9· Model and Meaning

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> It is impossible for the human mind … to actually understand anything except by the use of models in the imagination.
> *impossibile est intellectum nostrum … aliquid intellegere in actu, nisi convertendo se ad phantasmata.*
>
> — Thomas Aquinas, *Summa theologiae* I. q. 84 art. 7c (Deely 2007, 196)

Dialog and diagram

A scientific consensus can only be realized by a community of inquirers willing to learn from experience. Learning is always a change of habit. In science, this means adoption, modification or rejection of a *theoretical model*.

The function of a *theory* is to explain in general terms how *facts* are related to each other. Facts are themselves signs of real relations among things as indicated by observed interactions among percepts. A theory has to be more *general* than a fact, since a theory would not be very useful if it didn't account for a whole range of observations expressible as facts. Theories are ideas representing logical relationships which are not themselves visible, not accessible to sense experience, but the relations among facts which are involved in them can be visually represented in *diagrams*.

A diagram is 'a figure for ascertaining or exhibiting certain

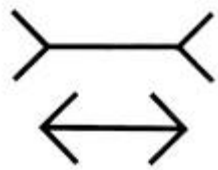
relations between objects under discussion by means of analogous relations between the parts of the figure' (CD). Peirce's 'Existential Graphs,' which he considered his outstanding contribution to logic, are diagrams used to investigate the process of reasoning. He described the actual use of these diagrams as a dialogue between an Utterer (or 'Graphist') and an Interpreter, considering it 'not merely a fact of human Psychology, but a necessity of Logic, that every logical evolution of thought should be dialogic' (CP 4.551, 1906). Of course the 'evolution of thought' (semiosis) is also *diachronic* (meaning that it takes place *through time*), and this can be represented graphically by making a series of changes in the diagram – or to put it another way, making a series of diagrams to be viewed sequentially (just as a 'motion picture' is a series of pictures). *Dialog* as communal inquiry often makes use of diagrams (recall the significance of the prefix *dia*-), just as a voyage of exploration might use a map – partly to make a more accurate map.

But public, scientific inquiry is not the only kind of thinking that uses theoretical models represented in diagrams. They are implicit in many an internal dialogue, whenever we are *thinking through* some question, deliberately or not, and every learning process seems to involve something vaguely like scientific inquiry. Gopnik and Meltzoff (1997), among others, argue that a protoscientific trial-and-error process, involving formation and testing of tacit theories, is going on in the mind of a human infant right from birth – this has been called the 'theory theory.' We might generalize the idea still further, beyond humans to all sentient beings: science is only the most conscious and public expression of a propensity pervading all of life. 'The method of trial and error is applied not only by Einstein but, in a more dogmatic fashion, by the amoeba also' (Popper 1968, 68). In this view – let's call it the *modeling model* – what makes humans special is that their modeling method is more flexible than that of other earthlings, so that we are more capable of modifying our habits, or forming new ones, instead of relying on inherited habits for guidance.

If we could look inside a living system to see its learning happening, what would it look like? The answer to this question would be a model of learning – and thus a model of modeling, since a scientific theory is just an explicit (explicated) version of a commonly implicit belief about how the world works. For a human

bodymind, for instance, a theoretical model of its learning would include some kind of diagram showing how relations between experiencing and habit are embodied in the brain. And it might also say – as many investigators do – that the embodiment of habit in the brain is itself a kind of model.

Of course the term *model* (like any other) can lead to misunderstandings. The prototypical idea of a *model* might be something like the plastic model airplanes that were popular in the mid-20th century. This kind of model, once assembled, is essentially a 3-D iconic sign: you can look at it, and look at the original (or a picture of it), and see a resemblance. But we can't do that with an internal (mental) model of the external world, because we can't look back and forth from one to the other, since the mental model itself is not visible: we have to use an iconic sign such as a diagram to visualize it. Besides, our *looking* itself involves modeling which is not subject to conscious control. The Muller-Lyer illusion, illustrated here, is typical of many visual illusions: even after you measure the two horizontal lines to see that they are the same length, and even after you grasp an explanation of how the illusion works, the upper line still looks longer than the lower – which shows that our conscious control of perception is limited. Psychologically, the perceived world is *external* to you just to the extent that your perception of it is a brain function beyond your control.



Autopoietically speaking, this automatic modeling is part of the 'structural coupling' process, which is facilitated when you focus attention on objects 'out there,' but usually hindered when you become self-conscious and focus attention 'inward.' Even the role of your own body in the interaction is much better left unconscious; it is the environment that you owe attention to, because you must continually adapt to it, and/or adapt parts of it to your intent. Pragmatically, we have no choice but to 'bring forth a world' which is the only real world we know, even when we know that we 'know' it only by modeling. We learn by trial and error how to act into it, constantly trying various acts which seem to make implicit sense, and then monitoring the results: if they are

unexpected, then the model gets adjusted, perhaps to fit better the next time (assuming that we survive the surprise). But a symbolic species like ourselves can sometimes carry out the trial-and-error process *virtually*, by imagining the consequences of *possible* actions, so that we don't have to suffer the consequences of errors in order to learn from them. According to Peirce, we do this imagining with *diagrams*. Merleau-Ponty argued in his first book (1942, 118) that the ability to map one's own possible moves 'into a visual diagram' makes the real difference between the human imagination and that of other animals.

