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DYNAMICS OF DISSYMMETRY

It is not impossible, it is almost inevitable, to conjecture the existence of laws so general that their jurisdiction would be affected neither by the nature nor the scale nor the level of their object—so that they would apply equally to the relations of numbers or of inert or organic matter, to the progression of rigorous thought or the flights of an amused or charmed fancy.* If such laws did not govern the whole extent of the real, possible or conceivable world, or if, although autonomous, they could not be inferred from one another by some system of relations or transfers, I fear that human reflection, in spite of its partial successes, might seem condemned to reveal itself vain, since gaps, or fundamental absences of relationship, could put its cogency into question in a decisive fashion.

The only intelligible universe is one whose elements and mechanisms can be enumerated. It does not astonish me that religions commonly choose the opposite hypothesis—the infinite, the continuous (which contains the infinite in its smallest circumscription), and consequently the incommensurable, the

Translated by Mary Fradier.

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elusive, the radically strange or transcendent: in the end, it is this wager that makes them religions and that makes them situate an irreducible absolute outside of the world and beyond thought. Science, with its hopes and ambitions, is obliged to choose the opposite horn of the dilemma. But what examples can be proposed of laws so vast that they seem to permit of neither content nor definition and thus, from the start, to be condemned to emptiness?

As I sought for the broadest, the one which would apply to the various branches of knowledge and could be transferred from one to another, thus fertilizing a new field through the services it had rendered in preceding ones, it seemed to me that the play of symmetry, with its gaps and breaks, was apt to furnish a model of those universal characteristics whose ubiquity I was eager to see recognized.

The remarks which follow and the principle which is deduced at the end—without too many distortions, ambiguities or metaphors, I hope—are intended to be seen in this perspective. Thus seen, the remarks may appear as more than a mere enumeration, and the principle as more than a mirage that has dazzled a naive mind. If the principle is not to disappoint my hopes, it must (and that is enough!) show itself capable of indicating the necessity for an overall solution which would explain a set of phenomena so heterogeneous and yet so constant that specific explanations are excluded, and that, in consequence, there is clearly shown a need to find one single explanation sufficiently broad to apply to all of the data considered.

It does not matter if, in the beginning, the law in question seems to produce effects that may be considered incompatible, as was the case with what physicists called weight and what astronomers called gravity until Newton's genius showed that they were the same thing. Oppositions of this sort, whose unity at first seems scandalous, appear later, when this unity is recognized, as capital and irreplaceable proofs of the fortunate discovery. For science consists essentially of revealing an underlying unity of pattern or movement beneath a deceptive diversity.

* * *

Dynamics of Dissymmetry

A few preliminary definitions are necessary, not only to specify the notions used, but also—and above all—to make their fundamental character clear from the start. The ancient meaning of the word "symmetry," as the Greeks used it, corresponded to ideas of measure, proportion, harmony, pleasing relations between the parts and the whole.[1] The modern meaning, in the technical language of architects, used to be based on etymology and referred to the idea of a figure of which all the parts are commensurable and balanced. Today symmetry means either, within a figure, the exact correspondence in form, dimensions and position of parts which are opposite in relation to an axis, a pole or a center, or the regular recurrence of the same figure in a theoretically unlimited field. In contemporary physics and mathematics, the notion of symmetry ceases to be spatial and indicates the permanence of a non-varying element during a series of transformations within a group or throughout an experiment. Identity is then independent of the system of reference adopted and the theoretical framework chosen. Even a layman like myself cannot help realizing that such a conception is of capital importance. It is no more nor less than the essential basis of a unitary science. Symmetry—and the contestation of symmetry—thus seem to be more than ever in the forefront of demanding, exhaustive investigation. They predict the results: it seems as if the photographs made in physics laboratories were disputing the honor of filling in the gaps.

Nevertheless, in most people's minds, the meaning of the term remains purely geometrical—spatial, in any case. There are several types of geometrical symmetry. In the first place, there is symmetry by translation, when the same element occurs at regular intervals, as if it had been slipped along one or more lines arranged so as to mark out a precisely divided surface. Examples of such symmetry are furnished by a colonnade, a strip of embroidery, the links in a chain, the design repeated around a plate or a vase, the pattern on wallpaper, the bricks in a wall or the cells in a beehive. In such cases the symmetry is open, limitless (even if the decorated band is closed). The repeated images are superposable, and each may be considered the point of departure of the composition.

[1] Vitruvius, *De architectura*, I, 2.

The same is true of symmetry by rotation, when a given figure is turned around a fixed point and successively occupies one or several positions, regularly spaced around the circle, in which it remains identical to itself. Such symmetry may be seen in the arms of a starfish, the figures on modern playing cards when they are turned upside down, or the motif repeated around a rose-window, which, if the rose is turned the requisite number of degrees around the center, will coincide precisely with the preceding or following one.

On a plane, rotation around a fixed center thus divides the space into equal sections in which the same pattern reappears at regular intervals. Once again, each image is superposable on the next one, simply by slipping.

A closed volume, treated in the same manner, is symmetrical if it will reach other positions in which it fills the same space as before. A given fraction of a rotation makes a regular polyhedron occupy the same space as before—as happens, for example, if a cube is pivoted one, two or three right angles around an axis passing through the center of two opposite faces. For a wheel, a sphere, a right cone or a right cylinder—and, more generally, any volume with a circular cross-section—the order of symmetry is infinite: the number of sections in which the volume reappears identical with itself may be multiplied infinitely.

Symmetry presents new properties when it results from a reflecting plane, like a mirror. The object and its image are identical; however, unless the object itself is symmetrical, they are not superposable—just as the right hand is not superposable on the left, nor a signature on the imprint it leaves on a blotter. Such a strange property has not escaped the notice of philosophers. Kant, in particular, uses the paradox of equal but non-superposable objects to demonstrate the objectivity of space as evidence against absolute idealism: space must exist outside of the mind, and must possess its own reality, outside of objects, if it is impossible, because of their orientation, to make two structures coincide even though they are absolutely identical. The enigma may also be expressed in the following way: It is impossible to characterize the right hand by describing all its parts and their respective positions. Something is lacking which

can come only from the position of the hand in space.[2] Only the later development of mathematics provided a solution to the mystery.

I wonder if there would not be an advantage in reducing symmetry to this paradoxical and ordinary case. All the rest would be order, succession, the regular repetition of the same element.[3] Duplication by mirror-image, or a construction that reproduces its effect—for example, the facade of a palace or a temple which is symmetrical in relation to a median vertical axis—is probably the most frequent, the most striking and the most instructive form of symmetry. To such an extent that it might pass for providing the exclusive or at least the basic example. Man quite naturally considers it a privileged one, since he himself is built on the same model. For the only axis of symmetry of which his body admits is the sagittal section that divides it into two halves, of which one appears as a reflection of the other, to such an extent that the left hand is indiscernible from the reflection of the right hand and can be superimposed on it.

