

Mechanisms forming higher order integrons, population, tools

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Abstract

This is the fifth article in a series describing the subsequent chapters of the book "Draft of the Deductive Theory of Life" in a very short and accessible way. The titular integron concerns the level of organization of a theoretical object interpreted as alive (e.g. cellular, multicellular, colony of multicellular organisms), and not the structure within genetics. Subsequent levels arise gradually, at the same time selection at a higher level gains importance and natural selection at a lower level disappears, which is important in the controversial issue of group selection. Statistical mechanisms leading to the formation of higher-level integrons resulting from selection at different levels are indicated. During the process of integration, an exchange of hereditary information is created in the form of exchange of similar components of integrons, which leads to a strong acceleration of adaptation - the population mechanism and generative reproduction. A special case is the extremely probable integration of sister objects during reproduction, creating colonies. Maintaining optimized acceleration through the exchange of hereditary information at a lower level leads to the formation of ontogeny. The identified mechanisms of integration also describe biogenesis in terms of organization.

Keywords: Draft of the Deductive Theory of Life; levels of organization; origin of ontogeny; group selection; kin selection; self-adaptive systems.

1 Introduction

General

This article is the fifth in a series (Gecow 2024c-f, 2025b) describing, as accessible as possible, the subsequent chapters of the book "*Draft of the Deductive Theory of Life*" (Gecow 2024a). Unfortunately, this topic has not been explored as exactly as in the previous chapters. It is a collection of hypotheses, supported by heuristic arguments, about tendencies and their mechanisms, which require much more complex models, and these require the foundations laid by all the previous chapters of the book, including this fifth one. We assume from the outset that the object under consideration here has the ability to reproduce and is subject to the process of improvement. The covering tendency (Gecow 2022, 2024f) is frequently invoked. By presenting this research project, I demonstrate what it can explain at the theoretical¹ level, and I believe it is worth the anticipated effort.

Chapter 5 of the book first introduces *specialization* – a generally known and well-understood tendency, which I will omit here. Next, the *mechanisms for binding independent objects undergoing improvement, present simultaneously² in the environment*, are discussed. This process leads to the formation of higher-order integrons³ (including the formation of colonies) and their gradual taking over the role of the tested individual. This is related to the controversial idea of group selection and enters into ecological issues.

Different references to the elements being linked/bonded allow for several surprising but objective choices of tested 'objects,' including 'tools.' This process can be considered from the perspective of a single improved object – the 'farmer,' which builds an 'extended phenotype' – the 'farm' – from environmental elements, or one can treat

¹ Classical theory is inherently deductive, and therefore deductive in structure. The concepts formed in this way, based on specific assumptions, often also apply to objects observed in nature, which are not encompassed by everyday concepts. The resulting set of concepts is more objective, unlike everyday language, which is created from a human perspective, thus providing a subjective picture. This difference leads to surprising interpretations.

² Since chapter 2 of the book, described in (Gecow 2024d), the division of the state ('situation') of an isolated system into a single object and its environment has been considered. Chapter 5, described here, primarily notes the presence of other, similar objects in the environment and examines their mutual interactions. One aspect of such interaction was already discussed in chapter 3 of the book (Gecow 2024a), briefly described in (Gecow 2024e) as competition resulting from the limited carrying capacity of the environment.

³ In biology, integrons are most often understood as genetic mechanisms that enable bacteria to rapidly adapt and evolve by accumulating and expressing new genes (Domingues et al. 2012). In this article, however, they have a different, also commonly used meaning of successive levels of organization, such as: cell, multicellular organism, multicellular colony.

different 'linked' (integrated) objects initially improved independently as equals. Both of these approaches are extreme, leaving some interpretatively surprising situations between them.

During the process of binding (integration) of objects, an important opportunity arises for the exchange of hereditary information between the forming integrons through the exchange of similar, lower-level, linked elements. This leads to the emergence of a population mechanism, which is a powerful accelerator⁴ of the basic test of adaptation. The basic Darwinian test – natural selection does not require a population mechanism; it is sufficient to identify many features of the process and the objects involved. The current understanding of the Darwinian mechanism stems primarily from population genetics, and the role of the population mechanism is usually overestimated.

Darwinian natural selection applies to objects that are easily identifiable. This is the simplest intuitive representation of this mechanism, but the deductive method allowed for a more general description of this mechanism, which, together with the image of integration, indicated the possibility of this mechanism operating on objects that were not previously distinguished – this provided a 'local' test, applicable to large, homogeneous integrons in which variation occurs locally. Such cases occur in ecology.

The bonding that creates the tested set may involve entities⁵ that are difficult to immediately consider as reproducing objects and undergoing a process of improvement controlled by some test. Such a bonding process seems to accurately describe the first appearance of a tested, reproducing object, i.e., biogenesis. The bonding of objects during reproduction, which is the 'easier'⁶ case, creates a particularly important entity/object called a colony.

We will consider binding tendencies and their mechanisms: consolidation, and integration in several ways, including colonization (in the sense of colony building). A tendency is essentially an observed deviation from a random process, but it is desirable to identify the mechanism that creates this deviation, and it is these mechanisms that are of primary interest to us.

Chapter 5 of the book also contains other topics that did not fit in previous chapters or are related to the mechanisms discussed in Chapter 5. Specialization can concern an object's relationship to environmental factors (we will omit this), but it can also be a method for addressing conflicting tasks of the elements of the tested object, which generally results in the "replicate and modify" rule mentioned in (Gecow 2024e). The ability of a colony to utilize the production of certain substrates by a nearly identical neighbor allows this mechanism to break down with impunity or take on other tasks – such "internal" specialization unleashes variability.

The emergence of hereditary information exchange through the exchange of integron components and the maintenance of this accelerator for the colony gives rise to ontogeny, discussed earlier in Chapter 4 of the book, and in (Gecow 2024f).

Section (of the book) 5.7, "*Purposeful information collection methods, higher tests*" was already briefly described in (Gecow 2024e, 2025a), but much of the argument is based on conclusions from the discussion of integration. This topic is continued in Section 5.8, "*Controversial examples of purposeful information gathering*" which primarily challenges currently prevailing views and promoted concepts. They are represented by the slogans: "Plasticity and Genes," "Lamarckian Dimension," "EES," and "Developmental Bias." This is the topic of the next article in this series (Gecow 2025b). More extensive treatment of these topics can be found in the articles (Gecow 2024g,h).

The model discussed so far

When building a causality model to define purpose and purposeful information, we divided the situation—the state of a physical, isolated system—into two parts: a small, variable object, the carrier of the purposeful information of interest, and a large, statistically described, practically constant environment. The environment has taken on the role of an active natural coder transforming the passive object. The assignment of activity and passivity was arbitrary, for the sake of description, in which the encoder was supposed to be a function, but this is a conscious approximation and can be reversed. A more symmetrical description would be better, but I leave this to future authors to find.

We noticed that the object possesses information inherent in its structure on how to respond to given external conditions. A natural encoder transforms cause into effect. The decoder, therefore, indicates the cause for a given effect, and the effect for which the cause is sought is the goal. Identifying the cause that provides the goal constitutes purposeful information. This model of purposeful information is described in Chapter 2 of the book (Gecow 2024a) and in articles (Gecow 2024d, 2025a).

⁴ This accelerator was already mentioned in (Gecow 2024b,e).