In semiotic terms, a model or diagram is an *icon* 'even although there be no sensuous resemblance between it and its object, but only an analogy between the relations of the parts of each' (Peirce, CP 2.279). We all use such iconic diagrams in daily life, for instance to imagine possible consequences of acting in a particular way in some hypothetical situation. Logic as the scientific study of theorizing itself – which must involve models as *signs* – resembles the ordinary reflective process in which, according to Peirce, a person makes 'abstractive observations' of an imagined 'skeleton diagram of himself' (CP 2.227). This is essentially what Metzinger (2003) calls a 'self-model,' and Peirce argues that when you think about thinking, the 'abstractive observations' which you can make from such an imagined model are not essentially different from observations of external events. In other words, 'thought-experiments' really are experiments, if used honestly to understand how thought-signs must work. Like other experiments, they can also be used *dis*honestly, by manipulating or 'rationalizing' them to support some belief that you are tenaciously clinging to, rather than drawing the conclusions that are forced on you (or anyone), regardless of prior belief, by experience.

The conscious scientific use of a model involves inventing a hypothesis, conjecture, or guess which would explain some aspect of the world which doesn't already fit our general model of nature, and then testing the hypothesis by observation or experiment. Depending on the results of the testing, the new hypothesis may get modified, replaced, or (if it works well enough), integrated into a *theoretical model* embodying the consensus of the community of inquiry. If it turns out to be consistently useful in guiding conduct, it will eventually be entrenched as a habit or fixed belief.

Modeling nature

Since this modelling pattern is at the heart of all learning and guidance systems, we will take a closer look at it, beginning with a basic explanation (given by Albert Einstein and Leopold Infeld) of how it works in physics.

> **Physical concepts are free creations of the human mind, and are not, however it may seem, uniquely determined by the external world. In our endeavor to understand reality we are somewhat like a man trying to understand the mechanism of a closed watch. He sees the face and the moving hands, even hears its ticking, but he has no way of opening the case. If he is ingenious he may form some picture of a mechanism which could be responsible for all the things he observes, but he may never be quite sure his picture is the only one which could explain his observations. He will never be able to compare his picture with the real mechanism and he cannot even imagine the possibility or the meaning of such a comparison. But he certainly believes that, as his knowledge increases, his picture of reality will become simpler and simpler and will explain a wider and wider range of his sensuous impressions. He may also believe in the existence of the ideal limit of knowledge and that it is approached by the human mind. He may call this ideal limit the objective truth.**
>
> — Einstein and Infeld (1938, 31)

The first point here is that in physics, models belong to the cultural world which we 'bring forth' by creative collaboration. Einstein's 'picture' is not 'given' or impressed upon our passive minds by external forces in the way that patterns of light falling on film determine a photographic image. Rather the picture is an inference, a (tentative) conclusion that we actively *draw*. Or you

might say that, just as we invest our attention in the object of investigation, we invest our cognitive energy (or *imagination*) in the 'picture,' hoping to discover a real relation between object and model. But ordinary sense perception is also inferential, though differing from scientific theorizing in the speed of the process and the degree of conscious control we have over it.

The second point, already raised above, is that we can never *compare* model with reality. This is true of all cultural models, not only scientific ones. As Michael Tomasello put it, we are 'fish in the water of culture. As adults investigating and reflecting on human existence, we cannot take off our cultural glasses to view the world aculturally – and so compare it to the world as we perceive it culturally' (1999, 213-14). We can get closer to the ideal of 'direct perception' unfiltered by cultural biases, to the extent that we are *aware* of those biases; but there's not much we can do, as individuals, to get round our *biological* biases.

If we can't compare model with reality, what *can* we say about the relationship between them? We can begin by calling it a dynamic, interactive *process* – a 'conversation with nature,' as Peirce called it (W6:386). In the case of science we have a double interaction: the conversation with nature is intertwined with a conversation within a community which is itself a tissue of interactions. But for a relatively simple and familiar model of the learning process, we might think of it as a reciprocal organic process like breathing.

How can we *picture* learning as being like breathing? The diagram i will introduce here was originally based on a diagram of the 'modeling relation' by Robert Rosen (1991, 60; 2000, 159). Rosen was a theoretical biologist whose main work was an attempt to describe the essential nature of life by building mathematical models of living systems. This led him to the study of 'anticipatory systems' –

> systems which contain internal predictive models of themselves and/or of their environment, and which utilize the predictions of their models to control their present behavior…. much, if not most, biological behavior is model-based in this sense. This is true at every level, from the molecular to the cellular to the

> physiological to the behavioral. Moreover, model-based behavior is the essence of social and political activity. An understanding of the characteristics of model-based behavior is thus central to any technology we wish to develop to control such systems, or to modify their model-based behavior in new ways.
>
> — (Rosen (1985, vii)

We could also call this a semiotic model: 'Because every sign "stands to" or addresses itself to an interpretant, every sign – at least, every symbolic sign – is *anticipating* another sign' (De Tienne 2006). Indeed, symbolic semiosis and modeling relations are virtually the same in their relevance to guidance systems, despite some differences of terminology.

Rosen used his diagram primarily to explain how science builds formal/mathematical models of systems found in nature, and then extended it by analogy to explain what goes on inside living systems and guides their behavior. Here i will introduce what i call *the gnoxic diagram* of *the meaning cycle*, and explain it with reference to the Einstein/Infeld 'watch' scenario. Then i will explain the equivalent and additional features in Rosen's diagram of the *modeling relation*. (Later i will take up some of the conceptual problems resulting from Einstein and Infeld choosing a *watch* as their symbol of a natural system.)

The meaning cycle

In this *gnoxic diagram*, **W** stands for the natural *World* external to the modeling/anticipatory system, or rather for the relevant part of it, the object of its modeling, which must be part of its Umwelt (that part of the universe with which it can interact). Anyone observing this semiotic modeling process from the outside would typically see **W** as external to the organism's body as well, but the externality of the *World* represented by **W** is not primarily a matter of physical location; it's a matter of Secondness. In the Einstein account of concepts in physics (above), **W** represents the watch, which in turn stands for 'physical reality' (or rather for some aspect of that reality which is in focus for the physicist).