If a lace doily, a flower, a jellyfish, a starfish or a polygon usually strikes the eye as symmetrical, that is because its starlike pattern admits of one or several axes of reflection, so that—especially if it has an odd number of branches—it follows the same model as the human body: its two halves seem to be mirror images of each other. This is not the case with a regular succession or spacing of figures, not only because of the theoretically limitless nature of the repetition, but also because the element repeated would have to be in itself symmetrical if the pattern were to be symmetrical in its turn. A piece of cloth with a pattern of roosters all turned in the same direction—for example, with their heads raised and turned to the left—will never appear completely symmetrical, no more than will any fragment, however wide, of the Frieze of the Immortals at Persepolis. For the cloth or the procession to be symmetrical, there would have to be a real or

[2] Kant, *Prolegomena*... I, § 13: "On the first foundation of the difference between the regions of space." Cf. Vilma Reich, *La Gauche et la droite*, Paris, 1967, pp. 183-202.

[3] Supporting the opposite thesis: W. von Engelhardt, *Studium Generale*, II, July 1949.

imaginary line on either side of which two birds or two warriors would face each other or turn their backs on each other, with all those behind them doing the same, so as to suggest the presence of an invisible mirror.

Thus translation, even if rhythmical, is not in the last analysis a sufficient factor of symmetry in the limited sense of the word. Another proof of this will appear if translation is combined with rotation. These combined movements will give a new sort of regular repetition: helical succession, as may be seen in Archimedes' screw or the arrangement of leaves around a stem. Such succession is theoretically infinite, and the images obtained by slipping are superposable. This is not true of inversion, which may be similarly analyzed as a combination of rotation and reflection, but may be better defined as the symmetry operation which makes it possible to obtain a reversed reflection, like the image formed in the back of the camera after the light has passed through the lens. What was on the right is now on the left, and what was on top is on the bottom. Geometrically, inversion consists of finding the symmetrical equivalent of each point, not in relation to a plane (as for a mirror), but with relation to a point situated on another plane. Here again, as with simple reflection, the image is not superposable. It is clear that simple reflection, and only simple reflection, is the decisive factor: the factor which makes an identical object become, in a way, different from itself because of its position in space. It will be seen that this is far more than a geometrical paradox.

For the moment, it is enough to ask what the different types of symmetry correspond to. They are found in nature as well as in the works of man. This fact should not be surprising, since man is part of nature and consequently his own creations may be considered an extension of nature's work—a very special extension, to be sure, but subject to the same syntax, even if a new element has been introduced at the end of the line.

Mirror symmetry is a consequence of weight. It is the necessary condition for balance—for the fish, the bird, the horse or man as well as the houses the latter lives in, the furniture he uses, the vehicles which transport him and which he naturally constructs in his own image and (what is even more important) must construct according to the laws which govern him—that is,

endowed with the same bilateral symmetry which he has himself and which gives them stability. This is the only kind of symmetry man expects, the only kind whose absence makes him ill at ease and makes him consider that any facade or structure in which it is lacking is abnormal, lopsided or incomplete. It is true that to sagittal symmetry he often adds symmetry of front and back, but this is in response to supplementary needs, like the convenience of seating dinner guests facing each other around all four sides of the table or of protecting the defenders of a tower or fortress by identical walls on all sides, with the same narrow openings in all, whereas in non-military buildings, or dwellings, a showy facade with many big windows contrasts with the so-called "blind side" at the back of the building, which is analogous to the back of the human body. A chateau isolated in a park may be an exception; in this case as in the case of a military construction, but for other reasons, several axes of symmetry may be desirable. The architect may also adopt a radiating form of symmetry, as in the Star Pavilion near Prague, whose plan takes the form of a six-branched polygon.

As for transversal symmetry, the kind that makes the upper and lower halves reflections of each other, it is simply against nature: weight forbids it. One does not even think of it when one looks at a perfectly cylindrical tower, without a roof or battlements, for at one end it rises into the sky, while at the other it rests on the ground, so that this sort of symmetry can be seen only when weight does not come into play—that is, in virtual space: every time a reflection on the surface of a body of water makes it appear.

Weight governs living organisms as well as inert matter. But life, which is development, introduces the need to harmonize balance and growth. The propeller, which is a combination of rotation and translation, expresses the laws of phyllotaxis, that is, of the arrangement of the leaves along an adult stem, which has become cylindrical, at least approximately. But when the same stem was only a bud, its form was rather that of a cone, which, as it continued to grow, left behind it a stem of more or less constant diameter. The bud nevertheless needed to have time to reach maturity. In the same way, the shell of univalve gastropods—Heliolitidae or murexes or snails of any sort—grows

in a regular spiral whose plan—unalterable for any given species—accommodates symmetry to the requirements of life.

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From now on I shall admit, as a working hypothesis, that the same forces reproduce the same figures (or at least fairly analogous structures) on the various levels of organization of energy and matter, even on the level where both escape measurement. (At this point, science seems to give up trying to distinguish them. It notes that in fact they remain ambiguous, since none of them has yet affirmed its own mode of existence, as wave or particle.) From this pattern of behavior—presumed to be unchanging or at least persistent and perpetually renewing itself—it is tempting to examine (or to imagine) how, along a climb of rising complexity which gradually spreads, quickens, and finally arrives at freedom and consciousness, new symmetries are engendered, and how they are at the same time means of equilibrium and yokes, factors of stability but also of rigidity, conditions of continuity and bonds that must be broken at the proper time.

Here symmetry appears as a bolt which is periodically fastened to stop evolution. It tends to prevent the passage from one level of organization to another which will be both richer and more adaptable. If the essential contradiction of symmetry can be resolved, it is only at the price of a revolutionary definition—which will itself be equivocal and almost oscillating—of its nature and function. With the aim of arriving at such a definition, I propose to identify—to consider as one single and unique reality—asymmetry and infinite symmetry: that is, the state of matter that is absolutely amorphous and isotropic, both through its total lack of organization and through the statistical equality of disorder. I say that it is coherent to consider such matter, indifferently, either as totally lacking in symmetry or as endowed with infinite symmetry, since any point selected at random in the indistinct magma may be considered as a center, any straight line an axis, and any section as a symmetry plane. Such chaos may be only theoretical. I am willing to concede that it may be only the result of destruction, of necrosis, of

disintegration, and not an original state, a point of departure, as people usually assume, without admitting it. I conceive it rather as a marginal mode of existence, an extrapolation, an extreme reference to oppose to micro-or crypto-crystalline matter, which, not to the naked eye but under a microscope, reveals a beginning of arrangement. In such matter the atoms are regularly distributed so as to form links and networks; they form straight and parallel series like the bricks in a wall, the tiles on a floor, the cells of a beehive. They align themselves in all three dimensions simultaneously. An assemblage of this type (incidentally, there are only 230 in all) constitutes the simplest sort of order that can be realized in an indefinite homogeneous environment. It introduces a first type of symmetry, or at least the regular repetition which is engendered by translation but which is not yet symmetry in the precise sense of the word—if I am right in reserving this term for the correspondence and confrontation that only a mirror can provide.

For the moment, that does not matter. What does matter is that this first and imperfect symmetry is also the first dissymmetry, for it brings into the indistinct mass privileged axes that determine, in particular, breakage planes, along which it is easier to make a separation for the passage of light or a blade. An inequality has come into play which is the basis of a real form of symmetry and which, because of this very fact, has eliminated a multitude of virtual forms.

