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THE LOGIC OF TACIT INFERENCE

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I PROPOSE to bring fresh evidence here for my theory of knowledge and expand it in new directions. We shall arrive most swiftly at the centre of the theory, by going back to the point from which I started about twenty years ago.[1] Upon examining the grounds on which science is pursued, I saw that its progress is determined at every stage by indefinable powers of thought. No rules can account for the way a good idea is found for starting an inquiry; and there are no firm rules either for the verification or the refutation of the proposed solution of a problem. Rules widely current may be plausible enough, but scientific enquiry often proceeds and triumphs by contradicting them. Moreover, the explicit content of a theory fails to account for the guidance it affords to future discoveries. To hold a natural law to be true, is to believe that its presence may reveal itself in yet unknown and perhaps yet unthinkable consequences; it is to believe that such laws are features of a reality which as such will continue to bear consequences inexhaustibly.

It appears then that scientific discovery cannot be achieved by explicit inference, nor can its true claims be explicitly stated. Discovery must be arrived at by the tacit powers of the mind and its content, so far as it is indeterminate, can be only tacitly known.

But where to turn for a logic by which such tacit powers can achieve and uphold true conclusions? *We must turn to the example of perception.* This has been my basic assumption. I maintained that the capacity of scientists to perceive in nature the presence of lasting shapes, differs from ordinary perception only by the fact that it can integrate shapes that ordinary perception cannot readily handle. *Scientific knowing consists in discerning gestalten that indicate a true coherence in nature.*

[1]See my *Science, Faith and Society* (O.U.P., 1946, and as Phoenix Book expanded, 1964), also *Personal Knowledge* (London and Chicago, 1958, and as Torch Book, New York, 1964).

The study of perception by gestalt psychology has demonstrated the tacit operations that establish such coherence. When I move my hand before my eyes, it would keep changing its colour, its shape and its size, but for the fact that I take into account a host of rapidly changing clues, some in the field of vision, some in my eye muscles and some deeper still in my body, as in the labyrinth of the inner ear. My powers of perceiving coherence make me see these thousand varied and changing clues jointly as one single unchanging object, as an object moving about at different distances, seen from different angles, under variable illuminations. A successful integration of a thousand changing particulars into a single constant sight makes me recognise a real object in front of me.

Integration is almost effortlessly performed by adult eyes, but such powers of seeing things are acquired by early training in the infant child and are continuously developed by practice. Students of medicine struggle for weeks in learning to discern true shapes in the radiogram of a lung. Trained perception is basic to all descriptive sciences.

While the integration of clues to perceptions may be virtually effortless, the integration of clues to discoveries may require sustained efforts guided by exceptional gifts. But the difference is only one of range and degree: the transition from perception to discovery is unbroken. The logic of perceptual integration may serve therefore as a model for the logic of discovery.

Observe the way that integration works when we look at an object, for example a finger of our own, through a pinhole in a sheet of paper. If I do this and move my finger back and forth, I see it swelling as it approaches my eye. Psychologists have called this effect a 'de-realisation'. The moving object has lost here some of its constancy, for it lacks confirmation from the periphery of the visual field; and with the loss of its constancy the object has lost some of its apparent reality.[1]

The remarkable thing here is the way the appearance of a thing at the centre of my attention, depends on clues to which I am not directly attending. These clues are of two kinds. There are some that we cannot experience in themselves. The contraction of my eye muscles or the stirring inside of my labyrinth organ I cannot experience directly. These clues are *subliminal*. Other clues to the sight of my finger are the things covered up by the paper when I look at my finger through a pin-hole. I normally see these things from the corner of my eye and I *could* observe them directly, if I wanted to. We may call such clues *marginal*. To neither kind of clues do I attend directly, yet both kinds contribute to the apparent reality of the

[1]Buytendijk, F. J. J., *Mensch und Tier* (Hamburg, 1958), p. 59.

object, on which my attention is focussed. *We may say that my awareness of both kind of clues is subsidiary to my focal awareness of that object.*

These two kinds of awareness—the subsidiary and the focal—are fundamental to the tacit apprehension of coherence. Gestalt psychology has demonstrated that when we recognise a whole, we see its parts differently from the way we see them in isolation. It has shown that within a whole its parts have a *functional appearance* which they lack in isolation and that we can cause the merging of the parts in the whole by shifting our attention from the parts to the whole.

More than a century ago William Whewell described how the merging of hitherto isolated observations into elements of a scientific theory changes their appearance. 'To hit upon a right conception (he wrote) is a difficult step; and when this step is once made, the facts assume a different aspect from what they had before; that done, they are seen from a different point of view; and the catching of this point of view is a special mental operation, requiring special mental endowments and habits of thought.'[1] We may say that a scientific discovery reduces our focal awareness of observations into a subsidiary awareness of them, by shifting our attention from them to their theoretical coherence.