⁵ For example, hypercycles (Eigen, Shuster 1979) mutually supporting the production of their components.

⁶ Usually explained by kin selection when the integron is subject to controversial group selection.

In Chapter 3 of the book (Gecow 2024a) and articles (Gecow 2024e, 2025a), the question was posed as to whether an independent process of collecting purposeful information could exist. It turned out that this is possible despite the widespread increase in entropy, but only for the purpose of "continuing to exist." The object—the carrier of this purposeful information and process—must reproduce for the process to be long and effective. The effectiveness of this process is an increase in the size of purposeful information, primarily its effectiveness/perfection dimension (corresponding to fitness). We called this process improvement and identified its mechanisms, the primary one being Darwinian natural selection.

The similarity of this process to the process of life is so great that we concluded that it describes the process of life and a living object. However, this is an interpretation of the theory, so objects that reproduce and undergo the process of collecting purposeful information for a purpose continue to exist (improvement process), we called the "**#-objects**," and we will continue to address these. At the same time, we remember that they are functioning systems, described by dynamic, complex networks, where nodes perform functions by transforming input signals into outputs. Interpretively, nodes can also be considered systems, which can also be described by networks.

#-objects undergo random variability, i.e., they evolve. Therefore, they have an identity criterion, which was indicated by the detection of half-chaos (chapter 1 of the book (Gecow 2024a) and articles (Gecow 2024c, 2025a)). This criterion allows for small changes, and this variability allows for evolution, which increases perfection⁷.

Chapter 4 of the book (Gecow 2024a) and articles (Gecow 2022, 2024f) introduce the concept of structural tendency as a deviation occurring in the process of improvement from the free process. A covering tendency is defined there, it involves the restoration of functioning near system failure. It does not enhance perfection like most 'normal' evolutionary variation, which climbs the fitness slope, but rather rescues the object primarily in the event of significant environmental changes⁸. This important structural tendency will often participate in the further discussed tendencies for the formation of higher-order integrons.

Extending the model – new assumptions

The fundamental, 'new' assumption in the considerations of Chapter 5 of the book (Gecow 2024a) and this article is the presence of many #-objects in proximity (near each other), so that they constitute a distinct part of the environment for each other, that is, that interactions exist between them. This is not entirely a 'new' assumption. Excess objects resulting from reproduction were 'hidden' in the environment, and to a first approximation, this did not significantly change the environment. However, reproduction is efficient, leading to a quantitative explosion, and this simplification proved excessive. The finite capacity of the environment and the resulting competition had to be taken into account (Gecow 2024e). We considered the phenomena using probability, but it remained clear that implementing such a process required large numbers for the results to be approximately consistent with such predictions. We called the set of objects/clones – a **pool**, in distinction from a **population**, which possesses specific mechanisms resulting from the exchange of hereditary information.

The interpretation of the environment and the interactions of the objects within it strongly suggests introducing a range of these interactions, as indicated above by 'near each other.' The similarity of #-objects (hereinafter abbreviated as **#-ob**) resulting from reproduction and their movement through the environmental space suggests considering the interactions not of specific two #-ob, but of types of #-ob. Links in a network model give the suggestion that their interpretation is a mechanical connection – this is a false suggestion. Generally, the stable statistical presence of objects of a certain type within a certain range is sufficient for a causal relationship to occur. The frequency of interaction may be sufficient to consider a connection to exist and function. This introduces a measure of the connection's existence. One input link may receive the same signal from several objects, even those of different types.

These additional assumptions significantly complicate the model. For this reason, among other reasons, exact models and simulations were not developed; the considerations are significantly less rigorous than previous ones; they merely sketch future models and heuristically predict their conclusions. This is undoubtedly a necessary step before rigorous testing can be undertaken – whether this hypothesis is correct. The types of objects, their density, and the possibility of sporadic interactions clearly shift the model in a direction different from that of dynamic networks, bringing it closer to the concepts of Banzhaf's model (2003).

In addition to #-objects, the environment may also contain other objects with which interactions can be significant. This was the case, for example, during the formation of a cover (Gecow 2022, 2024f), where an environmental element that sent a significant signal to the #-ob disappeared, and the #-ob, in the covering reaction, maintained its presence, practically incorporating it into its structure.

⁷ Other factors can simultaneously reduce this perfection, such as a change in the environment that makes it inappropriate for the collected purposeful information, as discussed in the case of competition.

⁸ Other factors can simultaneously reduce this perfection, such as a change in the environment that makes it inappropriate for the collected purposeful information, as discussed in the case of competition.

2 Basic mechanisms of #-objects binding

From entropy

If several objects are nearby, within the range of interaction, the probability that the randomly connecting input and output will be from different objects is unavoidable. Connections are formed between objects located sufficiently close. The model is not specified here; these connections can, of course, be between outputs and inputs connecting objects to the environment, and this is the simplest interpretation. However, connections to nodes in the middle of the network describing the object can also be allowed, especially since we allowed for the node's input to receive signals from several similar sources. This possibility significantly complicates the model, which we will not elaborate on here, but it is important for interpretation.

It can be assumed that the random severance of each connection is equally probable, but that objects are more strongly connected internally than externally, which is the basis for their distinctiveness. Therefore, severing connections also leads to equalization of their density. However, assuming equal probability of connection severance inside and outside an object is generally rather inaccurate, although if these objects are not controlled by the improvement condition, this assumption is probably acceptable.

Let's call this mechanism and process "**object binding**." It is a typical process of irreversible entropy increase. The entropy of the distribution of possible connections is lower when this distribution is subject to the condition that connections can only occur within the boundaries of a single object. As can be seen, the process of binding objects does not require the assumption that these objects are undergoing improvement, although the improvement condition may influence it. The process indicated with the entropy increase mechanism is not formally a tendency; despite its directionality, it is a free process. Tendencies are deviations from the free process resulting from the improvement condition.

The longer the binding process takes, i.e., the more connections occur or their durability/intensity increases, the stronger the connection. It blurs the boundaries between the linked objects, thus losing some information about their initial individuality, properties, and quantity.

From the test - binding support for improved objects

Interactions/connections arise within the set of active objects that mutually determine their operation. Some of these objects (at least one) are undergoing a process of improvement; their new conditions will be of interest to us. We will call this set of already somewhat connected objects a '**integron**'.

To build a model of the influence on bonding resulting from the improvement condition, we need to determine what can be eliminated and on what basis. The test for a given type of object comprising the integron remains unchanged, but complex interdependencies develop between these types, and slowly, the presence and undisturbed functioning of other components of the integron increasingly influences the test result of the considered object. Over time, the stability of the entire integron becomes the dominant condition. The test of the higher-order integron—thus gradually emerges, gradually replacing the tests of the component objects. Both of these tests must be kept in mind and distinguished. Initially, the test of the object is more important, later the test of the integron.

If it is possible to combine the goals/patterns⁹ of the objects comprising the considered integron into a single goal for the entire integron, then such a integron can be treated as a single object undergoing further improvement (in the past, symbiosis; today, mutualism and commensalism). These goals may not be possible to combine in this way, for example, if they are contradictory. It can be expected that in larger integrons, some goals will always be contradictory. If these integrons are sufficiently persistent (losses do not clearly outweigh gains, the object typically resides and is tested within the integron, and therefore degenerates¹⁰ outside the integron), their components will specialize in this integron as their primary environment (see below: biotic environment, consolidation). After some time, it will no longer be profitable for them to leave the integron, and subsequently, they will be unable to exist outside the integron. A good example is the mitochondrion.

