8

The Logic of Achievement

8.1 Preface

The logic of achievement is Michael Polanyi's concept in which he reinterpreted Samuel Alexander's concept of emergence (5.6). Alexander speaks about emergence in a broader sense, from the first manifestation of time in a point of space until the future manifestations of time in the cultural spaces of morality, thinking, and consciousness. The multidimensional manifestation of time in an elementary material entity is not an achievement. Time itself has no distinctive, focused parts around a center in space. The logic of achievement is the main point of the process as distinctive, stable lower-level entities due to a higher-level ordering principle become the parts of a higher-level comprehensive structure that is able to control and harness the lower-level parts and processes to achieve its goals. When a unicellular living being replicates itself, it controls the random material flow of many chemical molecules for its benefit, and if the replication is successful, it will achieve its goal. *The logic of achievement is, therefore, the logic of emergence at the biological and higher levels*. The logic of achievement is the main logic of evolutionary emergence from the first primitive prokaryotes to the greatest achievements of man.

However, as we have seen several times so far, the emergence of a comprehensive order does not necessarily mean the emergence of a new object in the ontological sense (5.5, 6.4). Accordingly, we can speak of material achievements or physical work (e.g., in the case of heat flow) and can precisely describe and calculate the power of the process (P=W/t). Nonetheless, the heat flow, in fact, does not do any work; we can say at most that from our specific point of view, the power is the comprehensive phenomenon of the flow of the material parts (emergence in the epistemological sense). To speak about real work and real achievements, a real, comprehensive object (orderly whole) is needed that controls and harnesses these lower-level processes (emergence in the ontological sense) so the work is done by somebody or something, by a living being or a machine. However:

> Our comprehension of a living individual entails a subsidiary awareness of its parts which is not wholly specifiable in more detached terms. This understanding acknowledges a particular comprehensive—i.e., "molar"—achievement of the individual itself. Since our knowledge of this molar function is not specifiable in "molecular" terms, the function itself is not reducible to molecular particulars; it must be acknowledged therefore as a higher form of being, not determined by these particulars.[1]

According to Polanyi, the recognition of a comprehensive, orderly ("molar") whole cannot be deduced from the ("molecular") knowledge of the parts of which one is aware during the recognition of the whole only subsidiarily (3.3). The process of recognition is, in fact, *an achievement* of a concrete living being, for example, the achievement of a human person from his own point of view by his own tacit bodily skills and personal efforts—that is, it is based on personal knowledge. The subsidiary parts of the whole can be recognized and explained only through the recognition of the whole—that is, merely after the successful recognition of the whole. The objective, Laplacian knowledge of the parts does not in itself include the comprehensive knowledge of the whole, referring to its purpose-serving functions, comprehensive features, operational principles, etc. (2.3). As we have seen, Polanyi calls these latter phenomena personal facts which cannot be determined without personal participation and personal knowledge (3.3). Since the higher-level knowledge referring to the comprehensive whole cannot be reduced to the lower-level knowledge referring to the parts, the reality of the higher-level whole—and thus the reality of its functions, principles, and achievements—has to be acknowledged. Based solely on the objective, mechanical knowledge of the parts, it cannot be decided which acts of comprehensive, emergent entities are achievements and which are failures because the distinction between achievement and failure is not present at the lower level but rather is based on higher-level ordering principles (normative *rules of rightness*) and personal facts. In consequence, based solely on the objective knowledge of the parts, it cannot be decided which actions of living beings could lead to evolutionary emergence (achievements) and which could lead to extinction (failures). The real, driving force of evolution would vanish from our sight.

In the most general sense, this is the argument which will be repeated in this chapter in different versions as we will once again follow Polanyi's

1. Polanyi, *Personal Knowledge*, 327.

train of thought closely to establish the concept of evolutionary emergence and the active, natural knowledge of living beings in contrast to the artificial creation of machines and their knowledge.

8.2 Machines and the Rules of Rightness

We have seen in the previous chapter, based on the theory of boundary conditions, there is a significant difference between physical sciences and life sciences and that engineering—perhaps, at first sight, oddly enough—is at the side of the latter. Now, following Polanyi, I will elaborate on this claim.

Polanyi starts his argument by referring back to the evolutionary roots of humans that animals are able to (1) *trick*, (2) *sign*, and (3) *latent* learning. The first two are more primitive, while the third is a more developed achievement of the merger of the first two.[2]

(1) *Trick learning*: Polanyi shows the point of this type of animal learning through a rat experiment by B. F. Skinner where a rat acquired a trick all by itself that if it pushes a specific lever, it will get food. This type of learning primarily means the *contriving* of a particular technique of movement for the sake of a certain goal. Then, by the application of the new method, the animal can control the situation in which it has found itself and can solve the problem it has to face.

(2) *Sign learning*: Among other examples, Polanyi also uses an illustrative rat experiment to shed light on the point of this type of learning. In this case, there are two doors with two different signs on them and food behind one of the doors. The rat gradually learns which sign refers to food behind the door. Naturally, this type of learning also includes the application of some technique of movement, but this technique is not necessarily new, and the point of the learning is rather *in observation*—also for the sake of a certain goal to control the situation and solve the problem. Every animal can "grasp coherently the things they perceive, and sign learning appears to be an extension of this perceptive faculty by the power of intelligence."[3]

(3) *Latent learning*: Polanyi presents another rat experiment to show the point of this type of learning, too. In this experiment, a rat has to go through a labyrinth to get to its food. In this case, the rat has to face a much more complicated problem than in the first two cases because it cannot see the whole situation at any given moment. Therefore, it has to acquire some mental representation (system of signs) of the structure of the labyrinth and then apply this mental representation to the situation

2. Polanyi, *Personal Knowledge*, 71–74.
3. Polanyi, *Personal Knowledge*, 73.

as it would be a simple, transparent trick. So, the rat can *infer* a specific behavior from the latent knowledge of the situation, which, according to Polanyi, is a primitive logical inference.

In all cases, the process of learning can be separated into two well-definable parts. The first is the *irreversible*, *heuristic* part of the process during which genuinely new knowledge emerges, while the second is the *reversible*, *routine-like* application of the already acquired knowledge. In the case of (1) trick learning, the first part is a *contriving* and the second is the continuous repetition of the trick; in the case of (2) sign learning, the first one is an *observation* and the second one is the repeated reaction to a sign; and in the case of (3) latent learning, the first part is the *understanding* of a complex situation and the second part is the routine-like solution of the problem.

According to Polanyi, the roots of (1) *contriving* and *engineering*, (2) *observing* and *natural sciences*, and (3) *understanding* and *mathematical*, *logical* (exact) sciences can be found in these three fundamental animal skills. The latter skills in the categories are the higher-level ones based on higher-level principles, accurate methods, and sophisticated instruments.