M of course stands for the theoretical *Model*, the 'picture' which the physicist is trying to form of the internal workings of the watch – or the 'internal predictive model' of the anticipatory system. The actual *prediction* made by the physicist, based on the theoretical model, determines how he will test the theory in **practice**, just as the system's habit-set generally determines how it will act into the world. The scientist's *observations* of **W** in turn will determine whether the model needs to be modified in order to improve its predictive success – just as **perception** provides the 'data' from which the living system can learn, or modify its habits.

In Rosen's original diagram, the gnoxic **W** is labeled 'N' for 'natural system,' while the gnoxic **M** is labeled 'F' for 'formal system.' A formal system is the most explicit, public, consciously designed kind of system, and a mathematical description the most formal kind of model. The specific role of formal systems in science is a special case of the more general role of models in meaning.

For our **practice** and **perception**, Rosen uses 'decoding' and 'encoding' respectively, because the model itself has a syntactic structure which can also be called a *code* (a point we will consider more deeply later on). The 'encoding' part of a scientific process, the *measurement* or *observation*, furnishes the mathematical

modeler with the numbers which he substitutes for the variables in his equation or formula. In the case of humans generally, Leonard Talmy suggests that *perception* or *encoding* might be called *ception*. More commonly we subdivide it into 'perception' and 'conception,' the former being more directly related to the external world and the latter more internal to the 'ceiving' system. But as Talmy (2000, I.139) points out, there is no consensus on where or how to draw the line between them, so it makes more sense to consider *ception* as a single process which can be analyzed in various ways. For our purposes here, let's say that when we construct an internal model or *concept* of something by engaging in a relationship with it, we *ceive* it. Thus the arrow labeled **perception** actually includes 'sensation,' perception *and* conception treated as a single continuous process. The *concept* resides at the end of the process, in **M**; if we need a name for a preconceptual entity closer to the **W** end of the arrow, we can call it a *percept*. 'The fundamental cognitive role of concepts is to serve as a bridge between perceptions and actions' (Gärdenfors 2000, 122); we might say likewise that the fundamental cognitive role of percepts is to serve as a bridge between actuality and conceptions.

The arrow we call **practice**, Rosen's *decoding*, represents in science the process that turns a theory into a *prediction* or testable proposition. As Gendlin pointed out (1962/1997, 20), 'The role of theory is different from that of testable propositions. Theory has the role of *leading to* testable propositions.' In scientific **practice**, the prediction is drawn from the theory (or hypothesis) by *deductive* logic; this leads to design of an experiment. If the experiment is replicated many times with consistent results, *inductive* logic can test the hypothesis by comparing observation with prediction. If the observed facts remain unexplained, then a new cycle begins with **perception** and proceeds to 'studying facts and devising a theory to explain them' by means of *abductive* (or 'retroductive') logic (Peirce, EP2:205) – which brings us back to **M** in the diagram, a theoretical model which in turn can be tested.

In applied science or engineering, **practice** is the application of the theory. In the cognitive life of an organism, this part of the cycle begins with *anticipating* how its relation with the object of its attention is likely to change when it makes its move. It can guess about that to the extent that it has an internal model of its Umwelt

and is thus familiar with whatever inhabits its ecological niche. The set of self-modifying habits which constitute the guidance system can be described as an internal model of the external world, but more strictly speaking, it is a model of the organism's own interaction with its Umwelt or 'semiotic niche' (Hoffmeyer 2008, Chapter 6). It is not a separate component of a guidance system located inside the organism, nor is it a separable description of the ambience or of external systems. It is better described as a space of possible internal states or structures generated by the organism's dynamic maintenance of its own organization. To modify the model is to modulate the modeling process, which in the human case involves abstractive observation of a skeleton diagram of self, other and world.

This 'internal model' constrains the organism's behavior by enabling it to anticipate certain events and not others. In this it is like a scientific theory, which 'functions as a comprehensive idiom which consolidates that experience to which it is apposite and leaves unheeded whatever is not comprehended by it' (Polanyi 1962, 47). It also embodies a sentient being's continuing *experience* as a 'pattern of sensorimotor interdependence': 'as a skillful activity of the whole animal or person, perceptual experience emerges from the continuous and reciprocal (nonlinear) interactions of sensory, motor, and cognitive processes, and is thereby constituted by motor behavior, sensory stimulation, and practical knowledge' (Thompson 2007, 256). Motor behavior feeds forward into sensory stimulation, which (through perception) feeds back into practical knowledge (i.e. habit), which in turn guides motor behavior; 'feedforward control is sometimes referred to as predictive, while feedback control is sometimes referred to as reflective' (Llinás 2001, 37). For humans, feedforward includes production and use of external symbols (sentences, graphs, diagrams, books, databases, ...) to navigate and modify the world.

> Our vision of the general nature of things is our guide for the interpretation of all future experience.
>
> — Polanyi (1962, 135)

> What we see is a function of how we see, and how we see is a function of previous experience.

The cyclic process is essentially the same even when the object of attention is an inert embodiment of a symbol, such as a book: the reader is always anticipating the next turn of the text, based on her internalized model of the language and how it works (see Eco 1979, 0.7.2). Of course, if we are using this diagram to model a reading process, so that **W** represents a written or printed text, then the **perception** arrow could also represent the *decoding* of the visible marks on the page into mental events embodied in brain dynamics (words into thoughts, letter into spirit). This is a special case because **W** represents a system which is *both natural and artificial*. Natural languages, including any specialized codes branching off from them, are rooted in the biological nature of the human, and are not deliberately invented; yet they incorporate conventions which we have to learn before we can decode (or encode) any message in that medium.