Components with excessively contradictory goals (e.g., competing for the same niche) should resolve the dispute in favor of one of them, while those with less contradictory goals should create regulatory mechanisms. Predators and prey undoubtedly have contradictory goals, but they are naturally regulated (the Lotka-Volterra model) by mutual dependence. Generally, broadly defined parasitism, including herbivory and predation, are subject to such regulation, which is the basis for the persistence of such integrons. Without such regulations, integrons with conflicting component goals can briefly exist in unstable equilibrium, but after that time they are eliminated. That is, the weaker of the incompatible components is eliminated, leaving a distinctly different integron.

⁹ Here we should recall the adaptation model from the article (Gecow 2024f) or ch.4 and 5 of the book (Gecow 2024a).

¹⁰ The probability of change for the better is much smaller than degeneration - change for the worse (Gecow 2024f).

Let us summarize the mechanisms that support binding for improved objects. While the severing of the connection between objects not subject to improvement is not limited in any way, when the connections are tested, such constraints arise.

1. Each connection—an element of change that increases improvement (of an object or integron)—is soon stabilized, as with Muller's ratchet (Krzanowska et al. 2002), by permitted degeneracy (Gecow 2024f) elsewhere. In a typical competitive state, after such degeneracy, the severing of this connection results in elimination.

2. Improvement constraints statistically hinder the severing of old connections. This **build-up tendency** (Gecow 2024a,f) creates Weismann backward displacement, i.e., shifts the considered connection to earlier functional positions where acceptance of change is increasingly less likely. This mechanism applies primarily to the integron, but also to the input signals of objects.

3. **Covering connections are particularly difficult to break**, so we can expect them to play a major role in binding involving improved objects. The need for covering is indicated by the object's test. Objects' input signals are usually at relatively early functional positions at the beginning of binding, and assistance from a neighbor in the integron in the event of a loss of the appropriate signal from the environment is particularly valuable for the object's test. Covering prevents the object requiring covering from falling out of the integron, and the absence of its output signals does not cause the destruction of part or all of the integron – this indirectly impacts the integron's test.

Note that in the case of binding improved objects, the spontaneous increase in entropy and the process direction preferred by the test are consistent. The build-up and covering tendencies indicated in ch.4 of the book and (Gecow 2022, 2024f) therefore accelerate the binding of objects participating in the improvement process.

3. Consolidation – binding within an integron with an integron test

The above-mentioned mechanisms, based on entropy and initially supported by a test of the component objects, create an integron that gradually becomes increasingly subject to its own emerging test of the whole. The perspective resulting from the integron test creates a tendency I call **integron consolidation**. This tendency is present from the beginning of the integron's creation, but it becomes more significant at a more advanced stage. This process blurs the boundaries of the integron parts and unifies the whole, preventing the possibility of the improved integron/object breaking down into separate objects with different structures, i.e., with incomplete composition.

Consolidation also occurs within a single object, where the integron elements can be considered separable modules. **Mechanisms of module formation other than those resulting from integration are the opposite of consolidation**; they are phenomena composed of multiple, sometimes contradictory, mechanisms (Gecow 2017, 2023; Gecow & Iantovics 2022). Spontaneous classical modules occur in every network, but the growth of large modules, which can transition into chaos within them (Gecow 2017), is the only identified mechanism for the process leading to an object leaving half-chaos despite monitoring small changes. Genomic chaos, leading to cancer, among other things, can be interpreted as such a phenomenon (Gecow, Iantovics, Tez 2022).

4 Farmer and farm (tools) – binding by the farmer test

Tools – covering in more detail

From the perspective of a self-perfecting (improved) object, the absence of certain typical environmental elements results in a lack of necessary signals at its inputs, i.e., the requirement for covering. One could say that such elements were useful, **positive**. The object (**pf – the primary form** in the description of covering (Gecow 2024f)) "guards" by covering the presence of such elements, and by influencing them, it can improve them along with itself through its own test. **We will call such positive environmental elements, the presence of which within the object's range was influenced by object, tools.**

The cover model from the book (Gecow 2024a ch.4.5) and (Gecow 2022, 2024f) was too simple to define, as it did not allow for an object to influence the presence of elements in the environment. The network describing the object incorporated a new node into its structure, which recreated the faded signal and created cover—part of the object. In the model currently considered, the description of this event is much richer: a fading positive environmental signal is a reduction the frequency of a specific type of environmental object within the range of influence. Our improved object changes its behavior—it increases the statistical presence of the desired object nearby. Initially, this influence is weak, and there is no apparent reason to include this object in the improved object, but over time it grows, and the object's impact on the environment is no longer negligible.

Not every tool had to previously exist in the environment and now create cover; an object can "create" a new object belonging to the environment in a similar way (e.g., a bicycle, a nest). In the earlier model from ch.4.4 of the book, such an event was modeled as the addition of a new node at the network output.

The farmer and the farm – f&f

It is irrelevant here whether tools are improved objects or not; what matters is the benefit of their presence for the object we are considering, which we will call the **farmer** (this is another perspective on the primitive/primary form during covering), and the set of its tools – the **farm**. The farm is essentially a cover, but it explicitly contains objects originating from the environment, or even belonging to it. In addition to tools, the farm also comprises interdependencies, organized by the farmer's test. The fundamental novelty of the model here is the process of integration – a gradual, almost continuous transition from an element of the environment independent of the object, through the tool stage, to a situation in which it is clearly part of a somewhat broader entity/object. Let us call this whole – **farmer and farm** – **f&f**. Binding of f&f can only statistically grow (consolidation), so after a certain time, the farmer will be unable to exist and reproduce outside the farm.

The farm is a part of the environment controlled by the farmer, and the f&f is an extended phenotype of the farmer (Dawkins 1982). In creating the concept of the selfish gene, Dawkins (1976) positioned the gene as the farmer, and the vehicle as its farm. The cell nucleus could be considered the farmer, and the rest of the cell as its farm.

When we considered the layered structure of the cover and the division of the object into its primitive form and its cover (Gecow 2022, 2024f), understanding the cover as an integral part of the object raised no objections. Now, as we find our own place through suggestive anthropomorphic names, we note an ambitious resistance to assigning the status of an object to the farm along with its farmer, and to the farmer itself only to its primitive form. This resistance is similar to the struggle against human descent from apes.

F&f reproduction, tool production

The mechanism of reproduction of the farmer (primitive form), which is an #-object, is nothing new and requires no discussion. It should be recalled here that for now, we are not assuming¹¹ the more complex generative reproduction requiring two parents, but the simpler, vegetative (single parent) method.

Farmer reproduction requires the reproduction of the farm. The influence of the farmer on the existence of tools, as reflected in the definition of tools (and the farm), applies here. Therefore, **tool reproduction requires a farmer and usually some, not necessarily the same, tools**. A distinction should be made between the evolutionary formation of f&fs and their reproduction, in which tools from the parent farm play a significant role; at the time of f&f first formation, they are not yet present. Therefore, this usually involves tool production.

The presence of objects from the environment in f&fs and the need to increase their number during reproduction requires the utilization of new environmental resources, which corresponds to nutrition. Although not dictated by the law of conservation of mass or the need to acquire energy, it may be related to them.