This act of integration, which we can identify both in the visual perception of objects and in the discovery of scientific theory, is the tacit power we have been looking for. I shall call it *tacit knowing*.

It will facilitate my discussion of tacit knowing if I speak of the clues or parts that are subsidiarily known as the *proximal term* of tacit knowing and of that which is focally known as the *distal term* of tacit knowing. In the case of perception we are attending to an object separated from most of the clues which we integrate into its appearance; the proximal and the distal terms are then largely different objects, joined together by tacit knowing. This is not so when we know a whole by integrating its parts into their joint appearance, or when the discovery of a theory integrates observations into their theoretical appearance. In this case the proximal term consists of things seen in isolation and the distal term consists of the same things seen as a coherent entity.

But tacit knowing does exercise in both cases its characteristic powers of integration, merging the subisidiary into the focal, the proximal into the distal. We may say then that in tacit knowing we always attend *from* the proximal *to* the distal term.

In subordinating the subsidiary to the focal, tacit knowing *is directed from the first to the second.* Since this functional relation is set up between two kinds of awareness, its directedness is necessarily

[1]William Whewell, *Philosophy of Discovery* (London, 1860), p. 254.

conscious. Such directedness coincides then with the kind of intentionality which Franz Brentano has claimed to be a characteristic of all manner of consciousness.[1] This vectorial quality of tacit knowing will prove important.

We have seen that by attending from the proximal to the distal, we cause a transformation in the appearance of both: they acquire an integrated appearance. A perceived object acquires constant size, colour and shape; observations incorporated in a theory are reduced to mere instances of it; the parts of a whole merge their isolated appearance into the appearance of the whole. This is the *phenomenal* accompaniment of tacit knowing; which tells us that we have a real coherent entity before us. It embodies the *metaphysical claim* of tacit knowing. The act of tacit knowing thus implies the claim that its result is an aspect of reality which, as such, may yet reveal its truth in an inexhaustible range of unknown and perhaps still unthinkable ways.

My definition of reality, as that which may yet inexhaustibly manifest itself, implies the presence of an *indeterminate* range of *anticipations* in any knowledge bearing on reality. But besides this indeterminacy of its prospects, tacit knowing contains also an *actual knowledge* that is indeterminate, in the sense that its content *cannot be explicitly stated.*

We can see this best in the way we possess a skill. If I know how to ride a bicycle or how to swim, this does not mean that I can tell how I manage to keep my balance on a bicycle, or keep afloat when swimming. I may not have the slightest idea of how I do this, or even an entirely wrong or grossly imperfect idea of it, and yet go on cycling or swimming merrily. Nor can it be said that I know how to bicycle or swim and yet do *not* know how to coordinate the complex pattern of muscular acts by which I do my cycling or swimming. I both know how to carry out these performances as a whole and also know how to carry out the elementary acts which constitute them, though I cannot tell what these acts are. This is due to the fact that I am only subsidiarily aware of these things and our subsidiary awareness of a thing *may not suffice to make it identifiable.*

There are unspecifiable subsidiary elements present also in perception and in scientific discovery. We know a person's face and can recognise him among a thousand, indeed among a million. Yet we usually cannot tell how we recognise a face we know. There are many other instances of the recognition of a characteristic appearance —some commonplace, others more technical—which have the same structure as the identification of a person. University students are

[1]Brentano, Franz, *Psychologie Von Empirischem Standpunkt* (1874) quoted from edition by Oskar Kraus, Leipzig, 1942.

taught in practical classes to identify cases of diseases and specimens of rocks, plants and animals. This is the training of perception that underlies the descriptive sciences. The knowledge which such training transmits cannot be put into words, nor even conveyed by pictures; it must rely on the pupil's capacity to recognise the characteristic features of a physiognomy and their configuration in the physiognomy.

But does the successful teaching of skills and of the characteristic appearance of a physiognomy not prove that one *can* tell our knowledge of them? No, what the pupil must discover by an effort of his own is something we could not tell him. And he knows it then in his turn but cannot tell it.

This result actually takes me a step beyond the point I had aimed at. It exemplifies not only that the subsidiary elements of perception may be unspecifiable, but shows also that such tacit knowledge can be *discovered*, without our being able to identify what it is that we have come to know. This holds equally for the learning of skills: we learn to ride a bicycle without being able to tell in the end how we do it.

Some fairly recent observations have demonstrated experimentally the process by which we acquire knowledge that we cannot tell. The experiment in question produces a fixed relation between two events, both of which we know but only one of which we can tell.

Lazarus and McCleary[1] have shown this to take place when a person is presented for brief periods with several nonsense syllables and after certain of these syllables he is subjected to an electric shock. Soon the person shows signs of anticipating the shock at the sight of the shock syllables; yet, on questioning, he fails to identify them. He has come to know when to expect a shock, but cannot tell what makes him expect it. He has acquired a knowledge similar to that which we have when we know a person by signs which we cannot tell, or perform a skill by coordinating elementary muscular motions according to principles that we cannot tell.

