

# ***Looking Again at Teilhard, Tillich, and Haught***

## TEILHARD'S TWO ENERGIES

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*Abstract.* Resolution of the entropy-evolution problem was a significant issue for Pierre Teilhard de Chardin throughout his scientific career. Although never truly satisfied with his solution, he proposed that all energy must be psychic and contain two components. Tangential energy is related to physical energy. Radial energy in some way accounts for increasing complexity and consciousness in evolution. Analysis of developments in thermodynamics, statistical mechanics, and information theory show that Gibbs free energy contains both calorimetric and noetic components, thus validating Teilhard's intuition.

*Keywords:* complexification and centrogenesis; entropy and negentropy; free energy; hyperphysics; information; tangential, radial, and psychic energies.

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No concept of Pierre Teilhard de Chardin has been subject to greater criticism and derision than the problem of the two energies. A major scientific question for Teilhard was the organization of energy during cosmic and biological evolution. The purpose of this essay is to point to the validity of Teilhard's intuition as demonstrated by subsequent developments in

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statistical mechanics and information theory. The derision was at times mean-spirited and did not show an understanding of the deep thermodynamic and statistical mechanics that underlay the difficult problems of bioenergetics that troubled Teilhard.

To understand the roots of the paradox faced by Teilhard, we go back to the mid-1800s when in the same decade (1850–1860) Charles Darwin and Alfred Wallace developed the theory of evolution, and Rudolf Clausius and William Kelvin independently stated the second law of thermodynamics. These two principles immediately appeared to be in contradiction; physics seemed to be saying that the world was becoming more and more disorganized, while biology seemed to be saying that the world of life was becoming more and more organized and complexified.

Although this conundrum was solved by Ludwig Boltzmann in 1886, his solution was ignored by physicists and probably unknown to most biologists. Teilhard was probably unaware of Boltzmann's words:

The general struggle of living beings for existence is therefore not a struggle for materials nor energy (that is present in every body and in large quantity as heat, unfortunately not interchangeable) but a struggle for entropy [following Schrödinger we would regard this as negentropy] that becomes available in the transition of the energy from the hot sun to the cold earth. To exploit this transition as much as possible the plants spread out the immeasurable areas of their leaves and force the solar energy in an as yet unexplored way to carry out chemical syntheses of which we have no idea in our laboratories. (quoted in Broda 1978, 3)

Most biologists were either unaware of or did not face the resolution of the entropy-evolution problem until the second half of the twentieth century, and some are still unaware of it. Teilhard over his career faced this issue. In Part 1 we describe Teilhard's struggle with this problem and his solutions without final resolution. In Part 2 we trace the historical development of a noetic aspect of energy within the sciences of thermodynamics, statistical mechanics, and information theory. We conclude by pointing out the remarkable prescience of Teilhard's intuition despite its scientific ambiguity.

## PART 1

The concept of energy in evolution was a constant theme in Teilhard's private journals and essays. His scientific research, which included ten volumes of technical publications in geology and paleontology, supported his intuition that matter-energy is more than purely inert stuff. Observations and extensive reading about communication in nature, especially among organisms, led him to the realization that, besides the obvious emergence of consciousness and freedom, there is an increasing flow of information taking place during evolution. It is significant that most of the essays and private journals referred to here were not published until after Teilhard's death in 1955.

In the introduction to her splendid new translation of *The Human Phenomenon*, Sarah Appleton Weber writes: “The subject of the human phenomenon was developed by Teilhard in three earlier essays of 1925, 1926, and 1930, and it became the pivotal point for all his thought” (Teilhard 1999, xviii).<sup>1</sup> By 1938–1940 Teilhard was forced to clarify his thoughts about energy when he finalized previous drafts of his worldview. He wrote:

No concept is more familiar to us than spiritual energy. And yet nothing remains more obscure to us scientifically. On the one hand, the objectivity of the effort and work of the psyche is so certain that the whole of ethics resides in it. And on the other, the nature of this interior power is so impalpable that the whole of mechanics could be built up without it. (Teilhard 1999, 28)

Because of the inadequacy of the two laws of classical thermodynamics, of conservation and dissipation, to explain the human experience of energy, Teilhard proposes two aspects:

There is no doubt that material energy and spiritual energy hold together and are prolonged by *something*. Ultimately, *somehow or other*, there must be only a single energy at play in the world. . . . ‘To think we must eat,’ once again. But on the other hand, so many different thoughts come out of the same piece of bread! . . . The two energies—physical and psychical—spread respectively through the external and internal layers of the world behave on the whole in the same way. They are constantly associated and somehow flow into each other. But it seems impossible to establish a simple correspondence between their curves. (1999, 29–30)

This association of a noetic aspect to a purely material (traditional) understanding of energy forced Teilhard to introduce a new model:

We shall assume that all energy is essentially psychic. But we shall add that in each individual element this fundamental energy is divided into two distinct components: a *tangential energy* making the element interdependent with all elements of the same order in the universe as itself (that is of the same complexity and same “centricity”): and a *radial energy* attracting the element in the direction of an ever more complex and centered state, toward what is ahead.\*

\*Note, by the way, that the less centered an element is (that is, the weaker its radial energy), the more its tangential energy is shown through powerful mechanical effects. Between strongly centered particles (that is, particles with a high radial energy), the tangential seems to become “interiorized” and to disappear, in the eyes of physics. (Teilhard 1999, 30; the \* designates a footnote added by Teilhard)

A caution to the reader prefaces this model to understand energy: “Of course the considerations that follow do not presume to provide a truly satisfactory solution. Their purpose is simply to show, from one example, what line of research in my opinion should be adopted by an integrated science of nature and what type of explanation the science should pursue” (1999, 29).

“More naturalist than physicist” (1999, 11), Teilhard’s model introduces a potential research program that bridges science and philosophy to investigate “the axis and arrow of evolution” (1999, 7). He calls this new “science of nature” hyperphysics: “Take any major book written about the

world by one of the great modern scientists such as Poincaré, Einstein, Jeans, and the others. It is impossible to attempt a general scientific interpretation of the universe without *seeming* to intend to explain it right to the end. But only take a closer look at it, and you will see this 'hyperphysics' still is not metaphysics" (1999, 2).

Teilhard's studies in philosophy and theology early in his career supported an intuition of two energies as it developed in his own mind. Along with early versions of *The Human Phenomenon*, comparison of the traditional energy of physics to a psychical energy, especially human energy, is found in other early essays. For example, in "The Spirit of the Earth" (1931) he writes, "Love is the most universal; the most tremendous and the most mysterious of the cosmic forces" (Teilhard 1969, 32), and "Love is a sacred reserve of energy; it is like the blood of spiritual evolution" (1969, 34); in "Christianity in the World" (1933), "Through man, an ocean of free energy (an energy as real and as 'cosmic' as the others with which physics is concerned) sets out to cover the earth" (1968, 99); in "The Evolution of Chastity" (1934), "The day will come when, after harnessing the ether, the winds, the tides, gravitation, we shall harness for God the energies of love. And on that day, for the second time in the history of the world, man will have discovered fire" (1975, 86–87); in "Human Energy" (1937), "By the energy of man I here mean the always increasing portion of cosmic energy at present undergoing the recognizable influence of the centres of human energy" (1969, 115).

Teilhard finished an essay in December, 1944, "Centrology," that manifests advancement in his thought about two energies. The essay expands and clarifies the development of his intuition between 1938 and 1944 and is fundamental to Teilhard's understanding of both energy and matter.<sup>2</sup> "Centrology" clarifies the interdependence of each "individual element" of the same complexity (and therefore centrality) in *The Human Phenomenon*.

1. As the foundation for the whole edifice of propositions that follow we have an intuition and two observations:

a. *The intuition*: In the swarming multiplicity of living elements (monocellular and polycellular) which make up the biosphere, we find an authentic continuation of the granular (atomic, molecular) structure of the universe. In consequence, if the human body is restored to its position in the cosmic corpuscular series, it is simply a "super-molecule": once we see it in this light, we are in the happy position of being able to distinguish in that super-molecule, the properties in a "magnified" state, of *every* molecule.