In the special case of **tools being #-objects**, the farmer only provides them with favorable conditions. **Let's call such tools biotic**. The question arises as to how they differ from the farmer; they also influence the existence of the farmer, if only by virtue of their role as tools. This question is not trivial; the answer is dictated by the assumed perspective—the f&f is a continuation of the farmer. This does not mean that a different perspective and the resulting answer are incorrect. One could assume that the cow is the 'farmer' and the farmer is its tool; the criterion for selecting a farmer should be the maximum intensity of influence on the farm's organization.

The f&f is an extreme variant of the integron considered in the next chapter, also as an extreme form on the other side of the range of the degree of influence on the binding process by the considered #-objects. Anthropocentric names are intended to aid intuition, but the considerations concern the process and mechanisms from a point of view that is as objective as possible, as non-anthropocentric as possible. For example, from this perspective, a hammer would be considered a #-object.

Biotic environment

The presence of other #-objects in the environment, with which the #-object under consideration can interact, creates a **biotic environment**. It is undoubtedly changed by the process under consideration with respect to the abiotic one, but it can still be assumed that the influence of the object under consideration on this environment is negligible, and for the mechanism of collecting purposeful information it is irrelevant whether the environment is also biotic or only abiotic.

In a biotic environment, new, diverse, and complex elements emerge, not probable in an abiotic one. A greater complexity of the environment, on the one hand, requires greater information on how to protect itself within it—that is, greater complexity. On the other hand, **if certain elements/substrates are essential for our object, in the abiotic environment it had to "make" them itself** because they were not there. In a biotic environment, they are often already ready-made and can be obtained from the environment (e.g., from other, more industrious objects, preferably by force, but as we know, compromise is also possible). In this situation, the object may become

¹¹ This assumption of duplication also allows for, but does not require, generative reproduction.

simplified, losing a significant portion of previously accumulated purposeful information or failing to solve new problems independently. This is precisely how parasites evolve. This explains the short storage length of purposeful information in viruses. Animals, due to heterotrophy, have no reason to exist in an abiotic environment.

Tools as #-objects

Note that tools, even non-biotic (and therefore abiotic) ones, are subject to duplication, which is the result of f&f-multiplying. Changes that increase the effectiveness of a tool increase the perfection of the entire f&f, which translates into the number of f&fs and the tools under consideration. A state is created in which the tool meets the definition of an #-object, even though it does not have to participate directly in its own reproduction.

Hammers are plentiful because they are good and useful tools; sickles are already extinct. The fact that, from our perspective, hammers do not reproduce, but are produced, is merely our subjective perspective¹². A specific environment is necessary for the reproduction of tools, just like living objects. The purposeful information, also contained in the structure of a hammer, exists alongside the mechanism of its physical formation in a specific biotic environment, which constitutes a given type of f&f, and is tested together with that f&f. If it demonstrates its effectiveness, more hammers will be produced. Increasing its effectiveness in different circumstances, it undergoes typical adaptive evolution (radiation), creating different variants suited to different niches (tasks).

Each component within the tested object can equally well be treated as the tested object, and the rest as its environment. This requires only that the condition for the continued existence of this environment, i.e., a higher-level object, be met. Let's call this correction to the conditions of variability of a component object, allowing it to be considered as an #-object, a **superposition** (a combination of its conditions and those of its overriding object).

The formal relativity of the roles of the components of the tested object yields amusing (for us) results: For example, the role of the farmer is similarly relative. It is easier to assume that cows ensure the continuity of their species by ensuring the existence of the farmer (and, with his help, creating a farm) who operates them, than to assign the bucket to the farmer's role, and the cow and farmer to its tools. However, formally, both of these variants, along with the farmer as the formal farmer, have similar, correct meanings. The situation is different with the initiation of the process leading to f&f – the bucket certainly won't initiate it, because it does not exist in an environment without f&f. One can seek a measure of the reasonableness of specific interpretations, for example, based on the possibility of initiating the process of binding f&fs, but it is difficult to question their actual and formal correctness for an advanced f&f. An example of a 'better' criterion for a farmer might be its dominance in organizing the farm. While for highly complex objects, creating relatively simple tools, certain interpretations seem appropriate and others inappropriate, for objects of small or similar complexity, identifying the "correct" interpretations can be difficult, and this phenomenon need not be subjective. Bees and the plants they pollinate can be treated as a f&f, so what is the farmer here?

Blurring #-object boundaries

The model in its current form allows for the observation of an object's boundaries in relation to its environment. The formation of a cover in the form of a farm through the gradual binding of environmental elements creates a lack of a clear boundary for such an object. #-object is a test-controlled carrier of collected purposeful information, so it is distinguished from the environment by the scope of the test. Eliminating an object simultaneously eliminates its influence on environmental elements, which does not necessarily mean the elimination of these elements themselves, but certainly changes the environment. The initial phases of f&f formation do not impose an interpretation as a continuation of the farmer, but the subsequent process irreversibly creates a higher-order object without which its elements cannot exist. Therefore, the object under consideration generally lacks clear boundaries, neither temporally nor spatially, nor does it require immobilizing mechanical constraints, and its components do not even have to be the same objects, only the statistical presence of objects of a given type. Similarly, the strength/measure of the impact does not provide sharp boundaries.

Contemporary attempts to delineate the boundaries of biological objects, e.g., (Bich 2019), do not refer to the mechanisms of their formation. Bich, however, notes the problem of higher-order integron formation. The described process of f&f formation can have distinct phases, and then it is possible to treat one phase as a (nearly) completed f&f, which then recursively appears as a 'higher-order' farmer, which corresponds to the recursive layers of the covering model.

¹² The questions of whether artifacts are alive and whether artificial life is truly life are philosophical in nature. Krzysztof Chodasewicz discusses them in articles (2014, 2015, 2016) and others included in the collection (2021).

5. Binding equivalent #-objects with tests of these objects

In the f&f formation process, the farmer binding the f&f and its test was the reference, but other #-objects and abiotic ones in the environment merely submitted to this process. It is difficult to expect that the tests of other #-objects have no influence on this process.

Let us therefore (for preliminary simplicity) neglect abiotic objects, which, at least at the beginning of the process, have no "interests" and therefore no directed influences, and **let us treat the interacting #-objects symmetrically**. The equivalence of bound #-ob is also an extreme case, but on the other side of the range of the degree of differentiation of the influences of different objects.

If previously independent¹³ #-objects undergo bonding, we will call this process "**integration**," and the resulting object composed of connected #-objects "**integron**." A significant difference between integration and consolidation, and (primarily) the covering that creates a f&f, is the different initial reference point for the test: **for integration, the parts; for consolidation, the whole; and for covering and f&f, the pf, i.e., the farmer**. Therefore, we had paid particular attention here to the mechanism, not the structure.

Structural aspects of the integron

Integration is a structural tendency, leading to a multi-centered structure and recursive multi-level structure, systematically but statistically increasing the stability of the integron.

Integron stability

The collected objects must constitute environments for each other, in which they existed and were tested. **The more types of objects that comprise a given integron, the more stable it is**—different types of component objects can emit sufficiently similar signals.

The integron can be viewed as a changing biotic environment. **Each of the component #-objects "sees" only its own "interest"** during its variability and its testing. This self-interest also includes the obvious condition of not destroying its own environment (**superposition**), which is a reference to the test of the entire integron. Failure to meet this condition by one integron member leads to the entire integron's destruction if the villain is not the first to fall. Protecting the integron from the consequences of such a mistake requires the integron to **multiply (reproduction)** as a whole.