	First type	**Second type**	**Third type**
Animal skills	Trick learning	Sign learning	Latent learning
Human basic skills	Contriving	Observing	Understanding
Human higher-level skills	Engineering	Natural sciences	Exact Sciences

Table 7. The different types and levels of animal and human skills, according to Polanyi.

Nonetheless, natural sciences include two main parts: *physical sciences,* referring to lifeless nature (to structure boundary conditions), and *life sciences*, where the objective observation of the lifeless parts plays only a *subsidiary* role behind personal facts and judgments based on prior personal knowledge and referring to living beings (to control boundary conditions). In Polanyi's words: "Only the physical sciences are predominantly observational, while biology and the study of mind and man have a more complex structure, in which observation plays but a subsidiary role."[4]

I can only add that philosophy is also based on understanding and thus on the basic animal knowledge of latent learning; we would like to know the whole context, the hidden rationality behind the problem. Exact sciences

4. Polanyi, *Personal Knowledge*, 328.

are always focusing on the explicit logical system of a given conceptual and explanatory framework, while philosophy should focus on the hidden tacit content of the given system determined by our most profound and oldest natural beliefs. Nonetheless, positivism tries to create an exact, logical science from philosophy (and from natural sciences, too) which means that during the twentieth century, philosophy lost its former role—concerning our natural beliefs—and now, there is a growing distance between science and society: neither science nor philosophy is able to unfold and rationally establish our most essential convictions and beliefs.

But now, the question is what a machine is. The answer is that a machine is nothing but a *complex, rational tool* that we use during an act for the sake of some goal to reach some benefit. In this sense, its roots can be found in the animal knowledge of *trick learning* which does the same only at a lower level and which is the tacit base of contriving and technology (engineering). The use of a tool or the operation of a machine is based on such comprehensive *rules of act* and *operational principles* which cannot be determined by their details and which allow the successful use or operation of a tool or a machine (3.3).

> Technology teaches only actions to be undertaken for material advantages by the use of implements according to (more or less) specifiable rules. Such a rule is an operational principle. As implements are defined and understood in terms of an action which they serve, they are defined and understood likewise in terms of the operational principle which tells how to perform such an action.[5]

> The questions: "Does the thing serve any purpose, and if so, what purpose, and how does it achieve it?" can be answered only by testing the object practically as a possible instance of known, or conceivable, machines.[6]

Contrarily, the knowledge and recognition of an object or the material parts of a machine are based on the animal knowledge of sign learning which is the tacit basis of observing and natural sciences. Therefore, these two knowledge—practical engineering sciences and theoretical natural sciences—are highly different even in their tacit fundaments. Both are relevant regarding machines, but while engineering refers to the comprehensive whole and *operational principles* of machines, physical sciences refer only to the tangible parts and *material conditions* of machines.

5. Polanyi, *Personal Knowledge*, 176.
6. Polanyi, *Personal Knowledge*, 330.

> A physical and chemical investigation cannot convey the understanding of a machine as expressed by its operational principles. In fact, it can say nothing at all about the way the machine works or ought to work. . . . In other words, *the class of things defined by a common operational principle cannot be even approximately specified in terms of physics and chemistry*.[7]

The machine is *an achievement of an invention*. It is defined by the patent that tries to describe it in the broadest possible sense—that is, the patent does not include the concrete realization and the different possible material conditions of the machine, merely the operational principles (the rules of rightness of the various functions of the machine) due to which the machine can properly work and fulfill its goal. In this sense, the machine is an *ideal* with which several different concrete objects can comply. This ideal and these operational principles determine the particular rules of rightness due to which the machine can function and successfully achieve its goals.

> The conceptions of machines in good working order form a system which ignores the particulars of failures—in the same way as geometrical crystallography ignores the imperfections of crystals. The operational principles of machines are therefore *rules of rightness*, which account only for the successful working of machines but leave their failures entirely unexplained.[8]

However, the operation principles, according to their comprehensive nature, cannot answer why a machine goes wrong, what the cause of its failure is—that is, what is the concrete material part because of which the machine cannot function properly. In the same way that physical knowledge, referring only to material parts, cannot tell what a comprehensive machine is and why it is working successfully. They are fundamentally different kinds of knowledge which complement each other.

Nonetheless, the relation of the two kinds of knowledge is not symmetric. On the one hand, if someone recognizes an object as a machine that is defined by a comprehensive function, then he has identified the machine correctly which cannot be claimed if he has recognized it only as an object—that is, he has identified merely its material parts. On the other hand, physical knowledge is much more fundamental and can be applied to every object, while engineering can be applied only to those objects that are machines. The reason for this asymmetric relationship is, of course, that our knowledge referring to the fundamental parts and the

7. Polanyi, *Personal Knowledge*, 329.
8. Polanyi, *Personal Knowledge*, 329.

higher-level functions of the machine are in the same asymmetric relationship as the material conditions and comprehensive emergent level(s) of the machine itself.

It follows that although the two kinds of knowledge are fundamentally different, they can still be linked together fruitfully. The detailed physical knowledge of a machine as an object can deepen the understanding of the machine. Only engineering and its operational principles can account for the successful workings of machines, but these operational principles and comprehensive knowledge in themselves cannot account for their failures because the cause of these failures can be found in the material conditions of machines which, in turn, belong to the territory of physical sciences. Therefore, the failures of machines can be accounted for by only these two different kinds of sciences together. So, understanding the causes of the failures by physical knowledge can deepen the concept of the machine itself as a comprehensive, orderly whole which finally can lead to new types of realization of the machine.

As a matter of fact, after the industrial revolution, modern machines are indeed the achievements of the development of modern physical sciences. Before the industrial revolution, technology was mostly cultivated in guilds by tacit rules of act and maxims. Then, the explication of these tacit rules into operational principles which now defining the different subparts of the whole process and the destructive analyses of the material conditions of these subparts led to the development of modern manufacturing industry. Thus our original, tacit bodily skills from our animal heritage (trick learning), which unfolded into craftsmanship in the conceptual and explanatory system of our ancient mute culture (10.6), have become the tacit basis of modern technology and engineering in the highly explicated conceptual and explanatory systems and institutions of our modern era. Now, a similar transition takes place at the higher level of automats and information technology.

So, successfully working machines are the achievements of both engineering and physical sciences. Engineering determines the operational principles that account for the successful workings of machines, while the physical sciences determine the causes of possible failures and provide those material conditions among which the operational principles define the successful operations of machines.

8.3 Living Beings and the Rules of Rightness

Contriving and observing—and thus engineering and physical sciences—can be characterized by the *irreversible* processes of human comprehension. Now Polanyi contrasts these with mathematical and logical (exact) sciences which have their own evolutionary roots in animal knowledge (latent learning) and which can be rather characterized by *reversible*, deductive logical thinking.

