Nexus of Knowledge

Many at this point perhaps have some sense of the differences between inductive and deductive reasoning, but still the concepts could be strengthened. The Nexus of Knowledge is introduced to further help illustrate several fine points of these concepts and as well the limitations and shortcomings of inductive reasoning for certain classes of problems. The Nexus of Knowledge is a graph whereby any point represents a unique configuration for an experiment. In quantum terms, any point represents a unique quantum state of all the particles that compose an individual experimental arrangement. A hypothetical example is shown in Figure 6.1 where the paths

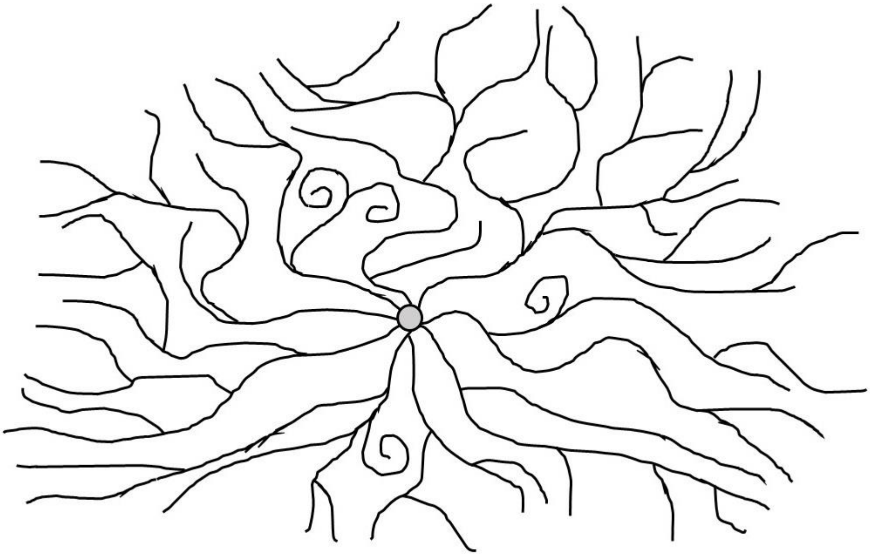

Figure 6.1: Initial configuration of Nexus of Knowledge.

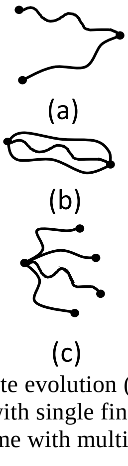

Figure 6.2: Types of state evolution (a) deterministic, (b) nondeterministic path with single final state, (c) nondeterministic outcome with multiple final states.

emanating from an initial condition represents a potential time evolution of the experiment. Each end point is a potential empirical outcome or result. The Nexus of Knowledge outcomes are ultimately empirically based, and there may or may not exist a theory that predicts state evolution from one state to another. One can consider any end point as a new initial condition for a branch. Paths are initially unknown and are used to designate state changes of phenomena that can physically occur, and have as yet no experimental or theoretical foundation for their prediction. As the paths are initially unknown, there may be a substantially larger number of possible paths that exist in terms of hypotheses in addition to the initial paths, and such additional hypothetical paths will be eliminated as the correct paths are discovered. The additional hypothetical paths are left out, to simplify the graph.

A transition between states in a fully deterministic Nexus has a single deterministic final state but could have more than a single initial state as shown in Figure 6.2(a). A nondeterministic path Nexus illustrated in Figure 6.2(b) includes the case of bifurcations from a single initial state to a single final state but for which there are multiple possible paths, but only one of which is taken in any particular trial. A nondeterministic outcome Nexus is such in Figure 6.2(c) where there can be different outcomes for the same experiment beginning at a common state. Bifurcations represent nondeterministic outcomes.