Blurred integron boundaries, integron integration, multilevelness

The integration process begins when the density of improving objects in the environment reaches such a value that the presence of another improving object within the range of influence becomes statistically noticeable, and this is a statistically similar type of object.

The speed of binding different types of objects is not necessarily uniform. It depends on many factors, such as the density and stability of a given component type, its size in terms of its diverse influence on other components (e.g., the number of outputs), the need for covering, and so on. The formation of even a single, even weak, direct or indirect (e.g., using signals from the same third object) link can facilitate the formation of subsequent links through more stable presence within the range of influence.

During the formation of a (stable) integron, some of its parts are therefore more strongly bound, while others are just beginning to bind. We can assume that one integron is already advanced and undergoes a second integration process. **Recursion arises, as in the case of covering layers**. The variety of interpretations is natural here, and the boundaries of integrons are, in reality, more or less well defined.

The image of the blurred boundaries of a integron is identical to the image of the boundaries of a f&f, which, after all, can also be an integron even from the beginning, when it contained #-objects from the beginning. The creation of a farm by a f&f as a farmer is a **integration of integrons**. The assumption that this is a continuation of an initial process or a new process at a higher level of organization is realistically arbitrary, and the adequacy of the selection can be assessed based on the degree of interconnection or other qualitative discontinuities or heterogeneities.

Multi-Centered Integron Structure

Early areas of component entities are bypassed by accepted changes (build-up), and these areas are more strongly interconnected as a result of longer-lasting consolidation. Therefore, a integron should have many such separate areas, clearly distinguished by the degree of interconnection and structural stability.

¹³ Adhering to this definition of a integron completely precisely would require providing many variants, each with slightly different meanings. In this case, we are discussing a specific mechanism, so this independence is useful. However, in general, we also want to view the f&f and, later discussed, the colony as integrons, and their integration processes should be encompassed by this concept. As you can see, we are operating with increasingly fuzzy concepts here, but this brings us closer to an objective description.

An advanced integron therefore has a structure of many old, strongly interconnected and slowly changing centers connected by a common layer of later bilded-up elements (new nodes in the network of connections, including tools, abiotic objects, or even #-ob), some of which participate in covering.

Growth and Reproduction of the Integron

Integron becomes the #-object.

The number of integron components – #-objects – increases if it can. The integron came into being because its influence on the test results of its components was positive, that is, it increased the rate of reproduction, which forced competitors out of the limited environment. We assumed a range of influence whose strength decreases with distance. In an environment without heterogeneity, the very large distance constitutes a barrier to influence, so the components of the integron evolve independently. They can therefore be considered almost separate integrons, let's call them **quasi-integrons**, and as their number increases, we experience a phenomenon similar to reproduction—**quasi-reproduction**.

From observation, we know that environments are usually not homogeneous and have local obstacles to influence, usually only reducing its intensity. Therefore, we can assume that the integron will be fragmented by such obstacles. A simple, intuitive example would be populations of a single species divided by geographical barriers. Maintaining the best, i.e. **typical proportions** in integrons with diverse composition is aided by negative feedback, which reduces the balance of the component with too high a density, which thus "spoils" its environment, meaning the integron loses its competitiveness.

As can be seen, not only can the integron reproduce, but the test of the entire integron also influences the abundance of its variants. The blurred boundaries of integrons make it difficult to treat them as separate entities – higher-order integrons, which also affects the degree to which they are subject to reproduction. However, it is already clear that just as the integron itself gradually emerges, treating it as an #-ob gradually becomes more appropriate.

The problem of completeness of a integron after division

If the integron is large, meaning it contains many examples of each type, the probability that one of the descendant integrons will be missing a significant type is small. Statistics solves the problem of completeness here, but when some types are present in small numbers, incomplete, 'defective' descendant integrons will occur. This creates a clear evolutionary pressure to ensure the completeness of the type set transfer. In this respect, the farmer stands out, naturally ensuring the completeness of the elements of the descendant integron. Therefore, it can be expected that among the observed organized integrons, integrons with a f&f structure will predominate.

Previously, the relativity of the farmer selection was considered, here a factor appears indicating a specific choice of this element, which has a real impact on the essential properties of the entire f&f.

Population mechanism, test II and local test

Emergence of purposeful information exchange mechanisms

In multiplying integrons, the components are almost identical in type, although variability slowly but systematically creates variants, differentiating the balances of integrons and the balances of the members of the integron. We have three distinct balances: 1) of the element type (let's treat a variant as a separate type) within a given integron; 2) of the integron as a whole within the considered set of integrons; 3) of a given element type in the environment, including the set of integrons.

As the integron variates and consolidates, the balances³ of its members increasingly depend on the balance² of the entire integron, until a state is reached in which most members cannot exist outside the integron. Due to their growth and reproduction, there should be many similar integrons in the environment, and the **barriers** underlying their distinctiveness **need not be tight, allowing for the exchange of components between integrons**.

Suppose that a certain component type in the integron changes from "a" to "A," increasing **its balance¹**. The mechanisms maintaining the proportions of both these variants combined create a barrier to integron capacity, and competition ensues – the one with the larger balance¹ will win, meaning component "a" will be displaced from that integron.

After component "A" enters another integron, its balance¹ compared to the native one is also important, so the **effectiveness of this transfer depends on balance¹**.

Therefore, the set of integrons will include integrons with "a" and with "A," and this difference can influence their balance². These **variants then possess characteristics of alternative integron properties crucial to its fitness**. If the balance² for integrons with "a" is smaller than that of the owners of "A," then the balance³ for "A" gains an additional growth mechanism relative to balance¹, and component "a" is eliminated altogether. In the opposite situation (the balance² of integron with "A" is smaller), the balances³ will be more similar, and the forecasts may differ. The former has a stronger impact on evolution. By treating elements/components with alternative variants resulting in different fitness levels of the integron as carriers of purposeful information, we achieve a **'horizontal' transfer/exchange of purposeful/heritable information**.

So far, we have considered only vegetative reproduction, as no other model has yet been identified. This reproduction/replication alone, without the exchange of hereditary information, creates a clone of descendants, which, as a set, we have called a pool (as distinct from a population). In a pool, a new trait variant resulting from random variation is passed on only to the inventor's descendants; descendants of the inventor's contemporary integrons have no access to this invention.

The ability to exchange components of integrons as #-objects allows for the collection of "inventions" from different integrons/genealogical strands, in which variation is tested simultaneously and independently, **providing a radical acceleration in the accumulation of new positive variations**. Such a trait undoubtedly provides an advantage over integrons without it, especially in situations requiring rapid covering. However, this is not a feature of individual integrons, but of a set of sufficiently similar integrons in which encounters and exchanges can occur.

Test II, population, species

Let's call a set of related integrons between which exchange of components associated with specific traits (the exchange of purposeful hereditary information) occurs a **population**. The process of exchanging hereditary information has many parameters, and their specific choices create various variants. Next, we will consider the statistical mechanism for dividing alternative versions of the integron's components and aspects of optimizing this task. For simplicity, let's assume that the transfer of a single component occurs infrequently. Balance 1 is only relevant after such a transfer, so we consider integrons after it has occurred. Balance 3 for advanced integron then depends on balance 2, as these components are no longer free-living in the environment.