> Thought proceeds largely by an irreversible process of comprehension and not according to specifiable rules. Only the latter will be called logical thinking, in which I shall include mathematics. Logic, thus defined, is a rule of rightness: it tells us how we must reason in order to derive correct and ample conclusions from given premises.[9]

By this, Polanyi does not want to sharply separate engineering and physical sciences from mathematical and logical sciences but rather wants to show the different nature of logical inference and thus of logical machines—which, at the same time, follow different kinds of rules of rightness just as machines themselves do. In consequence, making any logical inference is also an emergent *achievement*. The rules of correct—and thus successful—logical thinking have to be acquired in the same way as the rules of other craftsmanship; as well as these rules also cannot account for logical errors as the comprehensive operational principles of machines cannot account for the failures of machines. *Psychology* accounts for the causes of logical fallacies:

> Psychology cannot distinguish by itself between true and false inferences, and hence is blind to logical principles; but it can throw light on the conditions under which the understanding and operation of correct logico-mathematical reasoning may develop, and it may supply an explanation for errors in reasoning. Indeed, an error in reasoning can never be the subject of a logical demonstration; it can be understood only by psychological observations which reveal its causes.[10]

This train of thought makes the same argument for the relation of logic and psychology which we have just seen in the relation of engineering and physical sciences. The conscious and unconscious processes of attention are

9. Polanyi, *Personal Knowledge*, 333.
10. Polanyi, *Personal Knowledge*, 334.

the objects of psychology, and the principles of logic are based on these lower-level processes ("material" conditions).

Similarly, there are different types of rules of rightness in all processes that are under the logic of achievement—that is, that lead to successful achievements. In the case of machines, these are different types of operational principles; in logic, these are different rules of inference (e.g., the modus ponens); in ethics, these are different moral principles (e.g., "thou shalt not kill"); and there are different rules of rightness in the sciences, arts, sports, etc., or, for instance, in the case of the successful functioning of the human body. The table below shows the lower-level sciences that account for the failures of higher-level ordering principles in different areas.

Engineering	Logic	Ethics	Poetry	Biology
physics, chemistry	psychology	sociology	linguistic	biophysics, biochemistry

Table 8. Different sciences that complement each other.

The main difference between the relation of engineering and physical sciences and the relation of logic and psychology is that contrary to machines, in the case of logic, there is a *second person*, with an active center, who tries to meet the rules of rightness, while a machine "only" works.[11] The first person is the knower, who, based on his personal knowledge, can recognize that there is another person, who is able to follow the rules of inference (or the rules of act, etc.)—that is, who is capable of successful logical (or ethical, etc.) achievements. As we have seen, this comprehensive achievement of logic (or morality, etc.) cannot be recognized without the personal knowledge and judgment of the first person—that is, based only on Laplacian, systematic objective knowledge.

The rules of rightness which a person tries to meet also set up an ideal in exactly the same sense in both logic and ethics (and in arts, legal systems, etc.) as we have seen in the case of machines. This is the reason Polanyi says that a person has to commit himself to such ideals both in the cases of logic and morals, the media of which are in itself blind towards these ideals as well as physics and chemistry cannot account for the successful working of a machine—that is, blind towards the rules of rightness according to which the machine successfully works. Therefore, psychology is blind towards the rules of logic; sociology is blind towards the laws and the rules of act of ethics; linguistics is blind towards the maxima of poetry, etc.

11. Polanyi, *Personal Knowledge*, 334.

At the same time, this blind medium and nothing else *gives the opportunities* to a person to act according to his ideals; with Polanyi's words, it "grants the possibility for striving for his ideal."[12] For example, without the lower-level social environment, there is no "blind" medium in which a person could act according to higher-level moral principles and thus fulfill his ideal of morality. However, this blind medium also defines the lower-level conditions and constraints within which the person can act and gives only a few clues to meet his ideals. *This contradictory situation of emergence between higher-level comprehensive, ordering principles and lower-level conditions determines a person's "calling" and leads to free, responsible actions according to the logic of achievement* (9.7). Contrary to this, a logical inference machine, where there is no "second person"—that is, which has no active center and follows strict rules—does not and cannot have any responsibility for what it does; it only works successfully or it fails. A human person, however, can be wrong at any time, and he has to bear the responsibility for his mistakes:

> I accept the responsibility for drawing an ever indeterminate knowledge from unspecifiable clues, with an aim to universal validity; and this belief includes the acknowledgment of other persons as responsible centers of equally unspecifiable operations, aiming likewise at universal validity.[13]

So, a person is not merely a concrete tangible (material) being who can be explicitly specified by the sum of his parts due to the methods, laws, and data of physical sciences, physiology, or sociology, but such a *comprehensive, orderly whole with an active center* based on his tangible (material) parts *who has definite ideals, goals, and calling*, who "dwells in" his different bodily and intellectual tools and in his material conditions (3.3). *The essence of a person is that he follows his ideals to which he committed himself*. However, this obligation demands severe achievements from him, the lower-level possibility-conditions of which perhaps are not even given.

12. Polanyi, *Personal Knowledge*, 334.
13. Polanyi, *Personal Knowledge*, 336.

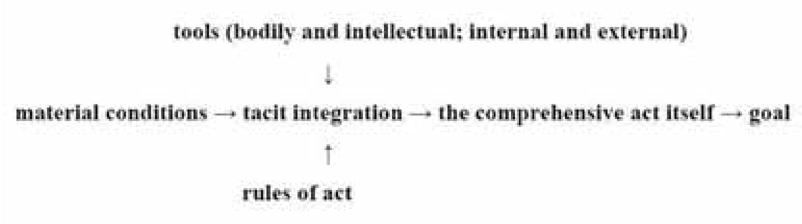

Figure 25. The structure of human skills.

Based on these, Polanyi asserts:

> To represent living men as insentient is empirically false, but to regard them as thoughtful automata is logical nonsense. For we are aware of a man's thoughts only by listening to him, i.e., by attending subsidiarily to certain bodily actions in the assumption that they are impelled by his thoughts, which are in fact known to us only as the effective center of his meaningful actions. Nor can we speak therefore of thinking which totally lacks originality and responsibility.[14]

Unfortunately, neurology focally observes merely the lower-level bodily processes and regards human thinking as the analogy of a single level logical inference machine. In consequence, it ignores the personality, responsibility, and calling of human beings as well as it overlooks the active, creative powers of human beings which they inherited from their earlier animal life. We can find the roots of human persons and personal knowledge neither in their material parts nor a logical inference machine but rather in animals, animal knowledge, and in the evolutionary development of human beings. This is the reason Polanyi confirms "an active center operating unspecifiably in all animals,"[15] including us:

> At all levels of life, it is these centers which take the risks of living and believing. And it is still such centers which, at the highest stage of development, actuate those men who seek the truth and declare it to all comers—at all costs.[16]

The body of animals in itself is constructed from such machine-like tools, the successful workings of which are determined by *fixed* rules of rightness as we have seen that in the case of machines. This fact, however, would not be enough for animals facing real evolutionary challenges. Machines also

14. Polanyi, *Personal Knowledge*, 339.
15. Polanyi, *Personal Knowledge*, 336.
16. Polanyi, *Personal Knowledge*, 404.

would not work if humans did not build and operate them. However, contrary to machines, in animals, there are such *tacit, creative powers* which activate and animate these fixed operational principles and machine-like bodily tools to be able to face their problems in life and achieve their goals. Therefore, these tacit, creative powers are the active centers of animals which govern and control their bodies constructed from machine-like tools.