To map Peircean semiotics onto the meaning cycle, emphasizing how signs relate to reality, consider the following text from Nathan Houser's introduction to EP1 (xxxix-xl). I have inserted [in brackets] the appropriate labels from the above diagram.

> Every sign *represents* an object [W] (in some way or other) to the interpretant [a modification of M]. The interpretant is, or helps make up, a habit that 'guides' our future (and present) actions or thought [practice] with respect to the object in question, or objects *like* the one in question. If the interpretant is untrue to the object, our behavior will not be (or *may* not be) successful—reality will have its way with us. Not until our interpretants (our ideas or intellectual habits) are fully attuned to their objects [M functionally coupled with W] will we avoid unexpected confrontations with a resistant reality. In this way, the real object determines or shapes our mind, our reservoir of intellectual habits.

Every interpretant is *significant* because it guides the next action,

thought or expression. This implies that it *becomes another sign* with its own interpretant. Peirce assured us that the end of this process is an unattainable (but necessary) ideal. There's no danger of ever *arriving at* the meaning of life, and that is why our icon for it is circular. But in another sense, which applies *within* the cycle, an interpretant which consists not of another sign but of a habit-change can be considered a 'final interpretant' (CP 4.536), since it achieves the end to which all thought-signs are the means.

Since all interpreters of signs (if not all signs themselves) are anticipatory systems, their attention is guided and limited by their current intentions and their ability to anticipate how the current situation will develop. Thus **W** in our diagram is not the *whole* of the World, or even the whole of the investigator's Umwelt: it is a part selected for special attention. Scientific inquiry, by focusing on the nature of **W**, separates it conceptually from the rest of nature, its *environment*. When we diagram the process of building a *biological* model, the 'natural system' denoted by the symbol **W** is an *organism* – that is, another anticipatory system. This is what makes the difference between biology and physics. In biology we distinguish between organism and environment, just as we distinguish between subject and object in order to understand perception, and distinguish between *self* and *other* in order to know ourselves.

This brings us back to the 'watch' which Einstein and Infeld chose to represent this object of attention. There is an obvious problem with that choice if the object of our attention is a *living* system, or a process (such as evolution) which necessarily involves living systems, because a watch is not alive. It is a system, because it has interrelated parts, each with its own function; but it is an *artificial* system, which makes it an inappropriate symbol for a *natural* system. When William Paley used the watch analogy in his famous argument that the complexity of life requires a designer (in *Natural Theology*, 1802), he was really assuming what he claimed to be proving, namely that *all* systems are artificial. This entails that the kind of complexity we find in nature is the same as *mechanical* complexity. We will consider this more deeply in a later chapter, but for purposes of our 'model model,' we need only point out the crucial difference between a machine and a living system is the modeling that goes on *within* the living or 'anticipatory' system.

A watch does not maintain an internal model, or use that model to maintain itself. It is of course possible to build an artificial system that does have an internal model (a guidance system), but that kind of model does not *develop* or *evolve* – it is inserted by the builder in order that the system will carry out the *builder's* intentions. Nor does that whole system self-organize: the parts of a mechanical system are made separately, according to a preconceived plan, and then assembled to make a working machine. This is not the case with the parts of any natural system, whether it incorporates a modeling system or not.

Loopwholes

In both the gnoxic diagram and Rosen's diagram of the modeling relation, the 'model' (on the right) appears to mirror the 'reality' (on the left) – even though, as explained above, we can never actually compare the 'picture with the real mechanism.' We can never actually look at our own modeling from the outside, but the truth and value of the model depend on the 'congruence' (Rosen's term) between 'model' and 'reality.' Faith in the *possibility* of such congruence is basic to the whole scientific enterprise: a scientist has to believe that the world *in itself* is intelligible – that our theories can actually reflect how the real world works. In other words, we have to believe that the various components and events making up the universe are interrelated, that there is some order to those relationships, and that the logical order embodied in our theories is at least analogous to the natural order. Routinely successful predictions lend support to that belief, while our many mistakes show how imperfect our models are. But the real ground of this belief is that neither theory nor practice makes any sense without it: if there's no way to make sense of the world, then living and learning make no sense either – even to say so would be pointless.

To represent this core belief, the original Rosen diagram adds two more loops to the central one. Rosen (1991, 60) draws an arrow departing from his **N** (our **W**) and then returning to it, and a mirror image of this looping arrow on the **F** side (our **M**). I prefer to picture these as two loops resembling the whole meaning cycle

but operating *within* **W** and **M** respectively. In terms of Einstein's analogy, the loop within **W** represents the inner workings of the watch, i.e. the natural order. Rosen calls this W-loop *causality*, and calls the loop within **M** *inference*, representing the logical order within the realm of theory. (We will consider below why these are depicted as loops, i.e. recursive processes.) For Rosen, the *inference* loop corresponds to the *syntax* of a language, the implicit rules governing our manipulation of words or symbols in the language. The modeling relation itself, which connects model and reality, is not syntactic but *semantic*: in science, whatever we *infer* from the structure of the model is theoretically true of some empirically observable phenomenon to which the model *refers*, something external to the language or symbol system used to make sense of it. Rosen emphasized that the *meaning* of any statement in a formal system has to come from outside the system: you can't get semantics from syntax. His point in Peircean terms is that a symbol, in order to have meaning, must have a genuinely indexical component. But Peirce would add that it must have an iconic component as well in order to mean anything, and the symbol must be connected *both* iconically and indexically with a real object in order to say anything *true*.