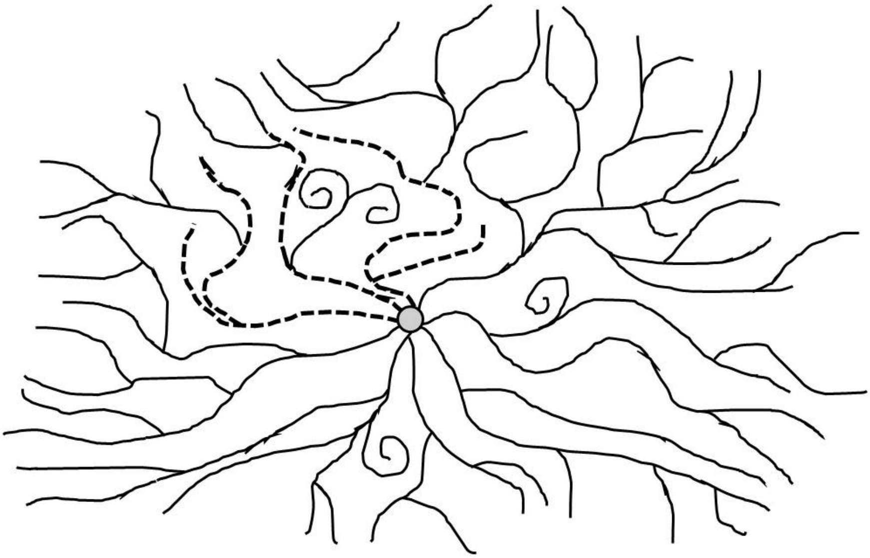

Figure 6.3: Verification of state evolution is indicated by the dashed lines.

When theoretical predictions, based on the current knowledge base and inductive reasoning, have been verified within some error ε that there has been observed state evolution from a given initial state to a final state, the path is changed to a dashed line as shown in Figure 6.3. Essentially dashed paths for which theoretical predictions and experimental predictions agree are indicative of a given theory being verified, or other theories that made different contrary predictions, being falsified. The fundamental scientific approach is based on such abilities and dashed paths of the Nexus reflect this, as stated in [633]:

> *Faced with difficulties in applying fundamental theories to the observed Universe, some researchers called for a change in how theoretical physics is done. They began to argue—explicitly—that if a theory is sufficiently elegant and explanatory, it need not be tested experimentally, breaking with centuries of philosophical tradition of defining scientific knowledge as empirical. We disagree. As the philosopher of science Karl Popper argued: a theory must be falsifiable to be scientific.*

Shown in Figure 6.4 is an example where the knowledge base is growing. The configurations of phenomena that are known to be understood within the current

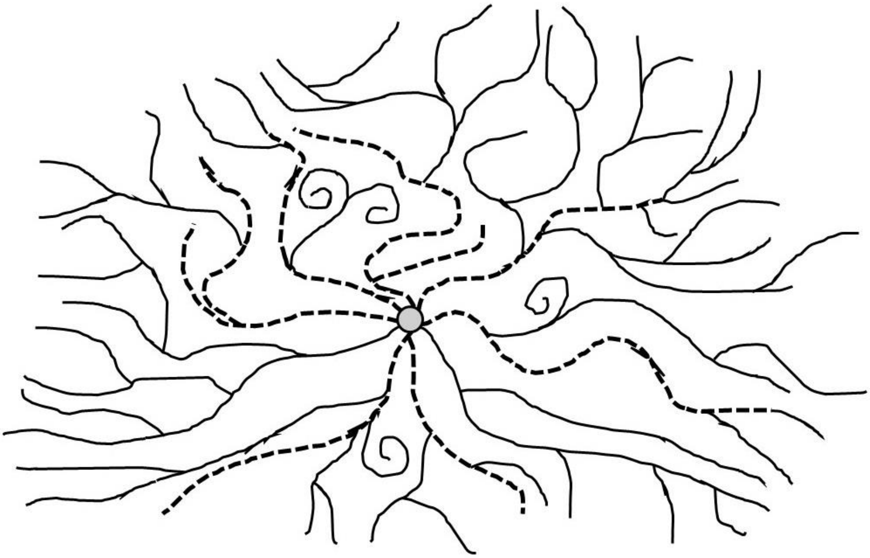

Figure 6.4: Growing knowledge base.

framework grow with time and the dashed areas expand.

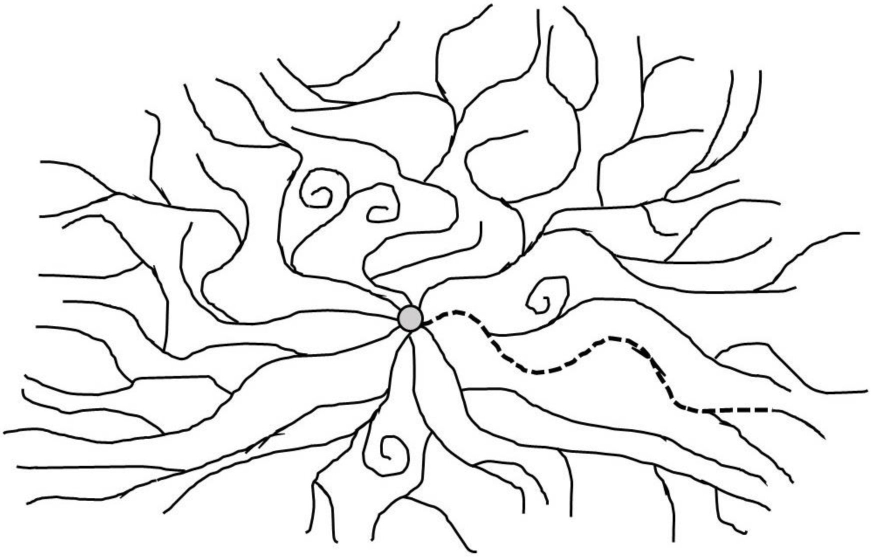

Figure 6.5: Deterministic knowledge base.

