "accords". Motion, progress in nature is not the succession of single sounds (unisons), but accords (1). During the yearly succession of these accords the character and essence of the relations between particular components of the accords are changed. These changes are the concern of phenology, especially synphenology, which is interested in studying complexes of phenological phenomena.

If we know the structure of an accord and on the basis of its recurrence in various years, on the basis of one or a couple of its "notes", we can deduce the sound of the whole. Such notes should be termed "leading" or "signal" (2).

"ISOPHENOTOPES"

For areas homogenous in biocenotic structure as well as in phenological complexes, we shall propose the term "isophenotopes". This term shall signify a greater or lesser fragment of the biosphere, characterized by identical or nearly so phenological complexes (accords), preserved in various contexts of the geographical habitat. The main difference which would differentiate particular isophenotopes would be their varying rates of coming into being and duration. In contrast to "isophenes", thus, which are lines joining places of identical time of a particular phenological phenomenon, isophenotopes would reflect entire expanses of identical or nearly so complexes (accords) of phenological phenomena, which are able to take place at extremely varying calendar times. The essence of isophenotopes is directly related to and is a consequence of the

proposed concept "isophene complexes" (8, 9), depending on the law of synchronization of phenomena in nature, reflected in the form of phenological accords.

"PHENOLOGICAL CROSS-SECTIONS" AND "COMPLEX ISOPHENES"

In biological and geographical sciences, the formulation of phenology which researches the yearly pulse of nature's various ecological-geographical systems as organic units is a chapter which is very poorly written to date. This is also connected with the paucity of the theory of phenology's elaboration. The methodology of the related research can be reduced to mainly carrying out "phenological cross-sections" throughout the habitat. The theoretical premises and ways of utilizing these "cross-sections" are as follows:

1. Phenological phenomena do not occur in nature in the form of unisons, but in the form of accords. The seasonal succession of phenomena in the yearly cycle is thus a succession of accords.

2. Phenological cross-sections through the habitat would thus give a picture of these accords, in other words the whole complex of synchronic phenological phenomena. They would indicate the phenological state of the researched habitat.

3. Aside from plants, the cross-sections would take into account mainly insects and birds because of the following advantages: a) a distinctly demarcated seasonal periodicity, b) their commonplaceness in many habitats, c) their aspectual occurrence in certain phenological seasons, d) their meaning in the life of natural and artificial biocenoses.

4. The first place in phenological cross-sections should be taken by signal phenomena, i.e. characteristic of a given phenological season, ecological habitat or landscapes.

5. Before starting to carry out a phenological cross-section, the locality should be divided as precisely as possible into its constitutive elements represented by particular habitats. Thus there arises the necessity of making a preliminary isolation of an environmental mosaic in the case where a locality is not homogenous.

6. The frequency of conducting phenological cross-sections must be adapted to the problem we wish to solve, to the concrete question we wish to answer by the help of this method. It is to be understood that the more comprehensive and precise a picture of the seasonal changes in the biocenoses and physiocenoses we wish to obtain, the more frequently such cross-sections must follow one another. In every case, however, it would be advisable to connect them with some kind of phenological stages which are turning points for the whole habitat ("developmental thresholds"), i.e. the disappearance of snow from

the ground, the foliation of trees, the large scale blooming or fruition of certain plants, etc.

7. The registration of phenological accords and their yearly succession, making-up, as has already been discussed, the basis of phenological cross-sectional methods, is the first, irreplaceable methodological step. The most interesting and significant would be the follow-up research on the structure of these phenological complexes, the type of relationships between their components, conditions preserving and disturbing the synchronization of phenomena, etc.

Thus the first stage we could call research on the "morphology" and "anatomy" of phenological complexes. The second, research on their "biology" and functioning. It should be unnecessary to underline how much such research on all these "micro-" and "macro-pulses" of nature could bring to the entire complex of terrestrial sciences.

The phenological cross-section method can have manifold meaning and application for various geographical disciplines (physical and regional geography, agricultural geography, biogeography, bioclimatology, agrometeorology, etc.). It is worthwhile mentioning here the possibility of applying "complex isophenes", which results from the existence of phenological accords. Lines which on a map join the places where phenological manifestations occur at the same date would not represent one phenomenon (as has been usual till now), but their entire complexes. Select signal phenomena (individual notes) would then supply the basis to illustrate the course of entire phenological accords.