Like Aristotle and Peirce (and unlike classical Newtonian physics), Rosen embraced a comprehensive concept of 'causality,' along the lines described in Chapter 4. As a mathematical theorist, his *inference* is mostly of the deductive kind, and he does not devote as much attention to inductive and abductive logic as Peirce, but something like Peirce's 'logic of relatives' (or 'of relations') is implicit in Rosen's thinking. In short, Rosen's 'modeling relation' is congruent with Peirce's 'semiosis.' In our diagram, the arrow of perception/cognition represents the semiotic process mediating between **W** as its *dynamic object* and **M** as its *dynamic interpretant*, which is 'whatever interpretation any mind actually makes of a sign' (EP2:499). Each interpretant is a model newly modified by the dialogue between expectation and surprise; the arrow of **practice** then represents the pragmatic part of the learning process, guided by the expectations which enable us to learn from surprises.

The diagram we are using to explicate the modeling model is an icon of diagramming. Peirce asserted that deductive reasoning

always involves some observation performed with the help of such an icon. Here is his explanation, keyed to the parts of our diagram:

> … all deductive reasoning, even simple syllogism, involves an element of observation; namely, deduction consists in constructing an icon or diagram [**M**] the relations of whose parts shall present a complete analogy with those of the parts of the object of reasoning [**W**], of experimenting [**practice**] upon this image in the imagination, and of observing [**perception**] the result so as to discover unnoticed and hidden relations among the parts.
>
> — EP1:227

Deductive inference, then, amounts to a kind of thought-experiment whether it leads to a physical experiment or not. It all takes place within the loop of inference, and thus represents a cycle within the meaning cycle. Even without acting upon (or observing) the external world, we can discover 'hidden relations' in this way, making what was implicit explicit.

At this stage in our journey round this wheel, this model, we could say that *the meaning of a percept is its effect on the model*, or the difference that perception makes to the structure of the model. In other words, what makes perception meaningful is that it is the model's means of modifying itself. If the model is a good one, then the perception will usually *confirm* it; but this too 'makes a difference' by entrenching the model as a more regular habit. We could also say that observation is the model's way of *informing* itself, in Gregory Bateson's sense of *information* as 'a difference that makes a difference.' In humans, the structure of the model may be called a *conceptual* or *cognitive structure.* (The 'cognitive' here is not separate from the 'affective' or emotional domain, as values and emotions are fully integrated with this modeling process. We will return to this point below, and to the subject of *information* in later chapters.)

The 'feedforward' of the model into perceptual judgments is indicated by George Lakoff's remark that 'the primal prejudice is our own conceptual system' (Lakoff 1987, 264). In order to be either familiar or surprising to you – and thus *meaningful* – a

phenomenon must relate in some way to your prior expectations, either confirming or violating them. Usually these expectations are intrinsic to the actions you have just performed – this is what makes an act *intentional*. We can refer to a rule which guides action as a 'belief,' but we can also call it a *precept* – the counterpart in **practice** of a *percept* in **perception**. Just as intentions are only rarely conscious in the living context of an organism, *precepts* are only rarely explicit. When you are actually living by a precept, and not just thinking about it or trying it out, it works implicitly.

Precepts, then, constitute the currency invested in **practice** by theory (**M** in our diagram). You could think of precepts as rays of light, and expectations as sources of that light which you bounce off the world; the light returns to you through *perception* in patterns which you see as the *objects* in the world. This recalls *Thomas* 24: 'Light exists inside a person of light, and he [or "it"] shines on the whole world' (5G). Such a model is of no use in optics, but it still works implicitly in ordinary language and 'ception,' as shown by Talmy (2000, I.123 ff.) And just as we can use *ception* to denote the entire rightward movement from **W** to **M**, we could use Thomas Kuhn's term *paradigm* for the entire movement from Model back to World. In Kuhn (1962), a 'paradigm' includes not only a theory but also the customary or exemplary demonstrations and applications of it – elements of practice specially informed by theory. Semiotically, this reflects the fact that a *law* is necessarily general, but is not *really* a law unless it will determine what happens in actual instances of the kind of situation it is supposed to regulate. This is as true of the laws of nature as it is of human legislation. Laws, as signs, are *legisigns*, and we will take a closer look at them in Chapter 13.

Now we can say that the *meaning of a precept* (or theory) *is the difference it makes in practice*; the meaning of your belief is how you actually live under its guidance. This is essentially what Peirce, James and Dewey called *pragmatism* (from *pragma*, the Greek root of *practice*). Practice in turn is whatever makes a difference to **W**, to the real world beyond the model (but including the modeler). So the 'ultimate' meaning of an act or 'decoding' would be the difference it makes in the world, to the *other* or others. You could only know this meaning indirectly, if at all – through dialog and the modeling relation itself; only an omniscient God could know it

fully. (Perhaps we believe in an omniscient God in order to believe that our acts can have meaning even when other people are unaware of them.) In the pragmatic (i.e. ethical) realm, the reciprocal nature of the process shown in our diagram is represented by the most universal moral precept of them all: Do unto others as you would have them do unto you; love your neighbor as yourself.

The diagram also shows *percepts* and *precepts*, or *objects* and *projects*, as complementary aspects of *experiencing*, which we can imagine as a *current* flowing in or around the whole *circuit*. The meaning of any part in the cycle – event, percept, concept, precept or act – is its role in the cycle. Classical empiricism considered **W**, or the 'first impressions of sense' received from it, to be the beginning and source of all knowledge and meaning, or the foundation on which theory was built. The *meaning cycle* model, though, allows us to see that the choice of beginning point is arbitrary, as in any circular process. The first shall be last, and the last first.