Lazarus has given the process he discovered the name of *subception* and this has been widely adopted. The connection of subception with gestalt has, however, gone practically unnoticed. In the long-drawn controversy between Lazarus and G. W. Eriksen, which ended in 1960 by Eriksen's confirmation of subception, its connection with gestalt was not mentioned.

[1]Lazarus, R. S. and McCleary, R. A., *J. Person* 18 (1949), 191 and *Psychol. Rev.* 58 (1951), 113. These results were called in question by Eriksen, C. W., *Psychol. Rev.* 63 (1956), 74, and defended by Lazarus, *Psychol. Rev.* 63 (1956), 343. But in a later paper surveying the whole field (*Psychol. Rev.* 67 (1960), 279) Eriksen confirmed the experiments of Lazarus and McCleary and accepted them as evidence of subception.

For my part, I regard subception as a striking confirmation of tacit knowing, as first revealed by gestalt psychology. I would indeed not rely so much on subception for demonstrating the structure of tacit knowing, had I not established this structure previously, from other, more richly documented evidence.

Psychologists have called subception a process of *learning without awareness*.[1] The description suits our present purpose. If there is learning without awareness, there must be also *discovery without awareness*, since discovery is but learning from nature. The way a novice discovers for himself the characteristic appearance of a specimen is but a minor replica of the act by which that appearance was first discovered by a scientist. Whewell's description of a discovery in mathematical physics (he had Kepler's discovery of elliptic paths in mind) has shown us a typical act of tacit integration at work. Discovery comes in stages, and at the beginning the scientist has but a vague and subtle intimation of its prospects. Yet these anticipations, which alert his solitary mind, are the precious gifts of his originality. They contain a deepened sense of the nature of things and an awareness of the facts that might serve as clues to a suspected coherence in nature. Such expectations are decisive for the inquiry, yet their content is elusive and the process by which they are reached cannot be specified. It is a typical feat of discovery without awareness.

Thus, in the structure of tacit knowing, we have found a mechanism which can produce discoveries by steps we cannot specify. This mechanism may account then for scientific intuition, for which no other explanation is known so far. Such intuition is not the supreme immediate knowledge, called intuition by Leibniz or Spinoza or Husserl, but a work-a-day skill for scientific guessing with a chance of guessing right.

But are all these tacit operations not merely provisional? Are we to abandon the ideal of explicit inference, which alone can safeguard critical reason? My answer is that there is an important area in which explicit thought is ineffectual. No explicit direction can make us see a pair of stereoscopic photographs as one solid image; a person putting on right-left inverting spectacles will go about helplessly for days on end though he knows that he has merely to transpose the things he sees from right to left and from left to right. He will eventually learn to see with inverting spectacles without knowing how he does it. We cannot learn to keep our balance on a bicycle by taking to heart that in order to compensate for a given angle of imbalance α, we must take a curve on the side of the imbalance, of which the radius (r) should be proportionate to the square of the velocity (v)

[1]Eriksen, C. W., *Psychol. Rev.* 67, p. 279 (1960).

over the imbalance: $r \sim v^2/\alpha$. Such knowledge is ineffectual, unless known tacitly.

We have seen *tacit knowledge* to comprise two kinds of awareness, *subsidiary awareness* and *focal awareness*. Now we see *tacit knowledge* opposed to *explicit knowledge*; but these two are not sharply divided. While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence all knowledge is *either tacit* or *rooted in tacit knowledge*. A *wholly* explicit knowledge is unthinkable.

We can watch the process by which an explicit prescription becomes increasingly effective as it sinks deeper into a tacit matrix. Take a manual for driving a motorcar and learn it by heart. Assuming that you have never seen a motorcar, you will have to identify its parts from the illustrations of the manual. You can then sit down at the wheel and try to carry out the operations prescribed by the text. Thus you will start learning to drive and eventually establish the bearing of the manual on all the objects it indicates and the skills it teaches. The text of the manual is shifted to the back of the driver's mind, and is replaced almost entirely into the tacit operations of a skill.

The speed and complexity of tacit integration far exceeds in its own domain the operations of explicit inference. This is how intuitive insight may arrive at unaccountable conclusions in a flash. This has been pointed out by Konrad Lorenz.[1] While language expands human intelligence immensely beyond the purely tacit domain, the logic of language itself—the way language is used—remains tacit. Indeed, it is easy to show that the structure of tacit knowing contains a general theory of meaning which applies also to language.