Nevertheless, since the real symmetry is that of translation, it remains limitless: it occurs at all the appropriate points of a lattice which, in principle, extends indefinitely. Between the liquid and crystalline states, recent science has recognized an intermediate, mesomorphic state in which the molecules appear regularly grouped in one direction only, or at most, regularly distributed on equidistant parallel planes. These are what used to be called "liquid crystals," in which the molecules have already lost part of their freedom: they are no longer isotropic, but have not yet reached the completely reticulated organization of the crystal. The "true" crystal appears at the higher level of symmetry which includes rotation. It implies the constitution of solid forms, with faces—that is to say, individual, closed, complete polyhedra, whose structural varieties may be quickly

counted: there are six different orders and 32 classes. They can be deduced by calculation, although all do not exist in nature.[4]

I shall now go on to the next step in increasing dissymmetry. Suppose we have a crystal which has a single axis and no center of symmetry. If we heat it or press it, it will take on a positive electric charge at one extremity and a negative charge at the other, so that it will be oriented. Where one of its directions is concerned, it has acquired the property of a vector. The two directions of the segment have ceased to be equivalent: a dissymmetry has just been created, at least for a property which does not, it is true, belong to the body itself. But the body furnishes the field. It opens a passage for it, and along a single path—better still, in a single direction. Such inequality could not have been foreseen. A dialectic already noted has come into play once more. Dissymmetry, whenever it is not simply asymmetry, but the breaking up or abandonment of symmetry, gives birth to a property. The rarefaction of the centers, planes and axes of symmetry marks a liberation, and not a deterioration, of organized matter.

With the exception of those of Order 3, minerals do not present symmetries of odd-numbered orders. Approximately pentagonal faces can be found in pyrite, for example, where practically regular dodecahedra are not exceptional, but this comes about through truncations of the cube. As a general if not absolute rule, symmetries of odd-numbered orders are so characteristic of living matter that they announce its frontier. Viruses are not cells, properly speaking, but they have certain properties essential to life. These intermediate beings are parasites, and grow and multiply only if they are sheltered by a living environment. They do not reproduce themselves, but force their host to reproduce them, to use Jean Rostand's expression. Their rigid structure permits them to be obtained in the bare form of real crystals, which, incidentally, correspond exactly to the perfect polyhedra listed by Plato: tetrahedron, cube, octahedron, dodecahedron and icosahedron—of which only the first three are represented in inorganic crystals. The crystalline polyhedra of viruses are covered with sub-units whose

[4] List with descriptions and examples in Fr. H. Pough, *Guide des roches et minéraux*, French translation, Neuchâtel, 1969, Pp. 64-76.

cross-section is pentagonal or hexagonal, which are arranged according to strict patterns of symmetry and whose number can be calculated from a single formula: it ranges from 12 for Bacteriophage 174, which is tetrahedric, to 812 for *Tipula iridescens*. In every case, observations through the electron microscope has confirmed the predicted figures. The icosahedron, which admits of a symmetry of Order 5, nonexistent in the mineral world, is the most common pattern for the nuclei of viruses: it has no less than 532 possible symmetry points. The least regular show a measurable dissymmetry. But even those that look like a tennis racket or a tadpole have an axial symmetry of Order 6.[5]

In the realm in which life clearly exists, the radiating skeletons of lower organisms, those of the Radiolaria in particular, continue to show structures identical with the Platonic polyhedra and especially with the most complex of them—that is, those which are closest to the sphere—and sometimes, among the Heliozaria, the sphere itself, which has a theoretically infinite number of symmetry planes. It is only with the shell of sea-urchins, the umbrella of jellyfish, the crown and tentacles of sea anemones—to take the most obvious examples—that the world of life (vegetable or animal), under pressure of the requirements of weight or nutrition, gives up one of the fundamental axes of symmetry, the horizontal section, which at half the height of the solid in question, permitted it, if reversed, to appear exactly the same as before, as is true for the sphere and the cube, the dodecahedron and the icosahedron—that is to say, the abandoned forms of a symmetry that was too complete and too enslaving.

With the conquest of top and bottom, dissymmetry marks an important advance. Henceforward, plants and beasts will have one side turned towards the sky and another, opposite, resting on the ground. Because of the radiating symmetry they still keep, for the moment at least, two of the dimensions of space remain indifferent to them. The restitution of their form by rotation around a fixed point remains possible. But the perpendicular axis which runs through the plane just defined has become a

[5] P. Lépine, "Les virus," in *Biologie*, Encyclopédie de la Pleiade, Paris, 1965, pp. 1894-1896.

vector, a privileged and irreversible direction which tears them away from impartial crystalline existence.

It is remarkable that, among living beings, it is the lower organisms that possess the most numerous and complex symmetries, the nearest to the isotropic symmetries of the equipollent crystal. Indeed, to rise in the scale of existence seems to consist of freeing oneself gradually from them. The elimination of transversal symmetry is, furthermore, only one stage in this process.

For among the vertebrates and the arthropods, which are situated at the extreme point of zoological development, and among flowers which, like orchids, occupy an analogous place in the vegetable world, there remains only one plane of symmetry, that which results from sagittal duplication—and even this, in the most evolved animal species, applies more to external configuration than to the position of the viscera within the envelope.

Whether the animal is quadruped or reptile, bird or fish, whether it walks or crawls, swims or flies, the head and tail no longer have any resemblance, nor do the back and belly; the left side of the body appears to be the mirror image of the right, and conversely. This is the final rampart, the last residue of symmetry. Furthermore, this symmetry is of another kind. It is no longer the effect of rotation, but of reflection.

In the realm of physics and morphology, it is impossible to go further without leaving the field free for lack of balance and monstrosity. However, man, and only man, finds means of going past the limit. Certainly he is not alone in having adopted an upright posture, and consequently in having freed his forelimbs—although at the heavy price of a loss of stability when he remains immobile and a loss of speed if he must flee or pursue. He is not alone, either, in being able to bring his thumb to meet his other fingers in what have become his hands. However, he is the only animal—except for the crab and the lobster, but nobody thinks about crustaceans in the present connection—whose two forelimbs are not equivalent. The difference has always seemed to him unique, inexplicable, and all the more shocking as he derived from it, through fabulous extrapolation, the idea that space was divided into two metaphysical hemispheres, which he came to consider as absolutely antagonistic and unequal. Convinctions which are

clearly superstitious sprang up in his imagination from the very real fact that in man there is a remarkable anomaly: the right arm is stronger and the right hand more adroit—or less gauche—than the left.

I shall have to come back to these twists of language. For the moment it is enough to note that, even in antiquity, such a lack of balance did not seem to be imputable to nature. Philosophers very early, and sociologists later, tried hard to discover its origin in customs or beliefs. Plato held nurses and mothers responsible for it because they usually hold a child in the right arm, pressing his left arm against their breast and thus reducing it almost to a paralyzed state. Unfortunately for Plato, mothers and nurses usually hold the child in the left arm in order to leave the right arm free. So that it is the right arm that should be the less agile. Another theory explains the difference in muscular development through a greater activity of the right hand in adult men, which resulted from the asymmetrical arrangement of the internal organs of the body. In old Greek, the right is often called the spear side and the left the shield side. Since it was only used to protect the heart, the left hand was destined to play a passive role, whereas the right, which was exempt from such slavery, was used for various exercises and tasks requiring strength and skill. The trouble with this reasoning is that the Greeks did not consider the heart as the essential vital organ, but rather the liver, which is on the right, so that it is the right hand, rather than the left, which should have had the role of protector.