Remembering

If it makes any sense to talk about *an* experience, as if it were separate from the rest of the experiential flow, then likewise we can theoretically isolate a corresponding *state* of the brain from its ongoing dynamic process. And if the occasion of experience is a specific interaction between organism and world, we can also specify a correlated *event* in the world external to the experiencing system. What then does it mean, in these terms, for an event to be meaningful, or *significant*? It must be connected with some *change* in brain state; and this change, this difference, cannot be just a random fluctuation. It must play a part in determining *future* brain states. At least some aspects of it must be regular and recurrent; otherwise the meaning would not survive the next change of state, would not distinguish itself from the chaotic background, and there would be no basis for *recognition* of it. There is no meaning without some kind of *memory* which lends continuity and recurrence to the stream of experience.

An organism can learn only by remembering patterns of

interaction with its medium. In other words, there must be some biological process going on inside the organism which is intimately related with whatever goes on outside of it that is relevant to the being's way of life. Since it is biological rather than mechanical, memory does not 'store' an action pattern by encoding it in detail on some physical medium like paper, film or disc, to be retrieved and replayed later. Recalling a memory, or repeating a habitual act, means reliving or recreating a general form which has been lived before, with specific details evoked by the current situation.

Psychological research going back at least to Bartlett (1932) has tended to confirm the Peircean semiotic view of cognition: each recall of an event, like each retelling of a story you've heard, represents the interpretant of your previous recall, which becomes the immediate object of your next recall, and so on through an infinite series of memory-signs – each genuine memory representing the original event, the dynamic object of the whole series. The series is infinite not because it has no beginning or end, but because no actual memory-sign can be singled out as the first or the last: the gaps between one memory and the next are theoretically infinitesimal. This may not be true for psychology, as laboratory experiments (depending on the measuring instruments) might find that human experience such as remembering has a temporal 'grain' to it, a level of resolution that can't be raised; but even in that case we must admit that *time* is continuous – otherwise we could never detect any discontinuity in the stream of events. For any conscious being, the current of cognitive time flows round the circuit continuously, and if the circuit is broken anywhere, the current doesn't flow at all.

This understanding of continuity should be in the background when we use static metaphors to model system dynamics, as when we say that every living system has an internal *model* which *represents* its world, so that its *structure* is coupled with that of the world. Sometimes it may be better to speak of *models* in the plural; psychologists recognize several types of memory, each of which has its own way of working, so that impairment in one does not necessarily interfere with the others. For instance, Damasio's patient 'David' had a full set of normal habits (procedural memory), but could not remember particulars of any events in his life if they had happened more than a minute before; nor could he

identify individuals (even his own son), yet he suffered no loss of linguistic competence (Damasio 1999).

As the meaning cycle is a whole, each way of breaking it into parts (so that we can study its 'mechanics') brings its own problems. For instance, when we consider the perceptual process as if sensations or 'inputs' to it are originally separate and unrelated, the 'binding problem' arises: how is this multiplicity constructed into a world, so that qualities are bundled into objects? At least one version of the answer involves anticipation:

> In order to deliver a reconstruction of the external world that is a seamless, dreamlike movie flowing continuously through time, it must forever be anticipating or looking ahead, operating and orienting its focus discontinuously in time, piecing it all together while jumping in discrete intervals of time.
>
> — Llinás (2001, 39-40)

But if we investigate how the perceptual system *developed*, or how it evolved, the 'problem' is not unification but differentiation. How do we end up with so many different kinds of cells in a body that began as a single cell? How did so many different multicellular species evolve on this planet from a single-cell ancestor? Explaining the biology of meaning requires us to integrate evolution, development *and* 'mechanics' into a single coherent account, using the comprehensive idea of causality introduced in Chapter 4.

Inhabiting

In perception, what psychologists call the 'stimulus' is the *efficient cause* of the experience, while the regulation of behavior is the *final cause*. In the visual system, for instance, the stimulus is a change in the pattern of light that triggers retinal neurons to fire, initiating a cascade through the visual system which amounts to an indexical sign of the presence of something visible in the external world. The interpretant of that sign emerges from its interaction with the internal model (an iconic sign) to inform the whole

bodymind's interaction with its world. The *material cause* of this 'internal model' consists of constant neural activity. All neurons, including sensory receptors, are oscillators with an intrinsic rhythm, which is merely modified by perturbations from outside.

> A chain of successive reactions … regulates the spontaneous activity of the oscillator, which preexists all interaction with the outside world. The impulses produced are therefore independent from the physical stimulus received from the environment and the nervous signal produced.
>
> — Changeux (1986, 83)

According to Antonio Damasio, the brain represents the environment 'by modifying the primordial representations of the body proper whenever an interaction between organism and environment takes place.' The 'primordial' maps represent states of biochemical regulation; viscera including organs, muscular mass and skin; and 'the musculoskeletal frame and its potential movement' (Damasio 1994, 230).

The internal model thus maps the external world *indirectly*, by mapping the complementary *relationship* to that world enacted by the organism – in other words, its habits. The development of habits is perhaps best explained by *dynamic systems theory*, which models them as *attractors* in behavior space. According to Thelen and Smith (1994, 227), this development of the bodymind

> is the trajectory of internal mental processes *through time*, processes which do not look like and do not model the external events. However, as this pattern of activity levels is repeatedly evoked by the repeated experience of the habituating event, it will become an attractor. It will increasingly attract "nearby" patterns of activity. And it will embody a set of expectations and knowledge; stimulus events that trace small regions on the trajectory will come to increasingly project continuing activity further along on the trajectory.