In such a mechanism for collecting purposeful information, the population is the owner of the trait—the exchanged component and the properties associated with its presence. The traits—the components—are tested, their score is the frequency in the population, and the integron, the carrier of this trait, is eliminated during the test. The persistence of the tested traits no longer depends on the random remaining participants of the integron eliminated during the test – they continue to exist in the population. Traits found in parallel, independent variation – solutions/inventions/variants of components – can be gathered into a single integron, a participant in the population. Such an object/integron has a particularly larger balance2, thus increasing its share in the population. This allows for a radically increased rate of purposeful information collection, thus outcompeting others or managing to cover them in time. Such a trait is very valuable to the population – let's call it **test II**.

In the case of a pool (of objects¹⁴) where there was no exchange of purposeful information, **test I** worked, in which the entire object was the owner of the feature, its carrier, and the eliminated (tested) object. The pool, being a large set, allowed for a statistical nature of the test. The 'invention' did not become the property of the previous pool in which the inventor participated. **If, after a change in the environment, several 'inventions' were needed for rapid covering, then once the pool contained objects possessing one of these 'inventions,' each of them had to 'invent' the others independently to survive. If none of them managed to do so, the pool dies out. In the population, these inventions will easily and quickly find their way to at least one object, which will survive, extending the population's survival.** Test I relies on random variation and the elimination of 'inadequate' solutions. Test II relies on this as well, but it also has an **accelerator** in the form of the exchange of prey stored in the population, and the frequency of alternatives, which suggests 'better' solutions more frequently.

Generative reproduction serves as an exchange of purposeful/heritable information and comprises at least three different mechanisms: test I, its acceleration, which together yields test II, and reproduction, for which we have not yet identified a basis for combining it with test II into a single complex mechanism. Furthermore, it incorporates several optimization mechanisms.

Small differences in the exchanged objects/traits allow them to constitute a similar environment for the remaining members of the integron. Larger differences require costly protective modifications and are unprofitable. Therefore, a **profitability limit for such exchange arises, based on similarity. Let's call the set of populations for which exchange is profitable a species**. Larger differences should develop defense mechanisms against statistically harmful exchange.

Local Test

Let's return to quasi-reproduction. The exchange of elements in quasi-integrons, with the growth of "better" ones and the decline of "worse" ones, creates a self-improvement mechanism for the whole, functionally corresponding to the population of integrons, but in the form of a unified "**super-integron**." Quasi-integrons are merely undivided sub-areas of a "super-integron". The criterion for separating a subarea appears with some change (e.g., the creation of component "A" from "a" with a better balance1, offering a changed balance2 of the area of occurrence of "A"). Interpretation problems arise here from the incompatibility of our object-oriented way of thinking with the concept of a quasi-integron as an improved object.

¹⁴ So far, I have tried not to use the term 'object' when referring to a set (integron) of objects, to make it easier to understand which level of integration I am referring to (especially in this chapter). An integron is also an object. Both a pool and a population are generally sets of objects, but here, in both cases, we are talking about integrons.

Let us call this mechanism a **local test**. It is an extreme form of test II, when there are no barriers dividing a large "super-integron" (corresponding to the population of integrons) into many integrons. Similarly, test II described earlier is an extreme form at the other end, when integrons well separated by barriers can be counted in numbers.

The lack of the concept of a local test was the main counter-argument to the Gaia hypothesis (Lovelock 1972; Lovelock, Margulis 1974; Margulis 1998).

Optimization of the mechanism of exchange of hereditary information

Optimization of exchange of hereditary information is a broad topic, encompassing many aspects, corresponding to broadly understood population genetics. Many known solutions from the eukaryotic sexual process results from easily identifiable, strong evolutionary pressures, which can be derived and demonstrated for implementation based on concepts already developed in this approach.

Immediately after the division, in both descendant integrons, the sets of types are identical, and the homologous types are identical. When these integrons meet after a longer period of variation, the sets may be "the same," but the corresponding homologous types may differ; let's call them "**alleles**" of a type. The names used here are intended to evoke biological knowledge for simplicity, but here they belong to the outline theory, and therefore do not conflict with biological definitions.

Occasional random migration of a member of one integron to another (e.g., plasmids) is already a sufficient mechanism for test II, but the frequency of these events is crucial. It can be assumed that one component determines a feature of the integron that influences its balance₂, but cooperation between several such members is more likely to be expected. Migration of an element of one type from an integron in which it is an important, modified element providing greater balance₂ will not necessarily produce this positive effect in the new integron, as there will be no other cooperating modified types. For the effect of allele transfer to be similarly positive for balance₂, it usually requires the simultaneous transfer of several other alleles, selected from the entire integron. This creates evolutionary pressure towards the simultaneous transfer of this complete subset. Determining such subsets and their simultaneous transfers requires complex mechanisms; a significantly simpler solution is the **fusion** of two entire integrons and the formation of a '**diploid**' integron, containing both complete sets of slightly different alleles.

If the diploid integron is **large**, and all the types are of considerable abundance, then immediately after fusion and mixing of the contents the integron may split, and both progeny will still be diploid. This 'statistical' mechanism has two distinct drawbacks in terms of the need for increasing balance₂: 1 – the impact of balance₁ may not be consistent with the needs of balance₂; 2 – the large number of random allele combinations, most of which reduce balance₂ (if it were the only combination), imposes 'costs' that reduce the chances of significantly increasing balance₂ in this way.

For **smaller** integrons, we expect f&f structures in which the farmer controls the completeness of the set of types during the division of the integron. This control can evolve in various ways, which creates the possibility of a '**controlled**' mechanism that eliminates both of the aforementioned drawbacks of the statistical mechanism. In f&fs, elements/tools can reproduce, but the farmer has control over this. By analogy, the exchange of content and set structure between farmers, such that each farmer receives a portion of its previous set and a complementary portion from the other farmer, is called '**crossing-over**'. After this, the integron may divide into two secondary f&fs. These will again be '**haploid**' integrons, but with mixed set contents. The completeness of the set of cooperating alleles will determine the balance₂.

The aforementioned structure of these sets can also help achieve exchange of entire cooperating sets. This mechanism, in its basic outlines, clearly **resembles meiosis** and the preceding fusion corresponding to fertilization. Let's call this entire mechanism of fusion of two integrons and "meiosis" with "crossing-over," which implements an optimized exchange of hereditary information, **hybridization**¹⁵, although this term has a slightly different meaning in biology. There is no evidence yet for gender differentiation or for linking this mechanism to reproduction. Both the "normal" haploid and diploid forms can reproduce by division according to the principles previously outlined.

The primordial integron – a model of biogenesis

The considered mechanism of integron assumed that its associated elements were #-objects. Although in the f&f approach, there were already associated abiotic objects without the trait of reproduction, the farmer was, however, a #-object. Produced abiotic tools acquire the trait of reproduction in f&f and can be treated as #-objects. The farmer test was useful for initiating f&f, but it is not necessarily the only mechanism for the formation of such an integron. Can an integron composed solely of such produced 'abiotic' tools arise independently without the participation of a 'farmer,' which already possesses the trait of reproduction? 'Utility' for the farmer was the basis

¹⁵ Here and below, the term 'hybridization', which is typically applied to closely related species, is understood as the generation of an offspring by two parents. Note, this is not yet a multiplication.

for controlling tool variability through the farmer test, but the integron is already affected, albeit weakly, from the outset by the test of the duration of the entire integron, which can serve as a reference point for this usefulness.