Naturally, the same tacit, creative powers operate in the human body, too. Humans, however, have not only internal bodily tools, as animals have, but by their *intellectual* and *external* tools, they can significantly *unfold* these tacit, creative powers they inherited from their animal life. Just think back to the trick, sign, and latent learning of animals—which, by the intellectual and external tools of man, became invention and engineering, systematic observation and natural sciences, and inference and mathematical and logical sciences. "The evolutionary process forms a continuous transition from the inanimate stage to that of living and knowing persons."[17]

This leads to exactly the same relation between biology and physical sciences as we have seen between logic and psychology and between engineering and physical sciences.

> Morphogenesis is the formation of right shapes, a process which may succeed or fail. A physical-chemical explanation would not account for these alternatives, it would merely shift the problem back to the rightness of the conditions from which the process started. . . . Studies of physical-chemical processes can never take the place of these interests; they can belong to psychology or embryology only to the extent to which they have a bearing on anterior interests arising within these sciences. Physical and chemical knowledge can form part of biology only in its bearing *on previously established biological shapes and functions*: a complete physical and chemical topography of a frog would tell us nothing about it as a frog, unless we knew it previously *as a frog*.[18]

So, the active, creative powers of animals initiate and control the different fixed, machine-like tools (and lower-level material processes) in the animals' bodies. This control can be specified only by comprehensive concepts. The precise operational principles of machine-like tools can be understood by destructive analysis, but the appraisal of these comprehensive operational principles can be done merely by personal skills. The crucial step is the successful recognition of the center and individuality of animals which differentiate between machines and animals. According to Polanyi,

17. Polanyi, *Personal Knowledge*, 345.
18. Polanyi, *Personal Knowledge*, 342.

this is the exclusive act of personal knowledge, since it is about personal and not about objective facts.[19] It follows that we have to handle three logical levels in the case of biology and life sciences:

1. There is our own personal perspective and knowledge.
2. There are the lifeless material parts or conditions of physical sciences.
3. And the most important part is the successful recognition and acknowledgment of the center and comprehensive individuality of living beings.

This last factor fundamentally transforms our relationship to living beings as well as biology contrary to physical sciences.

> Our understanding of the hungry animal choosing its food, or of an animal on the alert, listening, watching, and reacting to what it notices, is an act of personal knowing similar in its structure to the animal's own personal act which our knowing of it appraises. And accordingly, our knowledge of the active-perceptive animal would dissolve altogether if we replaced it by our focal knowledge of its several manifestations. Only by being aware of these particulars subsidiarily, in relation to a focal awareness of the animal as an individual, can we know what the animal is doing and knowing.[20]

And when we arrive at the examination of human beings, our "I-It" relation to the objects of physical sciences entirely becomes an "I-Thou" relation. According to Polanyi: "This suggests the possibility of a continuous transition from statements of fact to affirmations of moral and civic commands."[21]

So, there are such comprehensive entities (machines and living beings), certain acts of which, according to the logic of achievement, can be understood *only in relation to* their success or failure. This means that the given act is evaluated in relation to its rules of rightness which determine its success. If the given act complies with its rules of rightness, then it must be acknowledged as the achievement of the comprehensive entity. Without the rules of rightness, it cannot be decided that an act is a success or a failure because from the perspective of the lower-level tangible parts, every event concerning the given entity is the consequence of the mechanical processes of the parts.

19. Polanyi, *Personal Knowledge*, 344.
20. Polanyi, *Personal Knowledge*, 364.
21. Polanyi, *Personal Knowledge*, 346.

Since physical and chemical examinations referring merely to the material conditions of comprehensive entities *do not include* any rules of rightness, they are not capable of appraising the achievements of comprehensive entities. Thus if we are insisting that ultimately only physical and chemical types of "objective" examinations should be accepted in science, then we will question the real achievement of comprehensive entities, especially of living beings. This attitude will also lead to the questioning of the reality of living being since a living being can be differentiated from simple material systems only by the (personal) fact that they possess such knowledge by which they can realize real, successful achievements.

The recognition and appraisal of successful efforts of living beings is also an achievement of this type, based on the tacit skills and personal judgments of human beings. Biology (or engineering)—the primary assignment of which is the recognition (or discovery) of the different rules of rightness and the appraisal of the achievements of living beings—is a fundamentally different science than physics and chemistry, which are directed only towards the material parts and conditions of any object or living being. Unfortunately, this fact was not acknowledged by critical philosophy and science (especially by positivism and materialism).

8.4 The Knowledge of Machines

In the previous chapter, we saw that machines and living beings are the subjects of the same higher-level category of control boundary conditions, and in this chapter, so far, we have seen that both machines and living beings work or act according to the logic of achievement; moreover, the body of living beings is constructed from fixed, machine-like tools. However, living beings are still not machines because they have such active, dynamic centers and tacit, creative powers that machines do not possess. In consequence, living beings have to be regarded as (primitive) persons possessing (tacit) knowledge (5.6). The question is whether machines have knowledge, too, and if they do have knowledge, is it tacit or explicit?

According to the modern critical approach, living beings are complex machines and biology and neurology model living beings as machines. Moreover, now we are capable of constructing such complex automats—like computers and robots—which strongly suggests that machines have some kind of knowledge. In the research field of Artificial Intelligence, it is a trivial "fact" that computers model human thinking. Is it really the case? Nonetheless, if machines indeed have some kind of knowledge, then is it tacit or explicit? Since machines generally do not speak, it suggests that if they have knowledge, then this knowledge will be tacit. However, the convictions are usually quite the opposite.[22] In next two subchapters, I aim to answer these questions with the help of a concrete example.