When, in the experiment of Lazarus, certain syllables make the subject expect an electric shock, the approaching shock has become the meaning of these syllables to the subject. This view can be generalised, without straining the evidence, to all relations between a subsidiary and a focal term. The elementary motions that serve a cyclist to keep his balance are not meaningless: their meaning lies in the performance they jointly achieve. In this sense a characteristic physiognomy is the meaning of its features, which is in fact what we commonly say when a physiognomy expresses a particular mood. And finally, we may regard the appearance of a perceived object with constant properties as the joint meaning of the clues the integration of which produces that appearance. Such is the *semantic function* of tacit knowing.

[1]Konrad Lorenz in *General Systems*, ed. L. von Bertalanffy and A. Rapoport (Ann Arbor 1962), p. 50.

A *set of sounds* is converted into the *name* of an object by an act of tacit knowing which integrates the sounds to the object to which we are attending. This is accompanied by a characteristic change in our impression of the sounds. When converted into a word they no longer sound as before; they have become, as it were, transparent: we attend *from* them (or through them) to the object to which they are integrated. Current theories which would explain meaning by the association of sounds with an object, leave unexplained this vectorial quality of meaning which is of its essence.[1]

There is a parallel to this transformation of sounds into words in the conversion of an object into a tool. Someone using a stick for the first time to feel his way in the dark, will at first feel its impact against his palm and fingers when the stick hits an object. But as he learns to use the stick effectively, a transformation of these jerks will take place into a feeling of the point of the stick touching an object; the user of the stick is no longer attending then *to* the meaningless jerks in his hand but attends *from* them to their meaning at the far end of the stick.

I have spoken of the subliminal clues of tacit knowing which cannot be experienced in themselves and of marginal clues which, though clearly visible, may not be identifiable. But we have met now also a number of instances where tacit knowing integrates *clearly identifiable* elements and have observed the way the appearance of things changes when, instead of looking *at* them, we look *from* them to a distal term which is their meaning.

Once established, this *from-to* relation is durable. Yet it can be seriously impaired at will by switching our attention from the meaning to which it is directed, back to the things that have acquired this meaning. Turn your attention on a word you have spoken; repeat it several times, attending carefully to the sound you produce and to the motion of your tongue and lips, and the word will regain its sensuous body and lose its meaning. The same is true of a skilful performance. By concentrating attention on his fingers, a pianist can paralyse himself; the motions of his fingers no longer bear then on the music performed, they have lost their meaning.

We can identify then two alternative structures—omitting for the moment their necessary qualifications. So long as you look *at* X, you are *not* attending *from* X to something else, which would be its meaning. In order to attend *from* X to its meaning, you must cease to look *at* X, and *the moment you look at X again you cease to see its meaning*. Admittedly, meaning is tenacious; once it is established, its destruction is not always feasible and is hardly ever complete, but it

[1]See e.g. W. V. O. Quine in *Word and Object* (New York and London, 1960) p. 221. He rejects any reference to intentions as conceived by Brentano.

would be complete, if we could look at X again fully as an object.

In *Personal Knowledge*, I have described the destruction of the meaning of X when switching our attention back to X, as due to the *logical unspecifiability of X*. But this does not show how the destructive powers of this shift of attention arise. To speak of this destruction as 'the paradox of the centipede', as Arthur Koestler does, also fails to make this clear. What happens is that our attention that is directed *from* (or through) a thing to its meaning is distracted by looking *at* the thing. We shall presently see that to attend *from* a thing to its meaning is to *interiorise* it, and that to look instead *at* the thing is to *exteriorise* or *alienate* it. We shall then say *that we endow a thing with meaning by interiorising it and destroy its meaning by alienating it.*

Consider once more the process of perception; how we attend *from* a large number of clues—some at the edge of our vision, others inside our body—*to* their meaning, which is what we perceive. This transposition of bodily experiences into the perception of things outside, appears then as an instance of the process by which we transpose meaningless experiences into their meaning at a distance from us, as we do when we use tools or probes.

It may be objected that many of the feelings transposed in the act of perception differ from those transposed in the use of tools and probes, by not being noticeable before their transposition. But Hefferline (1959) has shown that spontaneous muscular twitches, unfelt by the subject, can be as effective as the nonsense syllables of Lazarus in foreshowing punishment.[1] And Russian observations, reported by Razran (1961), have established the same fact for intestinal stimulations.[2] This exemplifies the way subliminal events inside our body are transposed by the act of perception into the sight of things outside.

It has been said that perception cannot be a projection, since we have no internal experiences to project into things perceived. But we have established that projection of this type does take place in various instances of tacit knowing, even when we do not originally sense the internal processes in themselves. I would venture, therefore, to include in tacit knowing also the neural traces in the brain on the same footing as the subliminal stimuli inside our body. We may say then, quite generally, that wherever some process in our body gives rise to consciousness in us, tacit knowing will make sense of the event in terms of an experience to which we are attending.