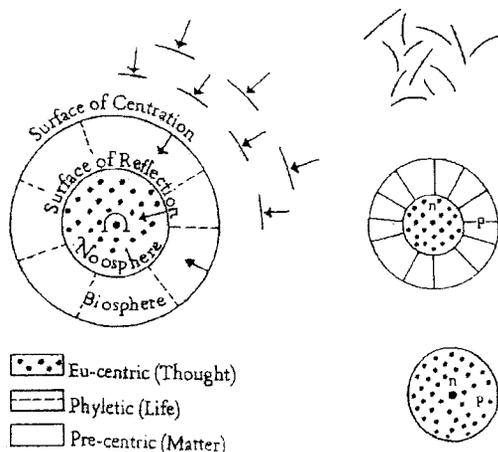
b. *The observations*: Man, the final product of planetary evolution, is both supremely *complex* in his physico-chemical organization (measured by the brain), and at the same time, viewed in his psychism, supremely *free* and *conscious*. (Teilhard 1970, 101)

Because of an innate fondness for diagrammatic portraits of his thought, Teilhard clarifies the "intuition" in a diagram (Figure 1).

The three principal zones of the evolutionary process are represented that engender consciousness and reflection. The left sketch outlines the general process, and the right explains each stage of the process in more detail. The diagram subdivides the zones of concentric isospheres that represent three levels in the process of evolution: preliving (Matter), biosphere (βίος—life), and the “magnified” state of reflection (Thought), what Teilhard calls noosphere (νοῦς—mind). This division of zones expands and clarifies his general understanding of the meaning of “elements” in his introduction of two energies in *The Human Phenomenon*. The top right sketch in Figure 1 illustrates fragments of preliving matter. The fragments are open at each end, offering a sort of curvature. At this level of disjunction of fragments, there is only a disposition to come together and to fit in with one another, not by intention but through the play of chance. This aspect of matter again recalls Teilhard’s division in *The Human Phenomenon* of the two energies in all elements of matter:

At every degree of size and complexity, cosmic particles or grains are not simply, as physics has recognized, centres of universal dynamic radiation: all of them, in addition (rather like man), have and represent a small “within” (however diffuse or even fragmentary it may be) . . . in which is reflected, at a more or less rudimentary stage, a particular representation of the world: in relation to themselves they are psychic centres of the universe. In other words, consciousness is a universal molecular property; and the molecular state of the world is a manifestation of the pluralized state of some potentiality of universal consciousness. (Teilhard 1970, 101)

Just as Teilhard noted in his footnote to the introduction of the two energies in *The Human Phenomenon*, quoted earlier, tangential energy has



**Fig. 1.** Complexification process: “Diagram symbolizing the principle phases of centrogenesis (convergence of the universe along its axis of centro-complexity or personalization,” from Pre-centric (Matter) to Eu-centric (Thought) (Teilhard 1970, 100).

the dominant role in these preliving fragments, although the psychic energy aspect is always present, no matter how small the element. Teilhard writes, "It is at this preliminary phase of centrogenesis that practically the whole of time and space is *quantitatively* employed: the reason for this being precisely, perhaps, that in order to bring about the appearance of the 'first improbable' the play of large numbers needs a more extensive laboratory for its experiments" (1970, 102).

Although his accuracy of measurements is according to 1944 standards, the principle remains: "While it [consciousness] is completely imperceptible to our observational methods below an atomic complexity of  $10^5$  (the virus), it can be plainly detected when we reach that of the cell ( $10^{10}$ ); but it enters its major developments only in the brains of large mammals ( $10^{20}$ ), in other words when we have atomic groupings astronomic in order" (Teilhard 1970, 102).

The "intuition" that is developed in "Centrology" links the description of physical and psychic energies with the description of tangential and radial energies, respectively, in *The Human Phenomenon*. Teilhard continues to maintain, "The behaviour of these two energies (physical and psychic) is so completely different, and their phenomenal manifestations are so completely irreducible, that we might believe they derive from two entirely independent ways of explaining the world" (1970, 120). However, he continues to see a hidden connection between the two energies: "Nevertheless, since they both carry through their evolution in the same universe, in the same temporal dimension, there must surely be some hidden relationship which links them together in their development" (1970, 120).