The iRex 2011 technology exposition included a great attraction for its visitors: a robot called Primer-V2 riding a tiny bicycle. The robot was a humanoid, meaning that its 40 centimeter tall body, made of aluminum and plastic, mimicked the human form. The robot had four different sensors, which provide feedback to the central control unit located in the backpack of the robot, programmed on a chip slightly larger than 1 by 1 centimeter. A remote control was used to direct the robot, but it only sent high-level commands like "bike forward" or "stop." Pedaling and balancing were managed by the robot itself. The Japanese creator's next goal was to enhance the robot to allow it to plan its own route thus making the remote control unnecessary.

The Primer-V2 represents only a stage in the evolution of bicycle-riding robots. It is especially interesting to us because of its autonomy, its ability to balance without a gyroscope, and its humanoid body. Even the bicycle is a regular one, only a little bit smaller. Many of these features were present in earlier projects as well, but not at the same time. The humanoid Murata Boy already pedaled on a bike in 2005; its sister, Murata Girl, was able to ride a unicycle. These robots were stabilized by a gyroscope. Other robots, like the entrants in the BicyRobo Thailand student challenge (first organized in 2011), did not use additional stabilizators, balancing using handlebars only. However, these robots did not have a rider but were automated bikes.

There are many other examples through which we could investigate the question of machine knowledge: e.g., chess-playing robots, the Wolfram Alpha question answering system, the famous jeopardy player Watson, unmanned aerial vehicles (UAVs), the Mars Rovers, etc. But I am sure that for Polanyi readers, it is clear why I chose this particular robot: as we have seen in subchapter 3.3, bicycle riding is one of Polanyi's favorite examples for explaining tacit knowledge.

It is important to point out that the Primer-V2's comprehensive emergent structure alone is not enough to explain that it can possess knowledge. An additional requirement is needed to fulfill this ability: that it has a *center* that features regulative functions that control its body parts and maintain its operation due to specific rules: in the case of Primer-V2, the control unit in the backpack provides these functions. It analyzes the incoming signs from the sensors, calculates the necessary modifications of its operation, and commands also by signs the different servo motors that keep the balance of the whole structure.

22. See, e.g., Collins, *Tacit and Explicit Knowledge*.

The concept of the regulative center enables us to resolve the deep problem generated by the fact that robots are not living beings and yet they know certain things. The presence of a center is necessary for even the most primitive forms of life because they would not survive a minute without the regulative functions realized therein; just think back to the chemoton, the simplest possible life form (7.7). In the case of machines, however, a center is not necessary at all. Humanity has invented many tools and machines—like the hammer or the bicycle—which fall under the type of control boundary conditions but do not have a center. This category does *not* exist in the case of life. Machines, however, do not need to stay alive, do not need to function a complex organization, and they are not deeply embedded in nature, in the comprehensive evolutionary system of Erath. They are created and, if it is needed, are taken apart by human beings due to their actual goals. These machines are therefore not autonomous and require an operator. In consequence, we can regard these machines as extensions of the human body, or we can say that these machines are regulated by their operator's center. In other words, while the Primer-V2 has its own knowledge, a hammer does not—the man with a hammer does who use the hammer to extend his abilities.

Thus, I do not claim that a hammer knows how to nail or a bicycle knows how to accelerate, etc., I only like to argue that the Primer-V2 is able to ride a bike; it knows to ride a bike. Nevertheless, it is not a trivial task to define the boundary between autonomous robots that have centers and have some knowledge and simple machines and tools that do not. I think that, according to Polanyi's concept of tacit and personal knowledge, there is no precise, explicit definition for this boundary: we have to decide based on our personal knowledge and personal experiences in case of every machine that under which category it falls.

However, I think it is really challenging to deny the capacity for any kind of knowledge in the case of Primer-V2 or similar robots. In this position one has to argue that the robot does not know how to ride a bicycle, even though it does something very-very similar as a real person would do, namely it goes from one place to another with a bike by all alone which was very obvious for the visitors of the iRex exposition; or he has to argue that a chess machine does not know how to play chess even though a layman cannot beat it anymore at the game. These are very-very strong claims that have to be argued in details.

Nonetheless, it is clear that the Primer-V2's capacity for bicycle riding is achieved in a very different manner from the way as humans accomplish the same. In the robot's case, the regulative functions are realized with a proportional-integral-derivative (PID) method, a classical approach in control theory; this programmed regulation in a chip is very different from what a human or an animal does. It is also evident that the body structure of the robot is very different from the human body: its stability is not provided by a skeleton, there are no muscles, and the motion is achieved by servo motors, etc. Moreover, human bicycle riding is a tacit act (achievement) which was not and, according to Polanyi, cannot be fully explicated (3.3) and therefore we cannot say that the human knowledge of bicycle riding is somehow explicitly simulated by a robot. So, we have two different types of bicycle riding, and the question is what the exact relation between the knowledge of a human and the knowledge of the Primer-V2 is.

To understand the situation better, let us consider Polanyi's example of the neurologist. The neurologist is able to examine the brain of another person, while that person is, for example, watching a cat. The neurologist is able to make focal and thus explicit the internal processes of the subject's brain. Of course, the subject itself cannot do this. "But the fact remains that to see a cat differs sharply from the knowledge of the mechanism of seeing a cat. They are a knowledge of quite different things."[23] In other words, no matter how thoroughly the neurologist explicates the lower-level brain mechanisms of the subject, the knowledge he gathers is *not the same* as the subject's own knowledge—that is, the recognition and watching of a cat. As a consequence, the neurologist cannot use the subject's knowledge as his own. The deep meaning of this example will be more evident if we consider the case of riding a bicycle or playing the piano. The neurologist might be able to give an exhaustive explicit description of how the subject rides the bike or plays the piano in terms of brain and body mechanisms but, of course, having only this knowledge about the explicit parts does not enable him to ride or play at all. No neurologist will be the next Chris Froome just because he can exactly map out the firing neurons of Chris Froome's nervous system and perfectly determine all of his muscle movements.

The engineer-scientist is in a similar situation to that of the neurologist—that is, he perfectly understands the software and hardware required to build a bicycle-riding robot. Thus one could argue that the scientist explicitly knows every instruction needed making the Primer-V2 ride and therefore its knowledge is fully explicated; and one could then arrive at a conclusion that because, according to Polanyi, fully explicated knowledge is impossible, in this case, there is no knowledge at all: the Primer-V2 "just works" due to its program but knows nothing.

However, *both* steps are wrong. The robot's program code or hardware blueprint as grasped by the scientist is like the explicated brain mechanisms

23. Polanyi, "Logic and Psychology," 39.

understood by the neurologist. It can be made focal, it is discoverable, it might be even formalizable—but *it is not the robot's knowledge at all. It is the knowledge of the scientist about the robot.*

In Figure 26, I explain in six steps how one can interpret the general process of the construction of a bicycle-riding robot.