This answers an old question. Imagine a physiologist to have mapped out completely all that takes place in the eyes and brain of a seeing man. Why do his observations not make him see that which

[1]Hefferline, F., Keenan, B. and Herford, A., *Science* 130 (1959), 1338–39.
[2]Razran, G., *Psychol. Rev.* 68 (1961), 81.

the man sees? Because he looks *at* these happenings, while the subject attends *from*, or through, them *to* that which they mean to him. If the subject were to watch his own nervous system in a mirror, he would see there no more than the physiologist does. What we have here is a curtailment of meaning by *alienation*. The alienated view is not quite meaningless in this case, because the visual apparatus has a meaning as a mechanism of vision. To make the situation clear, imagine one person, looking through a telescope and absorbed in admiring the moons of Jupiter, while another watched him using the telescope and observed the laws of geometrical optics. We are touching here on the problem of Cartesian dualism.

The way the body participates in the act of perception can be generalised further, to include the bodily roots of all knowledge and thought. Our body is the only assembly of things known almost exclusively by relying on our awareness of them for attending to something else. Parts of our body serve as tools for observing objects outside and for manipulating them. Every time we make sense of the world, we rely on our tacit knowledge of impacts made by the world on our body and the complex responses of our body to these impacts. Such is the exceptional position of our body in the universe.

Phenomenology contrasts this feeling of our body with the view of the body seen as an object from outside.[1] The theory of tacit knowing regards this contrast as the difference between looking *at* something and attending *from* it at something else that is its meaning. Dwelling in our body clearly enables us to attend *from* it to things outside, while an external observer will tend to look *at* things happening in the body, seeing it as an object or as a machine. He will miss the meaning these events have for the person dwelling in the body and fail to share the experience the person has of his body. Again we have loss of meaning by alienation and another glimpse of Cartesian dualism.

I have shown how our subsidiary awareness of our body is extended to include a stick, when we feel our way by means of the stick. To use language in speech, reading and writing, is to extend our bodily equipment and become intelligent human beings. We may say that when we learn to use language, or a probe, or a tool, and thus make ourselves aware of these things as we are of our body, we *interiorise* these things and *make ourselves dwell in them*. Such extensions of ourselves develop new faculties in us; our whole education operates in this way; as each of us interiorises our cultural heritage, he grows into a person seeing the world and experiencing life in terms of this outlook.

[1]This distinction is most widely developed in M. Merleau-Ponty, *Phenomenology of Perception* (London, 1962). Eng. Translation of *Phenomenologie de la Perception* (1945).

Interiorisation bestows meaning, alienation strips of meaning; when the two are applied alternately, they can *jointly develop* meaning —but this dialectic lies beyond my subject here.

The logical relation that links life in our body to our knowledge of things outside us can be generalised to further instances in which we rely on our awareness of things for attending to another thing. When we attend from a set of particulars to the whole which they form, we establish a logical relation between the particulars and the whole, similar to that which exists between our body and the things outside it. In view of this, we may be prepared to consider the act of comprehending a whole *as an interiorisation of its parts*, which makes us dwell in the parts. We may be said to live in the particulars which we comprehend, in the same sense as we live in the tools and probes which we use and in the culture in which we are brought up.

Such indwelling is not merely formal; it causes us to participate feelingly in that which we understand. Certain things can puzzle us; a situation may intrigue us—and when our understanding removes our perplexity, we feel relieved. Such intellectual success gives us a sense of mastery which enhances our existence. These feelings of comprehension go deep; we shall see them increasing in profundity all the way from the I—It relation, to the I—Thou relation.

I shall start by taking up a loose end, left behind when analysing the meaning of a word as a name for a single object. We shall ask how a name can come to designate a *group of things*, like a species of plants or animals. This is the ancient problem of universals. It can be summed up in the question: What is a man like to whom the concept of 'man' refers? Can he be both fair and dark, both young and old, brown, black and yellow all at the same time? Or, if not, can he be a man without any of the properties of a man? The answer is that in speaking of man in general we are not attending to any kind of man, but relying on our subsidiary awareness of individual men, for attending to their joint meaning. This meaning is a comprehensive entity, and its knowledge is wiped out by attending to its particulars in themselves. This explains why the concept of man cannot be identified with any particular set of men, past or future. The concept represents all men—past, present and future—jointly, and the word 'man' applies to this comprehensive entity.

The metaphysical claim of tacit knowing requires that this entity be real. This is confirmed by the fact that the members of a species are expected to have an indefinite range of yet undisclosed properties in common; this is the intension of the class formed by the species. Being real, the classing of living beings into species is fundamental to biology. Moreover, the distinctive nature of the human species

underlies all social ties, all emotions between men, and between men and women; all conceptions of responsibility; indeed our whole life as men. Thus do we dwell in our conception of a species.