The idea of a cultural origin for the pre-eminence of the right hand must be abandoned, I believe, for in this case there would be no way to explain why it admits of no exceptions. But even the least accessible tribes are now known, studied and catalogued: none has ever been found which was made up chiefly of left-handed people and in which the left, in consequence, held the various moral and symbolic prerogatives that are elsewhere reserved for the right. It is true that there are civilizations where the right enjoys no appreciable religious, institutional, juridical or moral privileges—the Biblical world and China, for example—but in such cases we find either indifference or alternations and correlations, not a pre-eminence of the left. In China the sex-related system of which the poles are the yin, which is feminine

and right, and the yang, which is masculine and left, holds sway—but without implying any hierarchy between the two opposing principles. In the Bible there seems to prevail a four-quartered conception of the cosmos which gives no advantage to either the right or the left. In any case, no special value is ever attributed to the left. Furthermore—and this is conclusive—there are no more left-handed individuals among the Hebrews and Chinese than among other peoples.

So that, even where ethical, emotional or superstitious extension are absent, the physiological basis remains. Such unanimity forces us to look in another direction. Some have thought of the attitude—which they assume to be general—of man in prayer, turned in the direction of the rising sun, which runs its whole course to the right of the person praying, and, in particular, is on his right when it is at the zenith. The sun is the source of light and life. It would thus have appeared to bless and favor one half of the world, while the other half was the asylum, or the den, of dark and cold, evil and death. Closer examination shows that the thesis in question could not have a universal application.[6] The movement just described for the sun's daily course applies only to the Northern Hemisphere. (It explains why, in French, the term *midi* also designates the south.) But the opposite is true throughout the Southern Hemisphere. The situation is even completely reversed south of the Tropic of Capricorn. Between the two tropics, the sun passes alternately to the observer's right and left, according to the seasons. I know that the Southern Hemisphere is by far less populated half of the globe and was so even in very early times. Nevertheless, it hardly seems probable that in Patagonia, on the tip of South Africa, in Australia or New Zealand, no culture, primitive or refined (both exist), has ever drawn the opposite conclusions from a precisely symmetrical situation—which means, in the present case, conclusions contrary to those with which the natives of the Northern Hemisphere are credited. Yet no Southern-Hemisphere people has ever considered the left the noble and privileged side. None of them is left-handed.

[6] Exposé of the thesis (and discussion, after I had conveyed my objections to the author) in Michel De Wolf, "Sur une des formes les plus élémentaires de la symbolisation," in *Cahiers internationaux de symbolisme*, nos. 19-20, 1970, pp. 102-106.

Hence I do not hesitate to discard the sun's course as a means of explaining the universal pre-eminence of the right hand. It becomes tempting to seek in physiology an internal cause which would be immediate and irrefutable. Broca noted that if the right hand is more vigorous and more industrious, it is because the left side of the brain is better irrigated. On reflection, this means that the question has simply been transposed to the level of brain physiology. In fact, the human brain is functionally dissymetrical—a surprising disparity that scientists were slow to admit, since it is in such contradiction to a law that biology used to consider without exception as applied to organs that are perfectly symmetrical where anatomy is concerned. Nevertheless, it has been shown that the two hemispheres are not at all equivalent. Lesions of the left hemisphere, which we know corresponds to the right-hand half of the body, lead to difficulties affecting speech, conventional gestures, and complex and constructive manual activities; this is to say that they affect, essentially, all activities of a verbal or symbolic character, and they do so independently of the type of material (visual, auditive or motor) to be identified. In a word, these lesions hamper activities of interpretation—and only these activities—which, like the pre-eminence of the right hand, are specifically human. Lesions of the right hemisphere, on the contrary, bring on difficulties with space perception, sensory-motor coordination, recognition of faces, inability to dress and loss of sense of direction—briefly, in the whole field of the concrete, in other words of the non-verbal, the non-symbolic, of all perception which does not have to go through the medium of the word or the sign in order to be understood. This difference clearly establishes the hierarchy of the two hemispheres. Their dissymmetry, I have recalled, is functional. It increases with age, but it is not at all impossible that it is structural and morphological. In any case, it is typically human: no experiment has ever shown it to be present in an animal; no diminution of performance has ever been noted in an animal in which one of the cortical areas was sound and the other injured.[7]

Such an observation does not solve the problem; it only displaces it. It does not even put it off, for it has been contended

[7] H. Hécuen, "La symétrie en neuropsychologie," in *Totus Homo*, vol. II (1970), no. 1, pp. 8-15.

that, since the function creates the organ, it was the pre-eminence of the right hand that brought about the specialization and the better irrigation of the left hemisphere, which had to be used more often, and used for tasks implying the invention of new forms of behavior.

Thus, whatever may be the culture to which he belongs and the geographical location of his ancestral habitat, man has taken a new step in the gradual elimination of symmetry. He had only one form of symmetry left, and this one now seems to have been undermined from the inside. On the outside, and where the skeleton is concerned, nothing has changed: the need for balancing forms and masses has seen to that. But the most recently conquered, and almost secret, dissymmetry which results from a differentiation—functional, at least—between the right and left halves of the encephalon has opened to him the vast field of symbolic and representational activities, those which distinguish him from animals and endow him with a superiority over them which has incalculable consequences. Pre-eminence of the right hand, pre-eminence of the left hemisphere—which is cause, which is effect? The problem is doubtless badly posed. All that can be induced from available data leads only to the affirmation that there existed, in bilateral symmetry, a possibility of tension from which one species was able to profit in a decisive way.

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First, since it acts universally on one animal species—certainly unique, but widely disseminated—such tension must be part of all of nature. It may even turn out to be a subtler sort of weight. Basically it does no more than introduce, between right and left, a polarity comparable to that which gravity introduces between top and bottom. Furthermore, if tension constitutes an influence which is everywhere diffused and available, it must be discernible elsewhere than in man. It must be exercised on more than one species; it may make its influence felt beyond life, in organic and even inert matter. It would also be interesting, although not obligatory, if this influence should turn out to be exercised with a certain continuity in the same direction; otherwise it could be claimed that chance alone explains the favor which the privileged side enjoys. But have we any guarantee, at

this point, that man is always able to discern what the privilege consists of? In the last analysis, it is the very occurrence of a disparity that constitutes the privilege, quite apart from which side is supposed to be favored.

Hence it is all the more striking that other animals than man give the right the same preference he does: gastropod mollusks, whose shells, with a few exceptions—*Busycon contrarium*, for example, whose name is so revealing—are coiled to the right; left-coiled specimens are almost unknown.[8] More interesting still, pagurians or hermit crabs are built so that they can live in the only shells they have a chance to encounter—that is to say, right-coiled shells. The lobster's pincers are morphologically and functionally different. The more developed is the right. But if the animal loses it, the left pincer becomes bigger and transforms itself on the model of the absent appendage, while the right pincer grows back in such a way that in size, appearance and utility it replaces the left, which has been called upon to exercise other functions.[9] Grasshoppers are able to emit their chirring because of a modification of the *right* elytron, which is provided with a sawtoothed vein, or bow, that rubs the thin, vibrating membrane of the left elytron.[10] In the vegetable world, among other vines, the hop coils itself to the *right* around the stake that supports it—that is, in the same direction as univalve mollusks. As will be seen, a similar polarization is common in organic chemistry.