The application of isospheres to evolution in "Centrology" proposes a solution to a problem Teilhard found in his more simple description of tangential and radial energies in *The Human Phenomenon*: "The only difficulty with this perspective, where tangential energy represents the abbreviated view of 'energy' habitually considered by science, is to explain the play of tangential arrangements so that it is in harmony with the laws of thermodynamics" (1999, 31). At this point in *The Human Phenomenon* he was seeking to recognize: "The fundamental discovery, that all bodies derive, *by arrangement*, from one initial corpuscular type is the flash that lights up the history of the universe for our eyes. From the beginning, matter has, in its own way, obeyed the great biological law of 'complexification' (a law we shall return to again and again)" (1999, 17–18).

In "Centrology" Teilhard questions his intuition, although he is convinced of a need for more detail than was offered by physics to understand the two energies experienced in an evolutionary world:

From the point of view of centrogenesis, in short, everything floats on a tide of convergent psychic energy which rises both qualitatively and quantitatively from isosphere to isosphere, in step with personalization. This being so, what is the relationship between this interior energy, always increasing and always more

“amorized”, and the goddess of energy worshipped by physicists—an energy that is always constant and at the same time (by dissipation) always more “calorized”? (1970, 120)<sup>3</sup>

To answer his question, he returns to the distinction between preliving cosmic elements (Matter) and elements inside the surfaces of centration in Figure 1 (Life and Thought):

Omega cannot act *internally* (nor, in consequence, by attraction *ahead*) on elements of the first type, since their centres are not yet individualized. It must, therefore, set them in motion *a retro* and by some sort of external impulse. Everything, *in fact*, behaves as if this setting in motion bore the characteristic of a single impulse, productive of a definite “quantum” of actions; this is precisely the energy, subject to conservation and dissipation with which physics is concerned. (1970, 121)

In general, Teilhard has seen Omega as a point of attraction in the universe, and so he sees a contradiction of inserting the “motion *a retro* [from behind].”<sup>4</sup> He adds in a footnote:

This is one explanation, but is there not another, which is simpler and fits in more smoothly? Let us admit that the attraction of Omega can make itself felt internally, even in the fragmentary (pre-living) centres (psychic energy . . .). In that case could not physical energy (and its over-all conservation) be interpreted as the statistical “by-product” of a great number of elementary psychic energies (energies of atoms) which combine tangentially . . . with practically no variation in number—just as the regularity of physical laws (the determinisms of matter) is explained by the statistical play of a great number of infinitesimal, inorganic, free impulses . . . ? From this point of view, one would have to say that everything in the universe (back to the most distant isospheres) moves in one and the same internal stream, emanating from Omega: *physical energy* being no more than *materialized psychic energy*. (1970, 121)

To summarize, in *The Human Phenomenon* all energy is psychic energy and is composed of two parts, radial (the axial energy of evolution) and tangential (the energy of physics). The two parts of energy seem to be equal at this stage. Four years later, in “Centrolology,” Teilhard classifies the two energies into psychic and physical components. However, the physical component is now “materialized psychic energy.” Thus, all energy is essentially psychic, although energy continues to be made up of two components.

The intention to apply the synthetic vision of two energies in “Centrolology” to the process of interiorization and unification of matter is manifest in succeeding relevant essays: “The Analysis of Life,” dated 10 June 1945, Peking (Teilhard 1970, 131–39); “Life and the Planets,” a lecture at the French Embassy in Peking 10 March 1945 (Teilhard [1946] 1964a); and “The Planetisation of Mankind,” dated 25 December 1945, Peking (Teilhard [1946] 1964b).

Teilhard never stopped thinking about the issue of two energies to explain evolution. His private journals and later essays reveal that he also never was fully satisfied with his definition of the two energies.

In his essay “The Singularities of the Human Species” ([1954] 1965) Teilhard reveals again his concern about the two aspects of energy. He distinguishes psychical or radial energy from physical or tangential energy, the former “escaping from entropy,” the latter obeying the laws of thermodynamics. Here two energies are not directly transformable but are interdependent in their function and evolution. His concept of the radial aspect of energy is that it increases with the arrangement of the tangential, but the tangential only arranges itself when prompted by the radial. Thus the fundamental interpretation of the two energies that includes a noetic aspect is retained and does not seem to be very different from the original analysis in *The Human Phenomenon* (Teilhard 1999, 30).