Indwelling becomes deeper as we pass from the conception of a species to the knowledge of individual living beings. The main points of such knowledge were established long before the rise of science. Life and death were known before biology; sentience and insentience, the difference between intelligence and mindless stupidity, were all recognised before they were studied by science; the knowledge of plants and animals, of health and sickness, of birth, youth and old age, of mind and body, of organs and their functions, of food, digestion, elimination and many others, is immemorial. Such pre-scientific conceptions have formed the foundations of the biological sciences and still represent their major interests. Modern biology has vastly developed these ancient insights and thus confirmed their profundity.

Moreover, biologists still know these fundamentals by the same integrative powers by which they were first discovered before science, and they use similar powers for establishing their own novel biological conceptions. Morphology, physiology, animal psychology—they all deal with comprehensive entities. None of these entities can be mathematically defined and the only way to know them is by comprehending the coherence of their parts.

To appreciate this achievement, remember once more how our eyes integrate a thousand rapidly changing clues into the appearance of an object of constant shape, size and colour, moving about before us. We have to multiply the complexity of this action many times, to approach the intricacy of the integrations performed in establishing our knowledge of life and of living shapes and functions.

This integration is guided by the active functions of the living being we are observing. A lion swooping down on the back of a fleeing antelope coordinates its impressions and actions in a highly complex and accurate way within a second. The naturalist watching the lion mentally integrates these coordinated elements into the observation of the lion hunting its prey. Some vital coordinations, like embryonic development, are much slower than this, but no less rich in coordinated details; the study of physiological functions fill many volumes; the coordinations performed by human intelligence are unlimited.

There are no mathematical expressions covering the shape of a lion and the way he pounces on an antelope; nor any that cover a million characteristic shapes and coordinated actions of numberless other living beings. None of these shapes and swiftly moving correlations are precisely definable.

I have said that we integrate these shapes and correlations by the tacit powers of perception. I may add, that our perception of living beings consists largely in mentally duplicating the active coordinations performed by their functions. To this extent our knowledge of life is a sharing of life—a re-living, a very intimate kind of indwelling. Hence our knowledge of biotic phenomena contains a vast range of unspecifiable elements and biology remains, in consequence, a descriptive science heavily relying on trained perception. It is immeasurably rich in things we know and cannot tell.

Such is life and such our knowledge of life; on such grounds are based the triumphs of biology. But this is repugnant to the modern biologist. Trained to measure the perfection of knowledge by the example of the exact sciences, he feels profoundly uneasy at finding his knowledge so inferior by this standard. The ideal of the exact sciences, derived from mechanics, aims at a mathematical theory connecting tangible, focally observed objects. Here everything is above board, open to public scrutiny, wholly impersonal. The part of tacit knowing is reduced to the act of applying the theory to experience, and this act goes unnoticed; while the fact, that tacit powers predominate in the very making of discoveries, is set aside too as forming no part of science.

The structure of biology is very different from this ideal. We know a living being by an informal integration of its coherent parts. Such knowledge combines two terms, one subsidiary, the other focal, that are known in different ways. The particulars of living beings are known as such by attending *from* them to their joint meaning which is the life of the organism. And this includes the sensomotoric centre of the animal as well as the human mind, as the bearer of intelligence and responsibility. Thus the *tangible focal obejcts* of exact science have been *split into two halves*. We have the tangible bodies of living beings that are not viewed focally, while at the focus of our attention we have such intangible things, as life and mind. Both of these halves are equally distasteful to the modern biologist, who finds their very duality unscientific and intolerable.

But tacit knowing is indispensable and must predominate in the study of living beings as organised to sustain life. The vagueness of something like the human mind is due to the vastness of its resources. Man can take in at a glance any one of 10^{40} brief sentences. By my definition, this indeterminacy makes the mind the more real, the more substantial. But such reality can be discerned only by a personal judgment: its knowledge is personal. The same is true of our subsidiary awareness of the organs and behaviour of a living being, by which we bring these to bear on its life or on its mind at the focus of our attention. All tacit knowing requires the continued

participation of the knower and a measure of personal participation is intrinsic therefore to all knowledge, but the continued participation of the knower becomes altogether predominant in a knowledge acquired and upheld by such deep indwelling.

An attempt to de-personalise our knowledge of living beings would result, if strictly pursued, in an alienation that would render all observations on living things meaningless. Taken to its theoretical limits, it would dissolve the very conception of life and make it impossible to identify living beings.