As early as the nineteenth century it was noticed that tartrate crystals deviate the plane of polarized light, while paratartrate

[8] A few definitions or conventions are needed here. In man, right and left determine themselves, as they do by similarity among the higher animals, thanks to the direction in which we walk. For a conch or other shell the movement is said to be dextrorotary, or right-coiled, if, when the object is placed opposite the observer, with its point at the top, it appears to him to be coiled clockwise, that is to say, from left to right, from its origin. Hence a dextrorotary shell is one whose orifice in seen at the right. The direction of rotation of a crystal is determined by supplementary, oblique facets located between the longitudinal faces and the terminal pyramids. Held vertically, the crystal is right-handed if, as they approach the pyramids, the upper facets are inclined toward the observer's right; it is left-handed if they are turned to the left. Because of the symmetrical arrangement of the facets, the direction remains the same if the crystal is inverted. These choices are not entirely arbitrary: they are all derived from correspondences with the upright posture and bilateral symetry of man.

[9] Herman Weyl, *Symétrie et mathématique moderne*, Paris, 1964, p. 45.

[10] *Zoologie*, Encyclopédie de la Pléiade, t. II, Paris, 1963, p. 682.

crystals remain passive. In 1848 Pasteur, at the age of 26, found the key to the mystery. He noticed that there are two kinds of paratartrate crystals, symmetrical and non-superposable, presenting supplementary facets. In one kind, these supplementary facets are inclined—I should say, by analogy with the shells of gastropods, coiled—toward the right; in the other, toward the left. If they are separated, the right-turned and left-turned crystals deviate the light in the direction of their respective facets. A solution containing the two types, mixed in equal portions by weight, is statistically indifferent. The chemical composition of the crystals is identical, but not their topology: molecular dissymmetry alone determines a series of properties of great consequence, for organic substances show forms to which their own reflection is not superposable, whereas such is rarely the case for purely mineral bodies: quartz, where this peculiarity is found, is an exception. Pasteur had the daring to present this specific characteristic as that "which may establish the only clear-cut line of demarcation that can be drawn today between the chemistry of dead nature and that of living nature".[11] Life does not produce symmetrical bodies. Dissymmetry begins with life. That is why the chemist who uses only non-dissymmetrical forces or elements in his laboratory never succeeds in producing anything but inert syntheses. Pasteur tried in vain to discover and put to work the mysterious energy that creates dissymmetry.

Dissymmetry, which is present in living matter on the surface of the earth, and in all the energies distributed through the universe, reveals a radical transformation wherever it occurs. Pasteur believed that the secret of the transition from the inanimate to the animate lay here. In consequence, he tried constantly, and by every means, to introduce dissymmetry into his experiments: in Strasbourg he had powerful magnets built; in Lille, where he installed a clockwork mechanism to make the appropriate rotations possible, he tried to make a plant live under the influence of inverted rays of sunshine.

In 1880 he attributed the existence of dissymmetry to a cosmic force which he could not identify, but whose actions it seemed to him natural, if not inevitable, to conjecture because "the system

[11] Pasteur, *Oeuvres Complètes*, t. I, "Dissymétrie moléculaire," Paris, 1922, p. 343.

of the whole world is dissymmetrical": the image of the solar system, if captured in a gigantic mirror, would not be superposable on the reality. (This intuition of the universe as an incomplete ensemble, whose twin is lacking, was echoed in a text published in 1910 by Ernst Mach, who, in a striking formula, presented it "as a one-sided being whose mirror complement does not exist, or at least is not known to us".[12] On December 22, 1883, in a lecture to the Paris Chemical Society, Pasteur summarized the series of his experiments with dissymmetry, some of which by that time appeared to him childish. In this lecture, which may be considered his testament in this field, he speculates about the best means to use to cross the formidable frontier at last: solenoids, elliptical polarized light—in a word, as he says himself, everything that can be imagined in the way of dissymmetrical actions. In fact, a moving collection of bric-a-brac.

The important thing is that Pasteur does not hesitate to envisage the consequences of a possible reversal of the direction of this general energy. He emphasizes the need to reflect without delay on the many theoretical consequences of such a permutation. "If the mysterious influence to which the dissymmetry of natural products is due should change its direction, the elements that constitute all living beings would take on an inverse dissymmetry. Perhaps a new world would be offered to us. Who could foresee what the make-up of living beings would be if cellulose, which is right, became left, or if the albumin in blood ceased to be left and became right? There are mysteries here which hold out the prospect of immense work in the future and which even now call for the most serious meditations of science".[13]

Observations were multiplied with the development of stereochemistry, but the barrier remained impassable and the mystery complete. Pasteur himself had noticed, as early as 1857, that certain fungi colonize only the right component of tartaric acid and leave the left intact. Similarly, microbes accept as sources of carbon only the right bodies of the sugar series, while they get their nitrogen exclusively from the left bodies of the amino-acid series. To which it should be added that, reciprocally, the right bodies of the same series seem to have an inhibiting power over

[12] Quoted by Vilma Reich, *ibid.*, p. 69.

[13] Pasteur, *ibid.*, p. 338. See also pp. 341-342, 369.

cultures of the bacteria in question. There are fish that can distinguish the right and left molecules of certain bodies by their smell or taste.[14] In general, one type hastens, while the other slows down, the growth of the bacteria that feed on them. Left camphor kills dogs and rabbits three times as fast as right camphor.[15] A serious disorder of metabolism, phenylkenoturia, brings on madness if a man absorbs in his food a small quantity of the left form of a phenol compound which, in its right form, is harmless.[16] Examples might be multiplied. Even among micro-organisms there exists a physico-chemical sensitivity to right and left, illustrated by examples which are continually increasing in number and broadening in variety.

In the physico-chemical sciences, since the work of Le Bel and Van't Hoff, and that of Pierre Curie, we have reached the point where dissymmetry has ceased to be merely an object of research and become a tool of discovery. It seems that Pierre Curie himself did not detect the existence of piezoelectricity, but deduced it from his reflections on symmetry, just as Le Verrier had inferred the existence of Neptune from his calculations. Dissymmetry now permits the properties of bodies to be predicted and their nature, characteristics and location to be conjectured. Symmetry appears to be the inertia which impedes the production of phenomena, while dissymmetry sets it in motion. "What is necessary," wrote Pierre Curie, "is that certain elements of symmetry not exist. It is dissymmetry that creates the phenomenon."[17] In reality, it does not create the phenomenon; it makes it possible and perhaps provokes it; but it results, itself, from unequal stresses whose precarious balance topples, when the time has come, and gives rise to a new pattern of organization. The great number of biochemical phenomena in which the presence of dissymmetry turns out to be decisive has convinced scientists of the fruitfulness of the path opened up by Pasteur. If they no longer pose the problem of the origin of life in the same terms—and they certainly

[14] J. Nicolle, "Questions relatives à la symétrie," *Zeitschrift für Aesthetik und allgemeine Kunstwissenschaft*, XIV, 1 (1969), p. 21.