The depth of Teilhard’s knowledge of classical thermodynamics is uncertain. Although he discussed and used the formalities of chance and statistics within evolutionary theory, there is no indication of his familiarity with formalities used in statistical mechanics. He comments in the private journals about his readings of many contemporary scientific authors. His positive review of Erwin Schrödinger’s *What Is Life?* was published in *Revue des Livres* in 1950. Reading Norbert Wiener’s *Cybernetics* in 1951 stimulated and verified his interest in information as a component of the evolutionary process. In a 1953 essay, “The Activation of Human Energy,” he refers to a review by Louis de Broglie, “La Cybernétique” (1953), and concludes:

We still persist in regarding the physical as constituting the “true” phenomenon in the universe, and the psychic as a sort of epiphenomenon. However, as suspected (if I understand them correctly) by such coolly objective minds as Louis de Broglie and Léon Brillouin,<sup>6</sup> surely, if we really wish to unify the real, we should completely reverse the values—that is, we should consider the whole of thermodynamics [as an] interior energy of unification (true energy) gradually emerging, under the influence of organization, from the superficial system of action and reactions that make up the physico-chemical.

In other words, there is no longer just one type of energy in the world: there are two different energies—one axial, increasing, and irreversible, and the other peripheral or tangential, constant, and reversible: and these two energies are linked together in “arrangement”, but without nevertheless being able either to form a compound or directly to be transformed into one another, because they operate at different levels.

We may well wonder whether, if we refuse to accept such a duality (which is no dualism!) in the stuff of things, it is scientifically conceivable that a universe can function, from the moment when it *reflects itself upon itself*. (Teilhard 1970, 393)

The suggestion to reconsider a “gradual emerging” energy, axial in nature, within “the whole of thermodynamics” indicates the value of Teilhard’s long-held intuition. His propositions about two energies that were based on his scientific research and experience observing communication in nature had reached a level of maturity that also seems to validate what has been subsequently shown, described next in Part 2.

## PART 2

In this part we develop the thermodynamics, statistical mechanics, and information theory from 1875 to 1957 that provides a background to understanding Teilhard's two-energies viewpoint.

In a series of papers published from October 1875 to May 1876, Josiah Willard Gibbs developed the foundations of chemical thermodynamics (Gibbs 1875–1876, 108–248). He introduced a number of energy functions, including (in Gibbs's notation)

$$\begin{aligned}\chi &= u + pv \\ \zeta &= u - TS + pv\end{aligned}$$

$T$ ,  $S$ ,  $u$ ,  $p$ , and  $v$  are the conventional thermodynamic variables: temperature, entropy, total energy, pressure, and volume. The conservation of energy is usually given as the first law of thermodynamics,  $du = dq - pdv$  (change of energy is heat in,  $dq$ , minus work done,  $pdv$ ). We can combine the above to get

$$d\chi = dq + vdp$$

$\chi$  is now called the enthalpy and at constant pressure measures the heat change. In modern usage  $\chi$  is usually noted as  $H$ .  $\zeta$  is now called the Gibbs free energy and is represented as  $G$ .

$$d\zeta = dq + vdp - TdS - SdT$$

At constant pressure and temperature this becomes

$$d\zeta = dq - TdS \text{ or } dG = dH - TdS$$

$G$  is the function used in biochemistry, because its minimization for a system under consideration leads to global entropy maximization in accordance with the second law of thermodynamics. Note, however, that as early as 1876 the Gibbs free energy could be represented as the sum of two terms: one the calorimetric enthalpy and the second dependent on the enigmatic negentropy,  $-S$ . As early as 1876, there were thus two components of energy within the formulation of conventional thermodynamics.

In the late 1800s Boltzmann and Gibbs created statistical mechanics, which enabled the development of the equations of thermodynamics starting from molecular mechanics. In 1902 Gibbs introduced the thermodynamic probability of a state as

$$W = N! / \prod_e N_e!$$

where  $e$  designates the  $e^{\text{th}}$  element of phase space and  $N_e$  the number of members of the ensemble in that state. An element of phase space was determined by the positions and momenta of all the atoms in the system. The ensemble consisted of the very large array of systems, macroscopically identical but varying in the microscopic details of the coordinates of the atoms. It is averaging over the ensemble that is the statistics of statistical mechanics. Gibbs then postulated that

$$S = k \log W$$

and was able to show that with the appropriate choice of  $k$  (now known as Boltzmann's constant)  $S$  is identical to the entropy of classical thermodynamics to within an additive constant. Then

$$S = -k N \sum w_e \log w_e$$

where  $w_e = N_e / N$ , and  $w_e$  is the probability of being associated with the  $e^{\text{th}}$  element of phase space (Page 1929, 399).