Allan N. Schore gives an account which is similar except that it affirms internal modeling of the external world:

> Developing organisms 'internalize' environmental forces by becoming appropriately structured in relation to them; and by incorporating an internal model of these exogenous signals they develop adaptive homeostatic regulatory mechanisms that allow for stability in the face of external variation. The regulation of the organism, which maintains internal stability and output regulation and enables an effective response to external stimuli, therefore depends on the formation of a dynamic model of the external environment. Self-organizing systems are thus systems that are capable of generating new internal representations in response to changing environmental conditions.
>
> — Schore (Lewis and Granic 2000, 160-1)

'The regulation of the organism' crucially involves emotions. Schore cites Damasio as concluding 'that emotions are the highest-order direct expression of bioregulation in complex organisms, and that primordial representations of bodily states are the building blocks and scaffolding of development' (Lewis and Granic 2000, 165). 'The emotions may therefore be seen as *bodily interpretants* that immediately release subsequent interpretants in the form of characteristic kinds of behavior' (Hoffmeyer 2008, 250). Emotions affect our habits at least as deeply as our factual or theoretical conceptions and perceptions. They are intimately involved in our guidance systems, in what Peirce calls 'self-control' – which involves not only control *of* our emotions but also control of our practice *by* our emotions in collaboration with perception and reasoning. Indeed our reasoning itself is motivated by an innate desire for truth and justice (fairness), which causes us to *care* about the truth and thus to be *careful* in our thinking.

Once again we see that the communal process of scientific inquiry which brings us the 'modeling model' is only the most public and deliberate manifestation of the universal semiosic process. In his 1904 essay 'New Elements,' Peirce describes how this process directs itself toward the ideal or 'perfect Truth,' using the Aristotelian term *entelechy* (introduced in Chapter 4):

> What we call a "fact" is something having the structure of a proposition, but supposed to be an element of the very universe itself. The purpose of every sign is to express "fact," and by being joined with other signs, to approach as nearly as possible to determining an interpretant which would be the *perfect Truth*, the absolute Truth, and as such (at least, we may use this language) would be the very Universe. Aristotle gropes for a conception of perfection, or *entelechy*, which he never succeeds in making clear. We may adopt the word to mean the very fact, that is, the ideal sign which should be quite perfect, and so identical,—in such identity as a sign may have,—with the very matter denoted united with the very form signified by it. The entelechy of the Universe of being, then, the Universe *qua* fact, will be that Universe in its aspect as a sign, the "Truth" of being. The "Truth," the fact that is not abstracted but complete, is the ultimate interpretant of every sign.
>
> — EP2:304

In terms of the modeling process, then, Peirce's *entelechy* could be called the *ultimate model*, which would appear if the process could completely close the gap between sign and reality, or model and world. In the next paragraph of 'New Elements,' Peirce described our 'meaning cycle' in terms of *Theory* (the lower, left-to-right arrow in our diagram) and *Practice* (the upper, right-to-left arrow). Scientific theorizing is analogous to the perceptual process, though of course differing in time scale; thus the term **perception** used in our diagram can be taken as a translation of the Greek θεωρία (which means primarily *observation* or *contemplation*), and is thus equivalent to 'Theory.' We can easily map Peirce's description of Theory and Practice onto the meaning cycle by inserting the other two labels from the gnoxic diagram:

> Of the two great tasks of humanity, *Theory* and *Practice*, the former sets out from a sign of a real object [**W**] with which it is *acquainted*, passing from this, as its *matter*, to successive interpretants embodying more

> and more fully its *form* [**M**], wishing ultimately to reach a direct *perception* of the entelechy; while the latter, setting out from a sign signifying a character of which it *has an idea* [**M**], passes from this, as its *form*, to successive interpretants realizing more and more precisely its *matter* [**W**], hoping ultimately to be able to make a direct *effort*, producing the entelechy.
>
> — EP2:304

Closing the circuit

We can also consider the gnoxic diagram in terms of the three 'categories' identified by Peirce as elements of the *phaneron*, or indeed of any phenomenon. Its *appearing* at all is its Firstness. The *difference* between Model and World (expectation and actuality) is Secondness. The *relationship* presented by the diagram as a whole is Thirdness.

Many cognitive cycles or patterns can be mapped onto our diagram of the meaning cycle by combining or further subdividing the two arrows of **Theory** (or **perception**) and **Practice**. For instance, saying 2 of the *Gospel of Thomas*, though not presented as a cycle in the original text, can be read in terms of the modeling relation:

The one who seeks should not cease seeking until he finds: the path of **practice** at the top of the diagram represents a quest for the 'hidden' mechanism in the Einstein/Infeld account (**W**). **And when he finds, he will be dismayed**: the impact of the discovery or revelation, via the *signs* of it (**perception**), will disrupt **M**, the habitual mental model. **And when he is dismayed, he will be astonished**: the model will re-form itself in a new and surprising way. **And he will be king over the All**: a *rule* or principle has arisen into consciousness, a new habit has been mastered, which may issue forth as a practice or a precept, and may well be identified with the primal person, if the seeker/finder realizes how all-encompassing this cycle is when the circle is closed.

The world is inside out: What the observer sees as Model is what the subject sees as the World. When observer and subject are

one, Model and World are one, are the *entelechy*.