[15] Vilma Reich, *op. cit.*, pp. 118-119.

[16] Hermann Weyl, *op. cit.*, p. 38.

[17] Quoted by Jacques Nicolle, "On Symmetry," in *Diogenes*, no. 12, Winter 1955, p. 87.

do not—they still connect the solution with the appearance of bodies possessing the subversive quality.

At a period which they locate about four billion years ago, they imagine a favorable and at the same time plausible state. They suppose that the sunlight, acting on the primordial organic environment, at that time engendered—through the effect of a chance occurrence which some consider almost miraculous, while others judge it relatively "not improbable"—the first living molecule (but is "living" the proper term?), which probably belonged to the enzyme family. It would have been enough for this event to have taken place *once*, for with it was born the possibility of ceaseless duplication and perpetual preservation: the change which was thus brought about became, through this very fact, indefinitely reproducible. It might not have been produced, but it was produced. An optically active body—the condition of life—was born, to the exclusion of its enantiomorphous opposite. The chances that the opposite would be formed were exactly the same. But it happened that "the first active molecule was left-turned,"[18] as were, later on, most of the mesomorphic bodies, in particular those of the cholesterol series.

I shall now leave aside these conjectures, which are still not very well substantiated and may have to be revised more than once. In the present context it is enough that they are unanimous in emphasizing the decisive role of dissymmetrical crystals in the beginning of life, of which they mark the threshold. Whatever conclusions may be drawn from it, the fact is that the enzymes—highly selective catalysts, whose action at this level seems decisive—infallibly distinguish optical opposites and geometric isomers "which are mirror images of each other."[19] This in itself is significant. But recent physics has discovered something more: an unexpected and fundamental dissymmetry at the infra-atomic level.

On the atomic level, symmetry is known as parity. Parity cannot be represented: nevertheless, in the world of micro-physics, liberated from spatial representations, it corresponds to bilateral symmetry on the microscopic scale. The conservation of

[18] A. Dauvillier, "L'Origine de la vie," in *Biologie*, op. cit., p. 1865-1866. Cf. Jacques Monod, *Le Hasard et la nécessité*, Paris, 1970, pp. 161-162.

[19] Jacques Monod, *ibid.*, pp. 62-67.

parity means that every observable phenomenon can appear as its own reflection—in other words, that itself and its mirror image are equally probable and that every movement which is symmetrical with an original movement is admitted by nature. Nature, then, must be conceived as necessarily tolerating planes of symmetry which create an opposition of the left-right type between non-superposable figures. In 1957, the physicist Li Zhen-dao and Yang Zhen-ming received the Nobel Prize for having demonstrated that parity is not conserved in certain particularly slow phenomena. The experiment carried out proved the existence of a fundamental dissymmetry of space: this time the reflection of one of the particles in the mirror was a physically impossible object.[20]

Physicists had to bow to the evidence—rather reluctantly, however, since the belief in symmetry is inveterate, as if it were impossible to uproot. Hermann Weyl, for instance, marvels at the fact that nature assumed the task of making right tartaric acid, leaving it to Pasteur to make the left variety. Similarly, Wolfgang Pauli, precisely in connection with the non-conservation of parity, says that he is perplexed by the thought that God is left-handed in weak interactions but ambidextrous in strong ones. Revealing comments, as we shall see.

In any case, the dissymmetry noted at the level of the elementary structure of the universe, the role played by molecules that deviate the plane of polarized light, and by enantiomorphous crystals, if not in the explanation of the origin of life, at least in the establishment of the line of demarcation which separates life from inert matter—all these make up a cluster of general and convergent phenomena which reverse the terms of the problem. Dissymmetry no longer appears to be an innovation which gradually clears itself a path through paralyzing weight whose influence it must constantly try to foil. It has become evident that it already existed in the delicate tissue of fine particles whose development gave rise to the diversified riches of the world. From the beginning it was inherent in this tissue, and it must be included among the latter's remarkable characteristics, since it

[20] Louis Leprince-Ringuet, "Leçon inaugurale au Collège de France," Paris, 1959, pp. 31-35, where the author clearly explains how the non-conservation of parity when mesons and hyperons are disintegrated led scientists to abandon, at least partially, "one of the most naturally supported laws of physics."

both presides over the general configuration of the universe and appears in its innermost mechanisms.

If it took so long to discover, this is only because it occurs in almost inaccessible depths which could not be fathomed before the advent of instruments as powerful and complex as the electron microscope. But it seems to have been clearly demonstrated that in these long-unplumbed depths, right and left are not equivalent. Their respective properties do not counterbalance each other with the precision that was expected. The side that the observer calls the left—even though this designation is hardly more than an almost arbitrary reference to his own position in space—appears as a general rule to be, if not privileged, at least more active, or more *present*, than the other. At bottom, there is nothing astonishing about such inequality of treatment. It is scandalous only in relation to habits that have been fixed and perpetuated by the obsessive ubiquity of symmetrical objects in the visible world. It is perfectly conceivable, and after all more satisfying, that the organization of the cosmos should not be based on simple, continuous and redundant duplication. Advantages may be seen in the fact that every physical "individual," every field of force, on whatever level it may be located, is not automatically repeated in reflections on both sides of an axis. Except for the weight of a long and erroneous tradition, nothing prevents science from coming to terms with a world that is subject to a certain disparity. Man cannot help living in an *a posteriori* universe of which dissymmetry is one of the laws and, if not the support, at least a more than intermittent spring.

However, at the macroscopic level, dissymmetry goes into a relative eclipse. At this level it has difficulty in consolidating its successive gains, and when it emerges from the end of the tunnel with increased powers, it is no longer the left but the right that seems to be the favored direction. Did a second chance occurrence—unique, like the first, and with no less complex and limitless consequences—determine, in an opposite way this time, which direction was going to win out? First we must look for the reason for the eclipse.

* * *

If symmetry exists at the level of what we believe today to be the smallest particles, it is endemic to them, does not build itself up

in them, and has no aim. This may be the price it pays for expressing itself without hindrance in the statistical disorder which I proposed at the start to define both as total asymmetry and infinite symmetry. The simplest beginning of organization implies balance. The more volume order acquires, the more density, the more it spreads, develops and agglomerates new elements, the more it must take account of the subjections and resistances which arise from its growth and which, be they external or internal, impede it, channel it, oblige it to find a new kind of strength. Under these conditions, absolute priority is necessarily given to the establishment of symmetries in which turbulence and anarchy tend to give way to stable structures—those which in some cases hold together systems of crystals and in others genetic codes. The coherences which succeed in establishing themselves are the ones it is hardest to break up. Increasing organization acts as a powerful coagulant. It paralyzes any dissymmetry that would threaten it with ruin. Then a fertile dissymmetry may appear. Such an event is rare and uncertain, for, in order to appear, the new dissymmetry must cease to float in a formless sea of indifference and emerge, cracking the armor which binds it but on which it nevertheless has the power to act. Its appearance is an exception and an act of prowess. It begins the climb whose principal steps I have tried to describe and which leads from mesomorphic bodies to the higher animal or vegetable structures where symmetry is no longer more than sagittal.