The components of this integron may be the products of independent abiotic processes, but the essence of the integron is interconnectedness, meaning that at least part of this production must be dependent on other members of the integron for it to constitute an integron. This creates the basis for the emergence of hypercycles (Eigen, Shuster 1979), mutually supporting the production of their components. Test of such integrons will select integrons that contribute the most, meaning they grow faster. **This can be a local test of quasi-integrons**, allowing the test to operate effectively without the need for actual division into multiple integrons.

In "Assembly Theory" by Sharma, Cronin, et al. (2023), new, increasingly complex, "discovered" objects are "assembled" along their own independent paths, but when used to assemble the next, more complex object, these paths merge, corresponding to the binding of elements into an integron. There is no multiplication here yet, but there is an increase in the number of highly complex objects with the most efficient assembly paths.

Quasi-reproduction results from the rate of production and growth of the super-integron. **Normal reproduction** occurs, as before for integrons, when environmental barriers, and then species barriers, arise. This picture resembles biogenesis. The integron in question is quite unique in its mode of origin; let's call it a '**primordial integron**.' Ługowski (2017) recalls Haldane's earlier statement: "It is not impossible that two or more different kinds of life began independently." An example is the membranome (Cavalier-Smith 2000, 2004), which is a mechanism for the inheritance of cell membranes and cytoskeletons, separate from the genetic one.

The primordial integron that successfully resulted in biogenesis already possessed the characteristic of sufficient (quasi-)reproduction speed from the beginning of its existence. At this stage, it is the growth of the integron of the tools only, which can be identified with biocatalysts. "The origin of life and the evolution of biocatalysts are inextricably linked," argue Vitas and Dobovišek (2025) in their latest paper, pointing out the great complexity of this prebiotic environment—many alternative, diverse, and mixed integrons barely emerging from this 'Darwinian soup.' However, these original integrons are already subject to local testing, i.e., the Darwinian mechanism (Pross 2011). The term 'reproduction' turns out to have a much broader meaning in these arguments than we might have initially expected.

6 Colonization - binding during reproduction

Colonization and the colony

General and true colony

Reproduction leads to an increase in the number of highly similar organisms, for example, those belonging to the same species. Their distribution in the environment is not necessarily uniform, even if this number is based on the carrying capacity of the environment. On the one hand, there is competition for limited resources. On the other, some goals may be shared, such as competition with other species, which can be the basis for cooperation. This cooperation creates integrons of single species, but not necessarily closely related objects. Let's call such a integron a **general colony**, and the process of such integration **general colonization**. A prime example is the flock.

Consolidation of a parent object during reproduction, i.e., the strengthening and prolonging over time of the links between a descendant object and its parent or sister objects, which are broken during reproduction, **is a narrower process, producing a similar effect, but more powerful** and with interesting consequences. **In this case, the support for binding results from the test of the dividing parent object and simultaneously from the test of the integrated object, as they are essentially the same evolving object – so there are no conflicting interests**¹⁶. Let's call this mechanism/process **proper colonization**, and the resulting integron a **proper colony**. A proper colony is a general colony, i.e. it is also formed by integration and is a integron, but not every general colony is a proper colony. A colony, like any integron, must reproduce to be subject to the test of wholeness.

By the term 'colony' here, we mean the result of the colonization process, regardless of its advancement, not just its early stage, commonly referred to as such. As we know, the processes of integration and consolidation of a integron continuously flow into one another, creating a single, cohesive process. **A proper colony is therefore an integron of sister objects** to the integration and a **continuation of the parent object** to the consolidation.

Tool colony

We can use the above definitions (understood somewhat loosely) for tools. The emergence of a high density of very similar objects can result from tool production. The possibility of considering tools as #-objects allows us to consider their integration. As components of f&fs, they are also subject to consolidation. As a result, structures that repeatedly repeat the same component element are formed in a farm, which is part of a f&f. This is how we should interpret apartments in an apartment building, apartment blocks in a housing development, housing estates in cities, a chain of stores owned by a certain company. A shopping center is no longer a colony, but a integron of stores of various types (species). A car was manufactured by a factory, and its connection to other cars of the same

¹⁶ Nowadays in biology this factor is called kin selection.

brand is supposedly breaking, yet marketing, parts stores, and specialized service stations continue to bind them, and gas stations and roads bind cars of different brands, affecting their usefulness and quantity. The decline in demand for apples of variety x does not mean the removal of orchards of variety y—these are separate colonies with different fitness levels. They reproduce because they take the place of orchards of variety x, and there will be more of them. After all, an orchard is a tool of the farmer.

Internal specialization, task division

In a typical integron, i.e., not a colony, the types of constituent elements differ, and the signals they emit are (at least partially) different by nature, which differentiates their importance within the integron from the very beginning. This is an extremely simple model of the division of tasks that must be performed for the integron to survive. In this respect, the 'interest' and its test of the entire integron are crucial. Specific signals – the effect of completed 'tasks' – are better interpreted as certain substrates necessary for other integron elements to function properly. The first source of the observed task division indicated here is not a tendency towards specialization, as this effect is no different from a random event. Here, task division does not arise, but rather is the reason for the formation of the integron.

However, a biotic environment develops within the integron, which releases variability and allows for further specialization of its elements, leading to further task division. Despite the differences in the types of objects within the integron, many of them can produce similar substrates, the production of which may be neglected by their neighbors, but within types there are usually many identical objects. In a colony, the objects are almost identical, and each certainly initially produces all substrates in the same way, so the extraction from its neighbor is waiting to be exploited. Freeing a given mechanism from the need to produce a specific substrate allows for its variability, which can lead to the invention of something else, also useful, but for slightly different purposes. Freeing a given component object from the need to reconcile sometimes conflicting tasks allows for the intensification of the production of the remaining substrate. In this way, the colony loses its uniqueness (in this respect) and transforms into a regular integron; the colony's uniqueness remains in the aspect of reproduction.

This leads to the network growth formula: "duplicate and modify," which seems more adequate to describe biological objects than the scale-free (Barabási et al. 1999) or single-scale (Albert, Barabási 2002) rules adopted in simulations of structural tendencies (Gecow 2024f).

Internal reproduction, sublevels of colonization

Even at the beginning of colonization, a colony must have acquired the ability to reproduce by at least one mechanism. Reproduction puts colonization to the test. This could occur through division, as in an integron, but also through complete separation after a single colony component reproduces. This initial object recreates the colony through its growth, roughly repeating the stages of colonization, but this time in a controlled manner, not randomly, as was the case during the variability that created colonization.

The subsequent colonization process, which binds colonies together during their reproduction, can be interpreted as colonization2 of colony1, resulting in a repeated structure of colony1 – an integron of differentiated original sister objects forming a new whole. Regardless of whether this mechanism of colony1 reproduction ever produced completely separated colonies (external reproduction) or whether such an evolutionary phase did not occur (internal reproduction), the resulting structure of colony2 is virtually identical.