For the seeker, finding is closure. For one startled by unexpected experience, knowledge is closure. Einstein's watch is closed, its works invisible: reality remains a mystery. Yet the modeling process *works* as a guidance system in the world we really inhabit. Experience is closed and private for each of us, yet we manage to bring forth a common, public world. Every organism, being autopoietic and autonomous, is a system enclosed, both operationally and physically, in its identity; yet that system must also be *open* to the flow of energy in order to live and grow – or to learn and evolve. A self has to interact with the other in order to go on being itself. So in order to make deeper sense of the meaning cycle, we need to reopen the question of *closure*.

According to Varela, Thompson and Rosch (1991, 139-40), cognitive systems are best understood

> not on the basis of their input and output relationships but by their *operational closure*. A system that has operational closure is one in which the results of its processes are those processes themselves. The notion of operational closure is thus a way of specifying classes of processes that, in their very operation, turn back upon themselves to form autonomous networks. Such networks do not fall into the class of systems defined by external mechanisms of control (heteronomy) but rather into the class of systems defined by internal mechanisms of self-organization (autonomy). The key point is that such systems do not operate by representation. Instead of *representing* an independent world, they *enact* a world as a domain of distinctions that is inseparable from the structure embodied by the cognitive system.

It should be clear that the word 'representation' is being used here in a peculiar way, quite different from its general semiotic use (which was introduced in Chapter 2). Otherwise, this last sentence would assert that there is no real world independent of the cognitive system, or if there is, the system is entirely out of touch with it. No thought-sign within it would have a dynamic object

distinct from its immediate object, and actual *experience* would never penetrate its cognitive bubble. Such a cognitive system would *not* be a 'scientific intelligence,' defined by Peirce above as 'an intelligence capable of learning by experience.' If a system like that came up with a biological model like the one above, describing its own autonomy, it could not be a *scientific* model, because the model would be indistinguishable from fiction; there would be no difference between observing an actual organism and imagining or dreaming one. In that case the cognitive system 'enacting' the model could not test its truth by observing anything external to its own imagination. To make sense at all, then, the denial of 'representation' by Varela et al. must be using the term in some way incompatible with the Peircean usage involved in the concept of semiosis as a triadic modeling relation or dialogue with nature in which sign, object and interpretant are always involved. Maturana and Varela (1992 and elsewhere) likewise deny that 'information' is a valid concept, because they use the word in a non-semiotic way (recall Chapter 7 for the semiotic way, which will be further explained later on).

The 'key point' expressed by Varela, Thompson and Rosch is the same one expressed by the Einstein/Infeld stipulation that the watch is closed: we cannot directly compare our picture of reality with reality itself. You could also argue that we therefore shouldn't call it a 'picture' in the first place; or we could say that the refusal to recognize representation represents a failure to distinguish between iconic and indexical signs. But rather than debate the proper usage of terms like 'representation' or 'information,' let us see whether a semiotic view of cognition is compatible with the view that systems '*enact* a world as a domain of distinctions that is inseparable from the structure embodied by the cognitive system.' A later sketch by Varela of the 'enactive' model seems to map easily onto our meaning-cycle diagram:

> In a nutshell, the enactive approach underscores the importance of two interrelated points: (1) that perception consists of perceptually guided action; and (2) that cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided.

— Varela (1992, 12)

The term 'sensorimotor' unites the functions which the older psychology divided into 'input' and 'output.' What unites them in the actual brain is a recursive pattern, a loop, a structural internalization of the meaning cycle. The 'recurrent patterns' of which Varela speaks must be tokens of the type represented in our diagram. Many recent neuroscientific models are also based on this kind of pattern, some suggesting that consciousness develops by the addition of more loops to those already inherent in the functioning of the vertebrate brain. These ideas can be traced back a long way, to work in the 1960s by Varela's colleague Maturana on 'the circular organization of living systems,' and before that to the 'functional circle' (*Funktionskreis*) of Jakob von Uexküll.

Recent attempts to explain the self-organization of systems (and the origin of life) have brought forth the 'hypercycles' of Eigen and Schuster, and Stuart Kauffman's 'autocatalysis.' Psychology and neuroscience have brought us 'action-perception cycles,' 'sensorimotor loops,' Walter Freeman's 'distributed nonlinear feedback,' Edelman's 're-entrant processes,' Damasio's 'body loops' and 'reverberating cycle of emotion-to-feeling-to-emotion' (1999, 101). The consensus is clear that 'cognition emerges in development through repeated cycles of perception-action-perception' (Thelen and Smith 1994, 129). Then we have the different versions of 'circular causality' developed by Bateson and Freeman. (We will return to some of the above in the next chapter.) Edelman (e.g. 2004, 117), Rosen (2000) and Kay (2000) refer explicitly to 'causal loops,' applying them to neuro-, bio- and ecosystems respectively. Thus we can find these loops at several different scales: within the brain, within the body, within systems defined by structural coupling, and so on, up to the biosphere level (and perhaps beyond?).

In short, the idea of 'processes that turn back upon themselves,' as Varela put it, is one whose time has come in biology and cognitive science. If it was a long time coming, perhaps Heraclitus already knew why, over two millennia ago. For a clue, we can turn back to a fragment already quoted in Chapter 3:

People do not understand how that which is at variance

> with itself agrees with itself. There is a harmony in the bending back *[palintropos]*, as in the case of the bow and the lyre.
>
> — Heraclitus, fr. 117 (Wheelwright 1959)

If we tried to depict these palintropic cycles in all their inside-outness, we might need at least the talents of an Escher. But maybe we can get a feel for them by reading the meaning cycle as a Moebius trip – pardon the pun – made with a cut and a twist in the path at the point (**W**) where cycle meets mystery, where habit collides with experience in the 'outward clash' of cognition and *rec*ognition. The next chapter will further investigate the 'operational closure' of such cycles.