My argument will gain in sharpness by narrowing it to the knowledge of another mind. We know another person's mind by the same integrative process by which we know life. A novice, trying to understand the skill of a master, will seek *mentally* to combine his movements to the pattern to which the master combines them *practically*. By such exploratory indwelling the novice gets the feel of the master's skill. Chess players enter into a master's thought by repeating the games he played. *We experience a man's mind as the joint meaning of his actions by dwelling in his actions from outside.*

Behaviourism tries to make psychology into an exact science. It professes to observe—i.e. *look at*—pieces of mental behaviour and to relate these pieces explicitly. But such pieces can be identified only within that tacit integration of behaviour, which behaviourists reject as unscientific. The actual result of a behaviourist analysis is to paraphrase this integration by the explicit relation of some of its quantifiable fragments. Such a paraphase can be badly misleading, as in Pavlovian conditioning, which identifies *eating* with *the expectation to be fed*, because both of these induce a secretion of saliva. The behaviourist analysis is intelligible only because it imitates, however crudely, the tacit integration which it pretends to replace.

The claim of cybernetics to generate thought and feeling, rests likewise on the assumption that mental processes consist in explicitly identifiable performances which, as such, would be reproducible by a computer. This assumption fails, because mental processes are recognised to a major extent tacitly, by dwelling in many particulars of behaviour that we cannot tell. But we would rightly refuse to ascribe thought and feeling to a machine, however perfectly it would reproduce the outward actions of mental processes.[1] For the human mind works and dwells in a human body, and hence the mind can be known only as working and dwelling in a body. We can know it only by dwelling in that body from outside.

[1]This view was expressed, e.g. by Professor Paul Ziff in *The Feelings of Robots* in *Minds and Machines*, ed. A. R. Anderson, *Prentice-Hall Contemporary Perspectives in Philosophy Series* (1964). Other authors contested it. I regard my argument in its favour as decisive.

But could we not conceive of the body as a neurophysiological machinery performing the manifestations of the mind? The answer is, that feeling, action and thought have mental qualities which we perceive by the same principles of tacit knowing by which we perceive the phenomenal qualities of external objects. All these qualities would vanish if we watched, how parts of the human body carry out the performances of the mind. We had an example of this when we noted, that looking at the neurophysiological mechanism of vision, we do not see what the subject sees. We have now before us the full range of the dualism of which that case was a particular instance.

But I shall show that for the case of organisms the dualism of looking *at* and *attending from*, has a substantial foundation in the existence of distinct levels in the organism. The structure of tacit knowing has its counterpart in the way the principles determining the stability and power of an organism exercise their control over its parts. This is true also for machines; so to simplify matters, I shall deal first with machines. The result can then be generalised to the mechanical aspect of living beings and from there to the entire hierarchy of an organism.

Let me choose as an example of a machine the watch I wear on my wrist. My watch tells me the time. It is kept going by its mainspring, uncoiling under the control of the hair spring and balance wheel; this turns the hands which tell the time. Such are the operational principles of a watch, which define its construction and working. The principles cannot be defined by the laws of nature. No parts of a watch are formed by the natural equilibration of matter. They are artificially shaped and sagaciously connected to perform their function in telling the time. This is their meaning: to understand a watch is to understand what it is for and how it works. The laws of inanimate nature are indifferent to this purpose. They cannot determine the working of a watch, any more than the chemistry or physics of printer's ink can determine the contents of a book.

Viewed in themselves, the parts of a machine are meaningless; the machine is comprehended by attending *from* its parts to their joint function, which operates the machine. To this structure of knowing there correspond two levels controlled by different principles. The particulars viewed in themselves are controlled by the laws of inanimate nature, while viewed jointly, they are controlled by the operational principles of the machine. This dual control may seem puzzling. But the physical sciences expressly leave open certain variabilities of a system, described as its boundary conditions. The operational principles of a machine control these boundaries and so

they do not infringe the laws of physics and chemistry, which operate within these boundaries.[1]

The same dualism holds for biology. Biologists will tell you that they are explaining living beings by the laws of inanimate nature, but what they actually do, and do triumphantly well, is to explain certain aspects of life *by mechanical principles*. This postulates a level of reality that operates on the boundaries left open by the laws of physics and chemistry.

Such duality opens a perspective to a whole sequence of levels, all the way up to that of responsible humanity, so that this sequence would form a hierarchy of operations, each higher level controlling the margin left indeterminate by the one below it. We can illustrate such a structure by the production of a literary composition, for example of a speech. It includes five levels. The first level, lowest of all, is the production of a voice; the second, the utterance of words; the third the joining of words to sentences; the fourth, the working of sentences into a style; the fifth, and highest, the composition of the text.

The principles of each level operate under the control of the next higher level. The voice you produce is shaped into words by a vocabulary; a given vocabulary is shaped into sentences in accordance with grammar; and the sentences are fitted into a style, which in its turn is made to convey the ideas of the composition. Thus each level is subject to dual control; first, by the laws that apply to its elements in themselves and, second, by the laws that control the comprehensive entity formed by them.