Figure 6.5 is an example of a fully deterministic knowledge base within a nondeterministic Nexus. It is known that the dashed evolution is possible although other nondeterministic possibilities have not been ruled out.

Paths represented by dash-dot pattern as illustrated in Figure 6.6 are used to denote

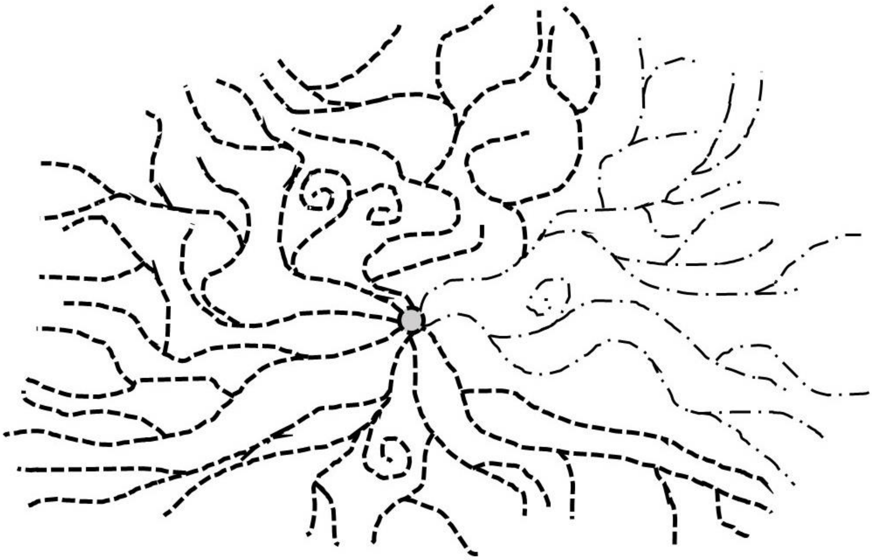

Figure 6.6: Theoretical predictions of state evolution that have not been empirically confirmed represented by the dash-dot pattern.

phenomena for which no exact experiment has taken place in order to test a particular arrangement, however, there exists general theory and confirmed experimental evidence for similar arrangements.

Double line paths, as illustrated in Figure 6.7, represent phenomena for which experiments or theory have called into question whether or not such phenomena can be accurately described by the current inductive knowledge base. Such lines may actually be dashed and the experiments to date have been performed incorrectly or the theoretical assumptions did not match the experiment, for example if the theoretical modeling was too simplistic. Examples of such paths are similar to the Turing halting problem, the result of the Michelson–Morley experiment and the perihelion precession of mercury.

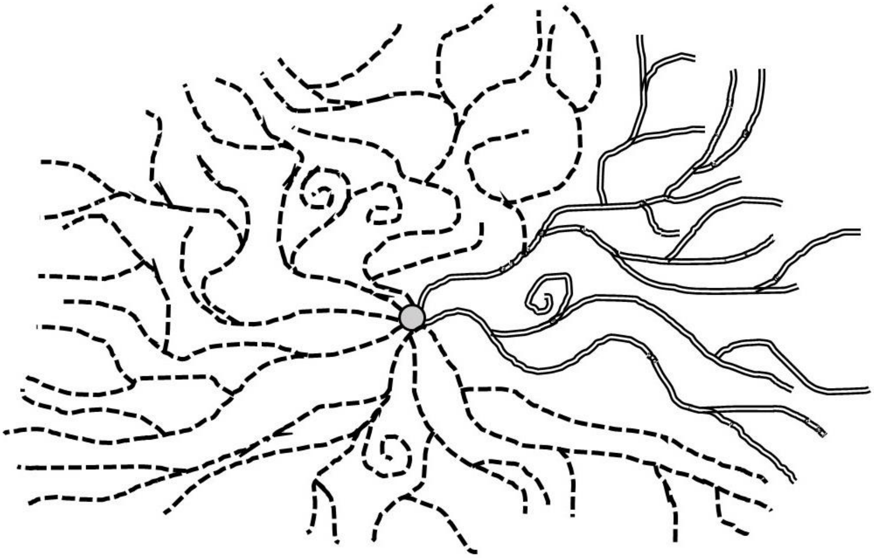

Figure 6.7 Double line paths in the Nexus represent potential exceptions to the currently understood inductive framework.