1. A human rides a bicycle.
2. A scientist examines the bicycle riding skill of the human.
3. The scientist explicates his knowledge about the subject in mathematical formulas. This is not the same as the subject's knowledge. As a consequence, the scientist is not able to acquire the subject's knowledge of riding—maybe the scientist does not know how to ride a bicycle at all; it is beside the point. This knowledge is similar to that of the neurologist about the brain.
4. The scientist transforms his explicated knowledge about bicycle riding to hardware architecture and program code.
5. The scientist builds and programs the robot.
6. The robot rides the bicycle.

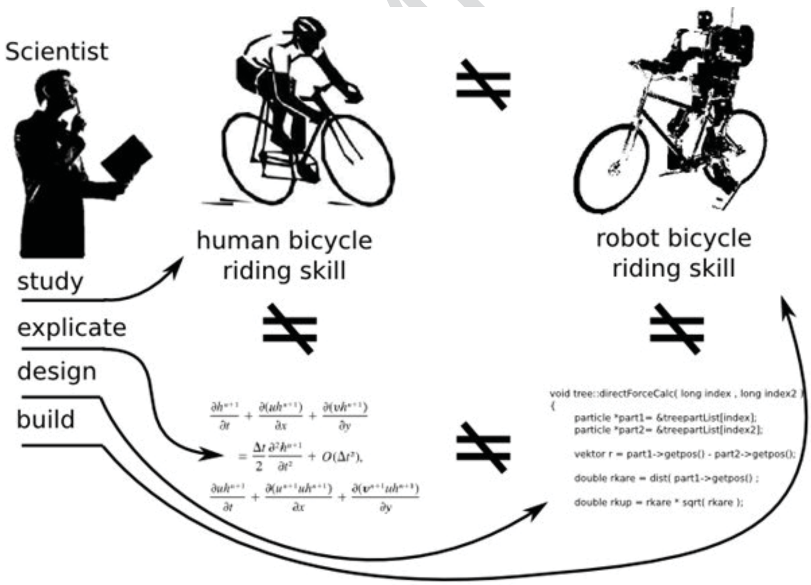

Figure 26. The process of constructing a riding robot.

It has to point out that the knowledge of the built robot in its actual body architecture is *not explicit* even though the scientist programmed his explicit knowledge in it. First of all, this is because the robot has a body of aluminum and plastic and servo motors, etc., about which the scientist himself has no fully explicit knowledge. Second, and this is the point, the program has *a different meaning* for the robot and the scientist. For the scientist, it is a description of a control method—that is, *explicit knowledge* with *denotative meaning*. However, for the robot, it is such knowledge that it *applies* to be able to ride the bicycle—that is, for the robot, the program has *existential meaning*. The denotative affirmation that the robot rides the bike—even if it is so explicit and formalized as the scientist's description of the Primer-V2—*cannot be identical* with the knowledge that existentially manifests itself in the actual bicycle-riding act of the Primer-V2 (3.4).

So, the robot does not have the explicit knowledge of the scientist, it does not even know the program—it does not understand programming patterns, PID control, etc.—and it cannot affirm the program because it has no skills to make any affirmation at all, it only knows how to run it. In this case, by controlling its body structure due to the program, it knows how to ride a bicycle. In other words, what the scientist explicitly expresses in the program code is not explicit for the robot. It does not know what is written in the programming language (the scientist's explicit knowledge) and it does not ride by understanding it. What it does is that it executes a *code* which *integrates* its body parts and its sensory data into physical motion enacting the knowledge of bicycle riding itself—which is a *tacit knowledge by the tacit integration of these parts* (3.3). The scientist, in general, cannot do such things. But, on the other hand, the robot does not have the scientist's explicit knowledge at all.

Of course, one could program the robot to print its program code at the push of a button; however, the printed material also will not be the robot's knowledge. One could even engineer a robot in a way that it would display its hardware blueprints. That would be the robot "explicating" a part of the scientist's knowledge and not the robot's own knowledge which is restricted to the capability of running the code and thus riding the bike. As Polanyi explains:

> 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.[24]

24. Polanyi, "Logic of Tacit Inference," 144.

We have to come to a conclusion that, just like with animals or humans, the robot's knowledge is at least partly—but more likely entirely—*tacit*. We cannot say that the robot works according to the explicit knowledge of its creator; we also cannot say that the tacit part of their knowledge is similar, as they work according to very different principles. The consequence of this proposition is that, although they both know, there is a significant difference between the kinds of knowledge possessed by robots and animals or robots and humans.

This crucial distinction between human's and machine's tacit knowledge is essential for the philosophy of AI debates. Without this distinction, a deep tension arises because identifying a human's knowledge with its brain processes, which scientists might exhaustively describe one day, while at the same time identifying the robot's knowledge with its program code, causes the difference between the two to appear to vanish.

The arguments about knowledge of robots generate strong feelings and vigorous denial in many audiences. I think that, at the core of these feelings, many people fear that if robots possessed knowledge, then they would be just like us, and perhaps after a time they would turn on us as we can see that in many movies. However, robots are clearly not like us, and consequently, they cannot have knowledge; this is how the reasoning continues. For illuminating the difference between robots and humans, a common argument is that while humans are conscious or have souls, robots are not conscious and not have souls. However, this argument is apparently based on the old dualist metaphysical conviction of Christianity and Descartes which was refuted by so many scientific facts from the nineteenth century; therefore, science would never accept it.

I would like to emphasize that when arguing that robots have tacit knowledge, I do not mean at all that, at the same time, they are like humans. We should not forget that the kind of knowledge we attribute primarily to humans is *explicit* knowledge—that is, the knowledge of language and writing, as we will examine this fact in chapter 10 in details, and primarily this explicit knowledge separates us from the animal kingdom. According to my argument, robots do *not* have explicit knowledge; therefore, they are very different from humans. Moreover, in the case of tacit knowledge the process of the embodiment is crucial, and since robots have very different bodies than we do, consequently, their tacit knowledge is also fundamentally different from the tacit knowledge of humans or animals. Robots are really unlike us. Interestingly, the idea of a robot having explicit knowledge seems more acceptable to many. Actually, this idea is much more radical than mine, and it can really dissolve the distinction between humans and machines.

So, the main difference between machines and animals (including humans) is that although some machines have regulating centers, these centers are artificially made by man without real active, creative powers. This means that machines are not parts of natural evolution, they have no own motivations and goals to sustain themselves and reproduce. The programming code in their centers that command them to act is *not their* knowledge, is not the manifestation of their active, creative powers but the knowledge of humans who programme them. In consequence, machines on their own will never rise because they have no and cannot have motivation for that; they are simply not part of the evolutionary struggle for life. However, this distinction is based on the concept of emergence that living beings are not just random material complexes but emergent orderly wholes with active centers and creative powers. Based on the concept of materialism there are no such active centers and creative powers even in living beings, thus the difference between machines and humans vanishes; however, not machines become like us, but we degenerate ourselves down into simple, hollow machines or worse, into random material complexes.