The degree of independence achieved after duplication/reproduction strongly influences our assessment of what constitutes a higher-level integron. Despite the appearance of new rings/segments (during growth after reproduction), the annelid remains the same, tightly connected object. The process of bonding structures called segments is barely visible, so we tend to consider the segment a sub-level of integration, rather than the annelid a higher level. However, this is a subjective assessment, which is worth noting. A budding polyp appears almost independent, so the coral colony is already perceived by us as a higher-level integron. The segmentation of the annelid was likely created by the mechanism of internal reproduction, although it may be related (in the form of a mechanism) to the strobilization of the polyp into a medusa, in which case it constitutes absorbed external reproduction. In arthropods, the entire colony is a colony2 of colonies1 segments that have undergone internal specialization (relative to colony2) and diversified tasks.

Reproduction is an algorithm of self-multiplication—self-similar structures, or fractals, are created. This is only visible when the parent and daughter objects do not mechanically separate after duplication, and the sister objects do not undergo differentiation, i.e., internal specialization. Typically, this is an incomplete division into two. Examples of this structure include plants, especially the simplest ones, such as liverworts and ferns, but also animals such as corals and most Edicarian fauna. The growth of the number of subsequent segments differs here only in the number of daughter colonies1.

Ontogeny

Let's assume that integron1 with hybridization undergoes proper colonization2. The exchange of hereditary information through this hybridization is optimized, but it applies to integron1, not colony2. Specialized elements

do not appear immediately after this, and their exchange between colonies² occurs even later. This exchange initially is at an early stage, not yet optimized, and colony² loses the specific properties of the colony – we have already considered the evolution and reproduction of such an integron.

Let's consider the reproduction of a colony not by division, but by a **single integron1, which in this situation must carry full information about colony2**, that is, the achievements of this colonization², along with the division of tasks among its components and the algorithm for reproducing the properties of its mature form. Let's call the process of reproducing this complex colony (from a single integron1 after hybridization) **ontogeny**. The loss of this old acceleration mechanism without a ready-made new one results in a loss in competition, so at the beginning of colonization², this form of reproduction stabilizes. The second integron1, to be fused during hybridization, must come from a different colony. For test II to assess the effects of the new composition, the altered integron1 during the hybridization should form a new colony. We will call this reproduction **'generative,'** and reproduction by colony division **'vegetative.'** Both mechanisms can be used in any proportion, which will, however, be controlled by the test. Reconciling both forms in more complex colonies will be rather difficult, and abandoning the vegetative form is a smaller loss.

Note: ontogeny is not colonization, although it is usually confusingly similar. **Colonization** is a long, adaptive evolutionary process, more generally called **phylogeny**, which, through **random changes**, 'invents' a complex colony form, adapted to the environment. In the description of covering (Gecow 2024f), we called such a form the **mature form (mf)**. **Ontogenesis** is a process **controlled** by a portion of so accumulated purposeful information, which distinguishes it from **randomly** created colonization. The information about the transformations that constitute ontogeny is largely¹⁷ contained in the initial integron1 (**primordial form - pf**), which initiated the reconstruction of the colony. This, as hereditary information, was exchanged during **hybridization**.

The emergence of ontogeny resulting from the need to maintain acceleration through hybridization during colonization is a statistically expected phenomenon, similar to the structural trends discussed earlier. This is an important conclusion that significantly complements the mechanism resulting from covering.

The rate of evolution of a species, crucial in competition, depends on the timing of the influx of the same set of alleles. This creates a need to limit the duration of reproductive capacity, and such an object then occupies a limited place in the environment, i.e., creates the need for **"death of the individual."** The condition of set variation favors the diploid phase for the initial pf and its clones forming the colony. This, after varying degrees of mixing during meiosis (including crossing-over), creates unequal haploid "delegates" to fuse with a delegate from another colony to form a new initial pf of the daughter colony. Mixing, however, is not the primary mechanism of allele formation; its role is to ensure the proper selection of cooperating alleles. Delegates at the end of ontogeny are expected to retain their full hereditary information; they cannot lose anything during internal specialization (final mf), which imposes the conditions for the specialization of integrons1. With greater differentiation, the simplest method is to create a strand of integrons1 specialized in maintaining pf (with precision down to meiosis), which frees the remaining integrons1 from maintaining this ability, facilitating their specialization. This is how the **soma** is formed.

The deductively obtained picture of ontogeny is remarkably similar to that known from biology, especially higher animals. It's no wonder, it was constructed according to this "cheat sheet."

Summary

This article is a long abridgement of the main part of chapter 5 of the book (Gecow 2024a). The title "higher-order integron" does not refer to its typical meaning in genetics, but rather to a more general one related to the levels of organization of living objects. The proposed perspective for describing the phenomena and mechanisms leading to the emergence of subsequent levels of organization is rather new in biology, particularly due to the currently prevailing view that if a phenomenon can be explained by known lower-level mechanisms, then you shouldn't look for explanation on a higher level. Group selection is usually questioned; only kin selection has gained recognition. The presented approach identifies mechanisms that should be classified as group selection and considers their impact on the evolution of structure. References to selection at the level of genes or cells are possible and encountered (e.g., the selfish gene of Dawkins 1976), but using this mechanism to explain selection, for example, at the mammalian level is rather excessive.

The binding of objects into a higher-level integron is subject to separate, sometimes contradictory, pressures resulting from tests by natural selection at both levels. Initially, the influence of the lower level dominates, slowly giving way to the gradually emerging role of selection at the higher level. Here, the mechanisms resulting from selection are consistent with a general increase in entropy, which equalizes the density of connections, blurring the distinctness of objects in the environment.

¹⁷ The remaining channels of information reproducing mf are subsequent layers of the cover.

Depending on the configuration components of the considered higher-level integron, the influence of selection can be viewed differently. Adopting the perspective of the object (reproducing and subjected to selection), we obtain the image of a "farmer" subjugating part of the environment, primarily as cover (considered in the previous article in this series (Gecow 2024f)). The managed part of the environment (the one over which the farmer exerts influence, increasing its fitness) constitutes its "farm," but the boundaries of this farm are poorly defined, suggesting the nature of the boundaries of the integron as a higher-level object. This image is captured by Dawkins (1982) in the concept of extended phenotype. An interesting consequence of this approach is that passive objects (called tools) obtained from the environment constitute a farm. These can also be objects subjected to their own selection (biotic), but also abiotic, which, during the reproduction of the integron—the "farmer and farm" (as a result of the farmer's reproduction), acquire the characteristics of evolving "living" objects.

If we adopt the perspective of selection of equal objects, we obtain a somewhat different form of integron. Such an integron grows because its component objects reproduce and, for various reasons, divides into descendant integrons. The exchange of similar components between similar integrons creates a powerful accelerator of adaptation—a mechanism for the exchange of hereditary information that creates a population. The problem of ensuring the participation of all types of component objects after division, along with systematizing exchange, leads to optimization pressures that provide a solution similar to fusion and meiosis, creating generative reproduction.

This mechanism of accelerated selection can occur in a large, homogeneous integron, even in its subdivisions, even those separated by nothing other than the presence of randomly modified components. This creates a "local test" that can explain phenomena in ecology. Another specific integron is the "primordial integron," whose integration begins without the presence of a reproducing object already subjected to selection. Here, from the beginning, only integron-level selection occurs, which is initially weak and may be a local test—such a case describes biogenesis.

A very common example of integration is "colonization"—the binding of related objects, even during reproduction. This creates a colony (e.g., a multicellular animal or plant). The need to maintain the acceleration present at a lower level gives rise to ontogeny, modeled in the previous article in this series (Gecow 2024f).

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