Such multiple control is made possible by the fact that the principles governing the isolated particulars of a lower level, leave indeterminate their boundary conditions for the control by a higher principle. Voice production leaves largely open the combination of sounds to words, which is controlled by a vocabulary. Next, a vocabulary leaves largely open the combination of words to form sentences, which is controlled by grammar; and so the sequence goes on.

Consequently, the operations of a higher level cannot be accounted for by the laws governing its particulars forming the next lower level. You cannot derive a vocabulary from phonetics; you cannot derive grammar from a vocabulary; a correct use of grammar does not account for good style; and a good style does not provide the content of a piece of prose.

A glance at the functions of living beings shows us that they have a broadly similar stratified structure. All living functions rely on the laws of inanimate nature in controlling the boundary conditions left open by these laws; the vegetative functions sustaining life at its

[1]Michael Polanyi, *Reviews of Mod. Physics*, 34, 601 (1962).

lowest levels, leave open, both in plants and animals, the possibilities of growth and leave in animals open also the possibilities of muscular action; the principles governing muscular action leave open their integration to innate patterns of behaviour; such patterns are open in their turn to be shaped by intelligence, and the working of intelligence can be made to serve the still higher principles of man's responsible choices.

Each pair of levels would present its own dualism, for it would be impossible to account for the operations of any higher level by the laws governing its isolated particulars. The dualism of mind and matter would be but one instance of the dualism prevailing between every pair of successive ontological levels.

* * *

I expect that the many points at which the views I have sketched out here diverge from those of current philosophic literature, are obvious enough. I shall only try to show that, despite this divergence, they broadly respond to the development of modern philosophy.

Current writings on the history of science have confirmed the view I have put forward years ago, that the pursuit of science is determined at every stage by unspecifiable powers of thought; and I have shown you today how this fact forms my starting point for developing a theory of non-explicit thought. You may call such a theory—using a term coined by Gilbert Ryle—an *informal logic* of science and of knowledge in general. Alternatively, you may call it a phenomenology of science and knowledge, by reference to Husserl and Merleau-Ponty. This would correctly relate my enterprise both to analytic philosophy and to phenomenology and existentialism.

Admittedly, my view that true knowledge bears on an essentially indeterminate reality and my theory of a stratified universe, are foreign to these schools of thought. And again, while knowledge by indwelling is clearly related to Dilthey and existentialism, its extension to the natural sciences is contrary to these philosophies. Similarly, while Kant's categories by which experience of external objects is deemed possible, reappear with me in the active knower participating in all live knowledge, such a knower, responsibly legislating for himself with universal intent, is more like the moral person of the Second Critique than the agent of Pure Reason.

The original intention of Logical Positivism was to establish all knowledge in terms of explicit relations between sensory data. In the course of the last twenty years this programme has been gradually relaxed, by admitting more complex data and making allowance for 'open textures' and 'flexibilities' of the framework. The most recent development in this direction came to my notice in Michael Scriven's assertion that problems of structural logic in science can 'only be

solved by reference to concepts previously condemned by many logicians as "psychological not logical", e.g. understanding, belief, judgement'.[1]

I suggest that we transform this retreat into a triumph, by the simple device of changing camp. Let us recognise that tacit knowing is the fundamental power of the mind which creates explicit knowing, lends meaning to it and controls its uses. Formalisation of tacit knowing immensely expands the powers of the mind, by creating a machinery of precise thought, but it also opens up new paths to intuition. Any attempt to gain complete control of thought by explicit rules is self-contradictory, systematically misleading and culturally destructive. The pursuit of formalisation will find its true place in a tacit framework.

In this light, there is no justification for separate approaches to scientific explanation, scientific discovery, learning and meaning. They ultimately rest on the same tacit process of understanding. The true *meaning* of Kepler's Third Law was *discovered* by Newton, when he *explained* it as an outcome of general gravitation. And *learning* by insight has the same three aspects on a minor scale.

The claims of cybernetics represent a revival of logical positivism in its original insistence on strictly explicit operations of the mind. Hence my rejection of a cybernetic interpretation of thought and of a behaviourism based likewise on the assumption that the data and operations of mental processes are explicitly specifiable.

My analysis of machines and living beings entails the rejection of Ernest Nagel's claim to describe machines and living beings in non-teleological terms.[2] Nothing is a machine unless it serves a useful purpose, and living organs and functions are organs and functions only to the extent to which they sustain life. A theory of knowledge based on tacit knowing, does not require that we purify science of references to mind or to the finalistic structure of living beings.[3]

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[1]Michael Scriven, *Explanation, Prediction and Laws* in *Minnesota Studies in the Philosophy of Science*, Vol. III (Minneapolis, 1962), p. 172.

[2]Ernest Nagel, *The Structure of Science* (New York, 1961), p. 417.

[3]I have published simultaneously with this paper a more fully developed statement of my Body Mind theory in *Brain* under the title *The Structure of Consciousness.*