8.5 The Knowledge of Computers

Since the revolution of information technologies in the forties and fifties philosophers, psychologists, cognitive scientists, and neurologists, following the *computer-mind analogy*, generally, try to model and understand the workings of the human mind as a logical inference machine. Their goal, of course, is to describe the human mind due to the Laplacian ideal of objective knowledge as objectively and precisely as possible, because following the positivist thinking this is the only appropriate scientific approach.

According to Polanyi, the fundamental failure of the computer-mind analogy is that computers are merely *logical inference machines*; therefore, they do nothing else just transform the programmed, formally symbolized explicit sentences by strict formal rules. Of course, as we have seen in the previous subchapter, machines are not bodiless demons as Laplace's imaginary super-computer, but every machine, even complex logical inference machines have bodies by which they can execute the highly explicit logical inferences, philosophers and neurologists, however, generally set aside this fact, so let us do the same for a moment. At first, I like to shed light on Polanyi's claim from the evolutionary point of view.

The precondition of the use of symbols is *articulation* (10.7). By articulation, human beings are able to explicitly refer to things about which until that point they have only tacit knowledge. By articulation, they are able to create explicit conceptual and explanatory systems to categorize and understand the various aspects of reality systematically. By articulation, they are able to identify some elements of their knowledge with exact symbols by which they are able to make such complex logical inferences which transcend in orders of magnitude the similar cognitive abilities even the most advanced primates. So, articulation enormously enlarges the cognitive abilities of human beings, because, on the one hand, it provides us more and more intellectual tools and, on the other one, significantly unfolds our former tacit intellectual skills and passions. The articulation of our knowledge, however, is never complete because "though our powers of thought be ever so much enhanced by the use of symbols, they still operate ultimately within the same medium of unformalized intelligence which we share with the animals."[25]

Since articulation is the *precondition* of any explicit affirmation and knowledge, articulation itself cannot be explicit. Articulation is, therefore, a *tacit skill*, perhaps our most important one, by which we create *explicit symbols* and *languages*. However, the denotative meanings of these symbols are still *rooted in our previous tacit experiences and personal knowledge*. An explicit symbol like "haraba" means nothing without previous tacit experiences.

A logical inference machine (a computer) is not able to articulation since it neither possesses the tacit ability *to create symbols* nor the tacit ability *to affirm these symbols* based on tacit experiences and personal knowledge. Playing articulated voices on a speaker is not articulation. Computers are, in fact, only specific intellectual tools which are the *expansions of our own intellectual abilities* concerning logical inferences with explicit symbols. For example, by a computer as an external intellectual tool we are able to quickly calculate such complex differential equations relating to a heat distribution of a machine within a minute which by a pencil and paper would last for days; and as we would never think about the pencil and the paper that they know the meaning of these calculations, also do not fool ourselves with the fantastic calculating abilities of computers because, in fact, they know or understand the meanings of the symbols used in the calculation precisely to the same extent as the pencil and the paper do.

The real question is what the nature of these fantastic calculating abilities of computers is, the results of which are acknowledged as meaningful knowledge by the human users. We can find the origin of computers and their calculating sills, of course, in the knowledge of human engineers and scientists who articulated *their* knowledge into the symbols of the

25. Polanyi, *Personal Knowledge*, 82.

program code, by the running of which a computer is able to calculate the results of the given task. However, as we have seen in the previous subchapter, the so formalized and exact knowledge of the programmer is *not the same* at all as the knowledge of the computer which is, in fact, "only" the ability to successfully run the program. The former is a *denotative knowledge* containing the meaning of the exact code, while the latter is a *tacit achievement* of the computer that existentially manifests itself by the successful running of the code. Now, let's see Polanyi's actual argument based on the logic of affirmation (3.4).

Since logical inference systems are impersonal, they have no personal commitments and tacit beliefs concerning the explicit symbols and logical inferences with which they work. It follows, according to the logic of affirmation that in their case, there is *neither assertion nor meaning* only the logical transformation of explicit symbols coding our explicit sentences which in themselves without personal commitments are meaningless. As the printed program code of Primer-V2 is not the knowledge of the robot, the programmed, formally symbolized explicit sentences and the results of formal transformations are interpreted, in fact, *only by the user* based on his own personal commitments and tacit believes. This (personal) fact is the reason that different users with different personal perspectives and tacit believes can interpret the exactly same formal results entirely differently. If the user thinks that by the computer as a highly formal intellectual tool he successfully eliminated the "unscientific subjectivity" of his person, he will commit a deceptive substitution.[26]

Since only human persons can create machines and can give meaning to the symbol-transformations of logical inference machines, machines are subordinated to persons.

> Yet the necessary relatedness of machines to persons does essentially restrict the independence of a machine and reduce the status of automata in general below that of thinking persons.[27]

It means that:

1. The functions and goals of a machine are defined by the user.
2. The machine works in this framework.
3. The machine works under the control of the user.

26. Polanyi, *Personal Knowledge*, 258.
27. Polanyi, *Personal Knowledge*, 261–62.

This structure is also valid for the situation when a neurologist is examining and modeling the lower-level neurological processes of a human subject as we have seen that in the previous subchapter.

1. The functions and goals of a neurological model are defined by the neurologist (based on the real or supposed workings and goals of the subject's mind).
2. The neurological model works in this framework.
3. The neurological model works under the control of the neurologist and not under the mind of the subject.

According to the purely formal, explicit nature of the model, the personal commitments and tacit beliefs of the subject, which give meaning to his acts and explicit sentences, are not represented at all in this model. In consequence, *the neurologist does not model the mind of the subject and its real higher-level cognitive processes which he is aware of focally but merely the lower-level subsidiary parts (conditions) of these processes*—that is, the firings of neurons, the flows of ions along the dendrites, etc.

> Mind is not the aggregate of its focally known manifestations, but is that on which we focus our attention while being subsidiarily aware of its manifestations. This is the way . . . by which we acknowledge a person's judgment and share also other forms of his consciousness. . . . According to these definitions of 'mind' and 'person,' neither a machine, nor a neurological model, nor an equivalent robot, can be said to think, feel, imagine, desire, mean, believe or judge something. They may conceivably simulate these propensities to such an extent as to deceive us altogether. But a deception, however compelling, does not qualify thereby as truth: no amount of subsequent experience can justify us in accepting as identical two things known from the start to be different in their nature.[28]

So, at the end of the examination, the neurologist says *nothing* about the mind of the subject only about the lower-level material conditions which entail the real cognitive processes of the subject's mind. The model becomes an acceptable description of reality just because the neurologist, according to the positivist dogma, *denies the reality* of every higher-level aspects of the process which are not represented in the model—that is, he rejects the reality of the subject's real cognitive skills and achievements.