On the level of elementary particles, the difference between right and left was merely the absence of parity in a few infinitesimal interactions. In man, it has become a gulf which separates not only the unequal strength of his arms and the relative skill of his hands, but, by extrapolation, two irreconcilable metaphoric universes. For the symbolic function has come into play—a hitherto unknown faculty that has arisen precisely out of dissymmetry's latest conquest: the hierarchy of the hemispheres of the human brain.

Suddenly, the interminable controversies over the natural or cultural character of the pre-eminence of right-handedness—if I have so far believed them pointless—take on new meaning. When Hermann Weyl writes, after having objectively justified the front-to-back and dorso-ventral directions: "Only the distinction between left and right remains arbitrary," has he forgotten that

he has just expressed astonishment at nature's *exclusive* preference for right tartaric acid? Such a repugnance, overcome, in one case and victorious in the other, deserves our attention because it is so common and so deep. It comes essentially from the fact that our minds are practically incapable of admitting that the "imaginary" difference between right and left has the same real foundation that we recognize in those differences which oppose top and bottom, front and rear. The fact is that these polarities have brought about divisions which are just as astonishing, but which have rarely been considered enigmatic or even surprising. This is because the configuration of our bodies makes these differences plausible, almost evident, whereas the bilateral symmetry that man has kept on the outside of his body incites him to consider as equivalent two areas which, to the eye, are indistinguishable from each other.

For it is clear that spontaneous analogies have led him to affirm the supremacy of the top. The mere fact that weight makes a body fall could but provoke, and did not fail to engender, antitheses which immediately required him to postulate a Manichean universe. The top and the bottom are also the high and the low, the ethereal and the coarse, spirit and matter, *high* sentiments and *base* instincts, lightness and heaviness, ascent and decline. At one pole we situate reason and disinterestedness, at the other *gross* appetites and sensuality. At an extreme, if psychoanalysis comes into the picture, sublimation (so well named!) becomes the antithesis of anal fixation, the ideal contrasted with the waste. In the same way, the opposition of front and back brings about a division which goes far beyond the difference in meaning of these two terms. It takes over the contrast between the future and the past, precocity and delay, progress and regression. We speak of *advanced* ideas and a *retarded* mind. The "advancement" of science is contrasted with the "backwardness" of the critical spirit. Examples could be multiplied. They may all be explained by the fact that it is practically impossible to doubt the pre-eminence of the front side, the direction in which we look and walk, the side whence come initiative and daring, over the disdained and disturbing dorsal world—blind and abandoned, as if it had been rejected. In houses too, the sumptuous facade opened on the outside world, hospitable and sculptured, lit up at night, contrasts with the dismal and forbidding back wall, without ornament or windows, cold and shameful.

The range of symbolic antitheses between right and left does not rest on such strictly morpho-biological bases—far from it. Yet it is considerably more extensive, denser, more systematic, and, above all, more deeply and generally ingrained, not only in vocabulary but in customs and institutions. Not only the realm of the concrete, but the moral, juridical and religious universe, that of values and emotions, even that of fancy, is impregnated by the antagonism it imposes.

The right hand is not only the stronger and nimbler, the more adroit, as its name in French indicates; it is also the one used when a vow is made, the one that represents loyalty and *rectitude*. On the contrary, the left represents awkwardness, misfortune, treachery, perjury, everything that is tortuous, disloyal, reprehensible, sinister. The right is noble and stands for happiness; the left is vile and of ill omen. Everywhere left-handed people make up an infinitely small minority. They are persecuted, if not massacred, in primitive societies; frequently thwarted and "re-educated" in more civilized ones. On one side there is opprobrium, disgust, superstitious fear; on the other, glory and reverence. Inequality of treatment has repercussions even in language. Thus, in the Indo-European tongues, the root that designates the right side has been kept in a great many cases (Latin: *rectus, directus*; French: *droit, rectitude, endroit*; Spanish: *derecho*; Italian: *destro*; German: *recht*; English: *right*; Greek: δεξιός), while the one that evokes the left is fleeting if not evanescent. Victim of a sort of taboo, it is generally replaced by a metaphor that is always different (Latin: *laevus, sinister*; French: *gauche*; Spanish: *izquierdo*; Italian: *sinistro, mancino*; German: *link*; English: *left*; Greek: ἀριστερός, literally "the better of the two"; εὐωνύμος, literally "which has a good reputation," the two terms being used through antiphrasis; σκαιός). These designations have generally become derogatory or of ill omen.[21]

[21] A recent development, limited to the field of politics, tends to give a favorable meaning to the *left*. With the left are associated ideas of progress, generosity, reforms, social justice and, more generally, an ideal and the future, whereas the right evokes stagnation and egoism, the maintenance of unjust privileges, and in any case order, experience and the past. We know that the designation of parties and movements by the epithet "left" is purely fortuitous (it happens that the deputies in question are seated to the left of the president of the Assembly), but the fact is that this designation has consolidated and perpetuated itself, and has even spread beyond the frontiers of France. The

Numerous studies have listed, though not exhaustively, the mental connotations of left and right. There is no doubt that they seem to be the richest of all those that illustrate the various dimensions. They are considered—quite correctly—as the least justified by a natural foundation. Indeed, anyone can see how mere weight, the opposition between the roots and the foliage, between the head which thinks and the intestines which eliminate, between the sensitive, eloquent opening which is the organ of nutrition, singing and speech, and the excremential sphincter which arouses disgust and scorn—how these oppositions provide an immediate and convincing explanation for the associations brought about by the contrasts between top and bottom. The way we walk, the position of the eyes, the difference between the nape and the face, the back and the belly just as obviously explain the opposition between front and back. On the other hand, thought remains perplexed by the couples which illustrate with emphasis and pathos the honor or the indignity of bilateral antipodes which the eye nevertheless sees as identical. Compared with the essential differences which justify our feelings about the other directions, the invisible inequality of right and left seems to depend entirely on characteristics (like the strength and skill of a limb) which may very well come from education. Hence the idea of relating them to culture, not to nature, without stopping to reflect that cultures are diverse but right-handedness is general, and that it goes far beyond the human species.

This inequality is, in fact, a deferred, resurgent consequence of the essential dissymmetry, that which furnishes the criterion of life, which shows itself even on the corpuscular level, and which remains available for a new manifestation whenever circumstances will permit. The unfathomable impulse that provokes it (terrestrial magnetism, direction of rotation of the planet, cosmic influence

analyses of sociologists predicted the contrary, and would have led us to expect "that the right would be the side of freedom and action, and the left the side of passivity and dependence" (H. C. Van der Meer, *Polarisation droite-gauche de l'espace phénoménal*, Groningen, 1958, quoted by Vilma Reich, *ibid.*, p. 85). It would be interesting to find out whether this break with usage was possible only because people's linguistic consciousness did not associate the new and quite accidental meaning of the word with the usual, long-accredited connotations, or whether it soon acquired the character of an act of defiance—the taking over of a world that was cursed, disdained, suspect, and miserable in the double sense of arousing pity and scorn.

or fortunate photochemical synthesis) admits of no exceptions, even if it does not show itself to the same degree where gravity predominates. For dissymmetry to be able to break through, one of two things is required: either that brutal necessities not enslave it completely, or that the thrust of life, and, later, the demands of the symbolic grasping of the world by consciousness, teach newly appeared organisms to combat the effects of symmetry. Against the imperatives of balance, dissymmetry seizes on every occasion, takes advantage of every opportunity to press against the weak points in the armature which constricts it and from which it wants to escape. It thus capitalizes on the favorable chances that confirm and enrich the first decision of fate.