"PHENOLOGICAL WHORLS"

The concept "phenological whorls" was transposed from botany, or, more precisely, from the morphology of plants. As we know, one of the types of leaf growth from the stem is the whorl type, when from a single node several leaves radiate around the stem and form the so-called whorl. This characteristic leaf growth occurs in the horsetail (*Equisetum* sp.) and many other plants from the family *Rubiaceae* (*Asperula*, *Galium*, et al.). The segments of the stem between these rhythmically placed whorls bear the name internodes. By analogy we can now say that phenological manifestations in every particular geographical-natural habitat can be compared with the rhythmically appearing whorls on a plant's stem. In such a comparison we should pay special attention to the following:

1. Processes of phenological maturing constantly take place both in plants and in the environment, but only at certain stages (when quantity changes into quality) do they become clearly observable in the form of qualitatively new phenophases.

2. The arisal of nodes with whorls of leaves is conditioned on the one hand by the hereditary endogenous rhythm, on the other by a particular state of a complex of meteorological-climatic factors, of which the thermal conditions usually rise to the forefront. In the geographical-natural habitat these "whorls" of leaves are the manifestations of a complex of phenological phenomena, also usually conditioned by a particular "node" of a complex of meteorological-climatic phenomena with temperature being the most important.

3. As in the leaf whorl, a row of leaves in a given node develop simultaneously (synchronically), so in an environmental phenological whorl, a row of phenomena also appear simultaneously, thus having the character of synchronic phenomena. Among the latter, some of them can be related with each other biologically, others can only be the result of the "node" community, e.g. thermal.

"Phenological whorls" would on the one hand reflect the process of the stages of the environment's maturing, on the other be one of the fundamental methods of researching phenological phenomena with their mutual conditioning and yearly dynamics. The knowledge of factors under which particular phenological whorls can arise and the conditions for their rate of arisal (the length of time between nodes, in other words how long the internode segments last) can have first-rate implications for the discovery of the regional rhythm of nature in a complex comprehension, and above all for predicting the type of phenological phenomena with times of their oncoming.

In relation to the fact that phenological phenomena in phenological whorls have, as has been previously discussed, a synchronic character, it would be enough to select one of the more characteristic indicative phenomena to attest a particular phenophase of the whole environment. It is understood that the face of such a phenological whorl (which changes in the yearly cycle) depends primarily on the character of the given biocenosis in a concrete segment of the biosphere. For every morphotaxonomic geographical-ecological unit² phenological whorls should primarily be selected in their yearly succession, after which further research should be carried out on the laws governing the appearance and successive following of whorls, on the type of relationships among the particular elements of the whorls on the phenology of whorls in various types of habitats and with various meteorological-climatic conditions, etc.

The concepts of "the phenological maturity of the environment" (described below) and "phenological whorls" organically tie in with each other due to the complex and dynamic way in which they try to render the essence of processes occurring in the yearly cycle at every section of the natural environment, always treated as a fraction of one great pulsating organic whole.

² Every natural, historically shaped and differentiated segment of the biosphere, in other words every taxonomic geographical-ecological unit, has in its yearly cycle a characteristic set of phenological whorls. We can thus speak of a peculiar succession of phenological whorls in every specific segment of biosphere.

"THE PHENOLOGICAL FAN"

Every natural segment of the geographical-natural habitat (region, landscape, biocenosis, et al.) has its own specific "phenological fan", which is among other things characterized by:

- 1) a particular composition of typical plants and animals (a particular type of biocenosis);
- 2) a particular rhythmicity of phenological manifestations, concerning both the order of manifestations and their duration;
- 3) a particular dynamics for the opening and closing of the fan, conditioned by particular climatic factors.

One and the same fan, constant in structure, is mutable in the time and rate of its opening and closing. It is dependent on the one hand on the course of meteorological-climatic conditions in a given year, on the other on the character of the given geographical-natural habitat. The yearly pulsation of the biosphere is the opening and closing of the phenological fan in all of its branches.

"PHENOLOGICAL BEATS OF THE BIOSPHERE"

Symptoms of the seasonal rhythm of the biosphere can be treated (having in mind the overlapping of endogenous and exogenous rhythms) as the penetration of successive invisible processes of the inorganic geographical-natural habitat in the phenological picture of phenological seasons, phenological complexes, etc. Symptoms of the rhythmicity of the biosphere reflecting among other things, particular successive phenological seasons can thus be treated as peculiar "beats" of nature. In the framework of the complex problems in the biology of the landscape we should tie these beats in with the morphology and the physiology of landscapes. For instance, the first three phenological seasons — "Pre-spring", "Early Spring", "Spring" — should be treated as the first three peculiar beats of developing nature. Phenological beats are easily observable only on the surface (morphology, phenology), since the rhythm of endogenous processes of the biosphere (biochemical and meteorological-climatic) infiltrates as it were and is hard to grasp (the physiology of phenology).