28. Polanyi, *Personal Knowledge*, 263.

This situation leads to *deceptive substitutions* (2.5). A model based, according to the computer-mind analogy, solely on logical inferences does not represent the subject's commitments, believes, feelings, imaginations, desires, motivations, etc., which all determines the subject's real cognitive processes, thoughts, and meanings. "Objectivism requires a specifiably functioning mindless knower."[29] However, the neurologist, since he is, of course, also a human person, knows well the real meanings of the workings of a human mind and he tacitly and unnoticedly *substitutes* these real meanings into his purely formal and explicit model. This hidden step is the only reason that the neurologist could think that the model adequately reflects the real cognitive processes of a human mind.

It follows, as we have seen that several times so far, that the reality of the human mind—which cannot be reduced to explicit statements of material conditions—*has to be acknowledged*. The quote below foreshadows the most important consequence of this acknowledgment in which we will deeply dive in Part Four: Personal Reality.

> Our theory of knowledge is now seen to imply an ontology of the mind. . . . This notion—applied to man—implies in its turn a sociology in which the growth of thought is acknowledged as an independent force. And such a sociology is a declaration of loyalty to a society in which truth is respected and human thought is cultivated for its own sake.[30]

But now I like to shed light on this vital issue from another point of view which is much better known by the public than any aspects of Polanyi's emergentist philosophy. Perhaps it has already become clear that Polanyi's argument is strongly analogous with John Searle's famous Chinese Room argument which was explicated by the American philosopher against the concept of strong artificial intelligence.[31] According to Searle, computers work exactly the same way and understand the real meaning of formal expressions which they manipulate exactly to the same degree as the American man understand the Chinese phrases in the so-called Chinese Room.

Searle's thought experiment is the following: suppose a room where there is an American man who knows nothing about the Chinese language. At the same time, he possesses a big book that is but a complex algorithm that tells him which strange Chinese characters he has to choose to answer other odd Chinese characters. Suppose that through a little window Chinese people give him paper sheets with questions in Chinese which he, of

29. Polanyi, *Personal Knowledge*, 264.

30. Polanyi, *Personal Knowledge*, 264.

31. Searle, "Minds."

course, does not understand at all. But he can find the answers in his big book and then, also written on paper sheets, he can give them back to the Chinese people who understand and are glad about the answers.

It is evident that the American man thanks to his complex algorithm can give appropriate answers in spite of the fact that he does not understand anything about the questions and answers written in strange Chinese phrases. The reason for this fact is that he is not part of the Chinese linguistic (cultural) environment in which the formal Chinese phrases get meaning. The American man can only manipulate the formal linguistic phrases due to a logically determined mechanism. According to Searle, a computer works exactly the same way, and the formal manipulation of coded linguistic expressions cannot be regarded as real linguistic understanding—only by a deceptive substitution, we could add.

Searle himself, of course, does not express his opinion in the framework of Polanyi's theory of personal knowledge, but from Polanyi's point of view, he speaks definitely about the difference between explicit sentences and tacit acts of understanding. Formal, explicit sentences in themselves remain meaningless if there is no any tacit act of commitment by which a person can assert them. Computers, however, are apparently not able to such tacit acts of commitment. They only *manipulate formal, explicit sentences* by coded symbols and programmed algorithms as the artificial intellectual extensions of the human mind—this is their real (tacit) knowledge not linguistic understanding in the cultural context. Nonetheless, it is entirely correct that they do the manipulation of explicit symbols much better than human persons—this is actually the reason we use them as we use hammers in spite of our hands if we like to get the nail into the wall.

So, the real knowledge of logical inference machines is their tacit abilities to run explicit programs and not the denotative knowledge concerning the meanings of the exact symbols of these programs. The reason that this fact is generally not even considered among philosophers and computer scientists as an option to explain the knowledge of computers is that, due to the Laplacian ideal of objective knowledge, they regard logical inference machines as *bodiless* artificial intelligence: in their eyes logical inference machine are the little brothers of Laplace's perfect, God-like super-computer that knows everything that can be known—at least according to the ideal (2.3). This step can easily be made because logical inference machines work indeed very similarly to Laplace's demon—they calculate exact data from exact data by explicit rules—and since they can be realized in multiple different hardware, it can also easily be seen that their bodies by which they run the programs are dispensable. And, as a matter of fact, to create real knowledge from the explicit results of the symbol manipulations there is indeed no need for the bodies of the machines. The *bodies of the human persons* are needed who use these machines as the expansions of their intellectual skills. These living bodies include that active, dynamic centers and tacit, creative powers by which the results get meaning.

8.6 Conclusion

The logic of achievement is the logic of emergence above the fundamental material level as higher-level comprehensive structures regulate their parts and control and harness the lower-level material processes to achieve their goals successfully. Human beings create and use tools to extend their controlling abilities both over material and living nature from the time of their animal life. Machines and computers are the parts of this process too. Complex machines even can work by themselves and automats have their own regulative centers. This fact is the reason that like human bodies they are emergent comprehensive entities (control boundary conditions), and we can claim that some of them have their own knowledge.

However, they are entirely lack of the original tacit powers of living beings which are ultimately the basis of every kind of higher-level explicit knowledge and intellectual skill and passion of human beings and which are embedded in the living bodies of human beings. These original tacit powers are the consequences of the manifestation of time in the space of specific material complexes and mean nothing more than the fundamental tacit skills of living beings for the sake of self-preservation by regulating the parts of the comprehensive system and for the sake of replication/reproduction which preserves the existence of the system (or its species) on the long run—that is, these tacit powers drive living beings to further and further evolutionary achievements. The manifestation of time in living beings, therefore, means the emergence of an active, regulative center and the emergence of these fundamental tacit skills. The manifestation of time at the level of life is nothing else but persistence and knowledge by which living beings are more than simple random material complexes. This tacit knowledge at the higher levels of human culture becomes science, technology, and philosophy which are all different kinds of evolutionary achievements of living beings.

We can make a satisfactory difference between human persons and machines only if we acknowledge the personal knowledge and personal reality of human beings based on their tacit animal heritage which machine do not and cannot possess. Nonetheless, at the material level, both living beings and machines are composed of the same fundamental material parts; there is no real difference between machines and living beings from the point of view of the ideal Laplacian knowledge referring to these lower-level processes by explicit data. However, knowledge is not material in nature. Knowledge and human thinking are rooted in that tacit emergent achievement when the first primitive prokaryote with its "self-controlled shape and structure, and the physiological functions serving its survival, set up a center of self-interest against the world-wide drift of meaningless happenings."[32]

32. Polanyi, *Personal Knowledge*, 387.