One thing is now certain: the world is not neutral. From the beginning and still more toward the most recent stages of its history, it has really been right and left. This situation may astonish man, but he must get along with it, just as he does with weight, and just as mesons and hyperons, quartz crystals and amino-acids get along with it. Furthermore, lateral dissymmetry is still fluid. It leaves a margin, an uncertainty. Despotic as it may show itself at times, it is never inescapable. The crystals of organic bodies usually admit of ambivalence. Shells can be left-coiled. Among men, there are left-handed individuals; the whorl of the hair may be turned in one direction or the other; the reverse coiling of the intestine and the reversal of the position of the visceral organs are extremely rare, but they do occur. In a word, predominance, even when it is overwhelming, is not automatic. It permits of exceptions. There is a preference, but also a substitute solution, even during the life-span of the individual, as we have seen in connection with lobsters' pincers.

In addition, for man as for all organisms to which the words advantage and disadvantage may be properly applied, the right is probably the privileged horizon or direction, as is true for numerous vines, for grasshoppers, for univalve gastropods and for a number of crustaceans. And as the left was and remains at the molecular stage. Every time, nature's partiality is flagrant—which does not mean fundamental: the contrary may be true. But the phenomenon calls for explanation nevertheless. Perhaps there is none. After all, the coin had to fall on one face or the other. Heads won. Probably nothing prevented tails from winning. But once the coin had fallen, the consequences were and are repeated

ad infinitum. What is more, nothing proves that there were two points of departure: the role played by convention is so great, and its interpretation such a delicate matter, that it is not at all certain that the left-hand side of the atom and the right-hand side of higher organisms do not, in reality, indicate the same side. In any case, it is the permanence of a disparity which is important, not the change of code in the middle of the journey.

The stakes had long since been put down when man entered the game. It should be recalled once more that he was by far the last player to come in, and that all the cards were already dealt. He could only continue, with an extremely limited margin of initiative. He nevertheless seems to represent the terminal point of a rise of dissymmetry which, from the level of isomeric bodies (and below), has succeeded in pushing aside all obstacles, irresistibly, insatiably. Every time, it discovers a point it can touch and carries out the same secret, fecund task, which I shall venture to define in the following manner: it brings in, with mirror symmetry, a germ of dissymmetry that is acceptable to symmetry itself. But how does it act beyond, when, with the separation of the functions of the two hemispheres of the human brain, the last bastion of symmetry has fallen?

Man, who in his beginnings was a puny and scattered excrescence of one of the dynasties of the animal kingdom, covered the planet in a singularly short time, then set about exploiting it until he began to exhaust its resources, cheerfully and fast. In his acts, calculation and invention have played an unwonted, not to say insolent, role. He is now watching with astonishment an explosion of efficient power of which he is the agent, and which awards him an unprecedented place in the same nature he came out of and is getting farther and farther away from. His coming introduced into mechanisms which had always been at work two hitherto unknown parameters, capable of modifying their mode of operation or at least their results—for example, by increasing them and combining them with certainty, thus saving an amount of time that can be calculated in thousands of centuries of chance. These essential innovations are called intelligence and technique: the capacity to foresee and to act with success. It may be asked—which is the same as saying it must be asked—whether, under these circumstances, there remains a place for the play of symmetries and dissymmetries which has led this industrious species

to where it is now. The symbolic contrasts between happiness and misfortune, good and evil, favorable and nefarious, base and elevated, front and back, right and left have already given us the answer: symmetry, and after it dissymmetry, impose their mechanisms even in the realm of the imaginary, if not in that of the most serene speculation.

* * *

This is not the place to extend into the uneasy, floating, uncertain, speculative world of the workings of the human mind our investigation of the spring whose continuous functioning I have tried to demonstrate, beginning with the most elementary manifestations of the total syntax of the universe. If this force exists there, it must be very hard to get free of. I shall have the temerity to formulate its principles, knowing that here as elsewhere—as has been said for the art of war and the other arts—the principle is simple; everything depends on its application. In this particular case, the principle can be stated in three propositions.

I. Every homogeneous and isotropic environment may be defined indifferently either as the complete absence of symmetry or as virtually infinite symmetry, without axis or center or privileged planes. Such a state properly constitutes asymmetry.*

II. Every asymmetrical state naturally tends toward stability, which brings about an equilibrium capable of introducing one or more effective symmetries.**

III. In every established symmetry a partial*** and non-accidental**** break may occur, which tends to complicate the equilibrium that has been reached. Such a break is, properly

* See pp. 69-70, above.

** *Effective symmetries*: by opposition to all of the *virtual symmetries* of the preceding paragraph, which are the same thing as asymmetry.

*** *Partial*: This does not mean a complete metamorphosis (as when the butterfly comes out of the chrysalis, after necrosis), nor a bursting apart that would destroy the continuity of the system, but its limited though decisive adaptation, its promotion to a richer equilibrium.

**** *Not accidental*: a shock, a fracture, experimental manipulation or a monstrosity is not enough; the change must be, on the one hand, prepared, ripened, required; and, on the other, irreversible and generalizable.

speaking, a dissymmetry. Its effect is to enrich the structure or organism in which it is produced, that is to say, to endow it with a new propery or to make it pass to a higher state of organization.

If there were no counterpart to the second principle of thermodynamics, the universe would gradually run down until it reached an absolute and definitive equilibrium, without tension, just as surely as a mixture of hot and cold water gives tepid water. The end— I do not say predictable, but inevitable—would be a fallout, or rather, not even that: a floating of dust or ashes or some kind of sickly, evenly distributed jelly, spreading out wherever its inertia might lead it. Yet everyone realizes that an antagonistic force is at work, just as calm and sure of itself, whose effects continually contradict statistical predictions: an opposing principle of increasing complication and organization, which permits more more and more choice, initiative, hesitation, freedom. It is sometimes called negative entropy.

Only in appearance does it contradict the second law of thermodynamics. Dissymmetry drains off, to put them together, all scattered energies, those that are out of circuit, in suspense, amidst perpetual, immensely prodigal, degradation. Thus at rare, precise, decisive points, it succeeds in reversing the general current. Anticipating the precepts of philosophers, its efficient, intermittent, rigorously and constantly negotiated strategy long ago discovered the only means of combating nature, which is to obey it, but to do so with method and purpose. The elimination of encrusted symmetries, the successive levels reached in its enriching, liberating advance, perhaps as fundamental as the opposite force, furnish a continuous and persuasive illustration of our special mission; for man, whether he realizes it or not, whether he wills it or not, belongs by lineage and ambition to the race in which the virulence of dissymmetry has shown itself more active than anywhere else in the world. He reaps its heritage, undergoes it, adds to it and adds himself to it. This is both his curse and his nobility.