With the development of quantum mechanics,  $p_i$  is the probability of being in the  $i^{\text{th}}$  quantum state and the entropy is

$$S = -k \sum p_i \log p_i$$

This provided an absolute value for the entropy and removed the additive constant.

Schrödinger published *What is Life?* in 1944 in which he followed up on Boltzmann with the notion that organisms live by eating negative entropy (Schrödinger 1944, 72–73). He attempted to resolve the points of view of biology and physics, stressing the informational nature of genes and hereditary transmission.

In 1948 C. E. Shannon introduced a measure of the information of a message generated by a sender with a probability of  $p_i$  for the  $i^{\text{th}}$  message (Shannon and Weaver 1949). This measure is proportional to  $-\sum p_i \log_2 p_i$ . Therefore the thermodynamic entropy and information theory entropy have the same functional form. Note that the information is measured by logarithmic to the base 2, while entropy is measured by logarithmic to the base  $e$ . These are related by a multiplicative constant.

In 1957 in an important paper E. T. Jaynes was able to put together the results of seventy years of investigation. He noted that

$$I = -\sum f_i \ln_2 f_i$$

is the information that an observer would be missing about the micro state, if he knew the macrostate. Converting to log to the base  $e$ , we get

$$I = -1.44 \sum f_i \ln f_i$$

therefore

$$\begin{aligned} S &= -k \sum f_i \ln f_i \\ &= 0.693 k I \end{aligned}$$

Entropy is thus proportional to missing information about the quantum state of a system when we know the macroscopic parameters. Thus  $TS$ , an energy, has a psychical or cognitive aspect as it deals with the observer's knowledge. Jaynes concludes, "thus entropy becomes the primitive concept with which we work, more fundamental even than energy" (1957, 629). This relation between the observer and system characterized a profound change in physics between the nineteenth and twentieth centuries.

Thus, in agreement with Teilhard, the modern view is that the Gibbs free energy has two additive components, one calorimetric and one informational bordering on the noetic. The Jaynes paper thus validates Teilhard's intuition.

## CONCLUSION

Examples from his essays manifest Teilhard's lifelong groping to explain the phenomenon of complexification and communication in nature that he observed. They also manifest his awareness that the classical interpretations of thermodynamics were not yet able to discuss evolution adequately. This required the insights and profound analyses of statistical mechanics and information theory. As he tried to clarify in his own mind this question of how to explain energy in evolution, he wrote in his private journal in 1951: "*Question encore obscure* [topic still unclear]." But his insight into how evolution takes place should serve as a lesson to those who have been prematurely critical of Teilhard's two energies.

## NOTES

A version of this essay was presented at the Tillich and Teilhard Session of the North American Paul Tillich Society Meeting held during the American Academy of Religion Meeting, Atlanta, Georgia, 21 November 2003.

1. An obvious example of early English mistranslations of Teilhard's works was "man" for Teilhard's French word *humain*.

2. For a detailed analysis in English see Salmon 2005. A thorough appraisal of Teilhard's writings on Urstoff (basic stuff) is found in Schmitz-Moormann 1956, 156–57.

3. Teilhard uses the French word *dégradation*, not *dissipation*, to portray the constant increase of disorganized energy (entropy). *Amorized* may be defined as "the activation during the course of evolution (Cuénot 1968, 40). *Calorized* is a word coined by Teilhard to portray the increase in entropy.

4. Omega, for Teilhard, can be looked at under two aspects: "1) under the aspect of emergence, a center defined by the ultimate concentration of noosphere upon itself; a natural point of convergence of humanity and consequently of the entire cosmos; a term of the social and spiritual maturation of the Earth. 2) under the transcending and preexisting aspect, Omega is one of two visible poles of God, that is to say God as end of creation acting by mediation of Christ-Omega. In fact both poles of God, Alpha and Omega, beginning and end, coincide with the divine unity and eternity" (Cuénot 1968, 138–39).

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