"THE PHENOLOGICAL MATURITY OF THE HABITAT"

The proposed concept of "the phenological maturity of the habitat" is more or less a paraphrase of the concept "vegetative maturity" introduced by Strażewicz³ to pharmacognosis in reference to plants of medicinal qualities.

³ W. Strażewicz: Dojrzałość wegetatywna jako biologiczny czynnik zmienności surowców farmakognostycznych. Państw. Inst. Nauk. Leczn. Sur. Rośl. w Poznaniu, Warszawa 1950.

The concept "vegetative maturity" is relative. It does not mean a given age for a whole plant or for any of its parts. It is characterized only by a dependence between a changing vegetative state of a plant and the changing biochemical processes particular to this state. Everything points to the conclusion that the above dependence is the expression of a general biological law which can be formulated as follows: the progress of a living organism's development is in accordance with an appropriate, but constantly mutating complex of biochemical changes, leading to the appropriate and also mutating complex of products from these changes. If we wanted to transpose the above formulation to the language of ecology or geography with particular reference to the phenology of the entire habitat in the yearly cycle (from the aspect of seasonal succession), then we could formulate it in the following way: the phenological phases of organisms (phenophases) and their yearly succession are the result of both the succession of internal-systemic changes (physiological) and the succession of changes in the entire external habitat (ecological). It means that every phenological phenomenon in the life of plants and animals corresponds with an appropriate state of the physiological (biochemical) maturity of the organism and an appropriate state of the phenological maturity of the habitat. As a consequence, particular phenological phenomena (both in the life of particular species and in complexes) will not arise before the habitat matures to this phenomenon. Many examples of such a dependency between phenological manifestations in plants and animals, with a particular phenophase in the habitat, can undoubtedly be presented and form various sections of ecology and phenology. What is more, these factors are right in the centre of the concerns of these natural science disciplines which examine the relations between organisms and the habitat in their yearly succession. Nevertheless, we should consider whether introducing the concept "phenological maturity of the habitat" to ecology and geography along with appropriately directed research, would not enrich their contents even more, laying greater stress on the yearly dynamics of processes in their organic interdependence. Strażewicz supposes that the concept "vegetative maturity" in plants and the processes tied in with it have the character of a general biological law. Thus it seems all the more justified to introduce the concept of "the phenological maturity of the habitat".

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STRESZCZENIE

Przedstawiono niektóre pojęcia i terminy z dziedziny fenologii, zaproponowane przez autora w pracach już opublikowanych (1–11). Za celowością ponownego ich zestawienia przemawiają następujące względy: 1) stanowią one swoiste przyczynki do mało opracowanej teorii fenologii; 2) wnoszą pewien wkład do teorii ekologii, geografii fizycznej i regionalnej; 3) znajdują się na styku zainteresowań całego zespołu nauk o biosferze; 4) są swoistym podsumowaniem wieloletnich dociekań fenologicznych autora.

W sposób syntetyczny zostały omówione (dosłowne wyciągi z przytoczonych pozycji piśmiennictwa) następujące pojęcia i terminy: „fenologiczne zegary biosfery”, „akordy fenologiczne” i „nuty przewodnie”, „izofenoty”, „przekroje fenologiczne” i „izofeny zespołowe”, „okółki fenologiczne”, „wachlarz fenologiczny”, „fenologiczne takty biosfery”, „dojrzałość fenologiczna środowiska”. Ponadto podano propozycję nowych ujęć definicji fenologii.

РЕЗЮМЕ

В настоящей работе представлены некоторые понятия и термины из области фенологии, предлагаемые автором уже в предыдущих публикациях (1–11); составление такого перечня терминов является целесообразным по следующим мотивам: 1) он составляет своего рода дополнительный материал к мало изученной теории фенологии; 2) вносит некоторый вклад в теорию экологии и физической и региональной географии; 3) находится на стыке целой группы наук о биосфере; 4) является своего рода итогом многолетних фенологических изысканий автора.

Синтетически представлены (дословные выписки из приведенной литературы) следующие понятия и термины: „фенологические часы биосферы”, „фенологические

аккорды", „ведущие ноты", „изофенотопы", „фенологические разрезы" и „комплексные изофены", „фенологические мутовки", „фенологический веер", „фенологические такты биосферы", „фенологическая зрелость среды". Кроме того в работе предложены новые представления дефиниций фенологии.

THE LIST OF PUBLICATIONS IN PHENOLOGY
BY SERGIUSZ RIABININ*

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* The list comprises the author's publications in the field of phenology being the main trend of his scientific interests; the list of all publications (chronological) for the years: 1946–1986 was published in 1986 by Maria Curie-Skłodowska University.

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