Paths with three lines are assigned to represent phenomena that have been verified at present to not be adequately described by proposed or current theory, as shown in Figure 6.9. Experiments are performed that prove within experimental error that a given theoretical prediction is wrong. An example of this is the Bohr-Kramers-Slater (BKS) theory which assumed that energy and momentum need not be conserved on every trial but rather on average. Compton found that experiments of electron-photon interaction conserve energy and momentum on every trial, even at the single quantum level. This invalidated the BKS theory. New theory was then needed to explain photon-matter interaction. Another historical example is the experimental Lamb Shift result showing that the weak coupling between the electromagnetic field and the atomic system needed to be taken into account in order to compute the levels of an atomic system.

Suppose there exists a theory that accurately predicts the Nexus in a particular

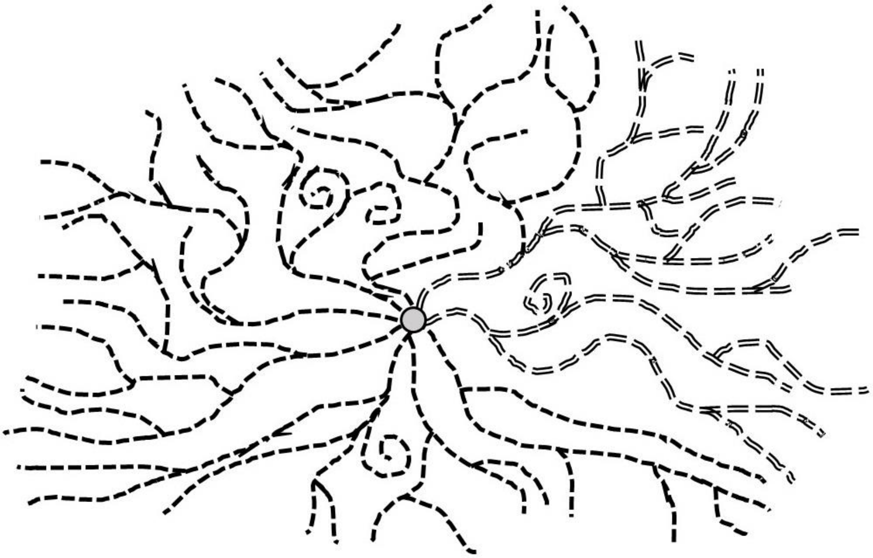

Figure 6.8: Dashed double line paths represent phenomena for which no a priori generalization of a theory can exist to make predictions, and one must take into account empirical evidence.

area. It may be possible that the theory can be generalized to apply to the Nexus states in a different area. On the other hand, it is possible that no generalization of a theory is applicable to other areas of the Nexus. In such a case, one must utilize empirical

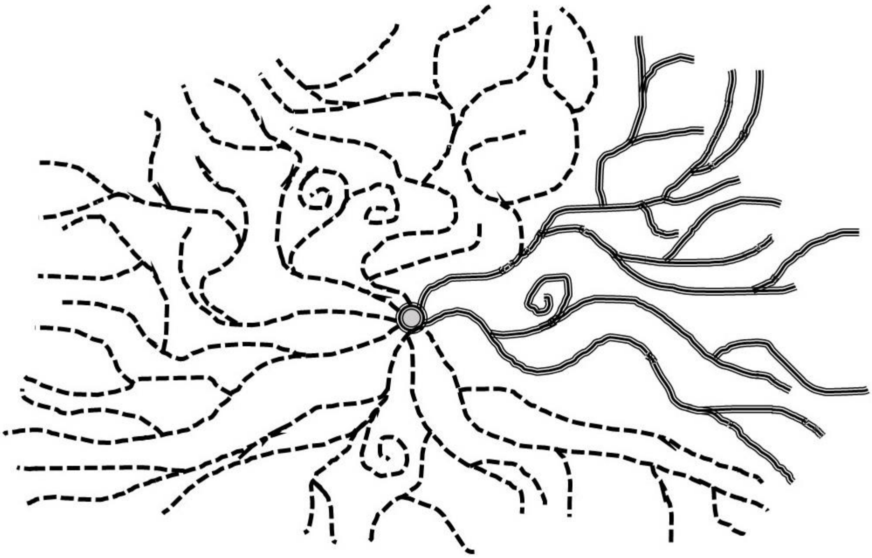

Figure 6.9: Three-line paths have been verified at present to not be adequately described by proposed or current theory.

evidence to make predictions. In such cases, dashed double line paths are assigned as shown in Figure 6.8.

When there is no possibility of verifying predictions either theoretically or empirically, the path will be shown using the dash-dot-dot pattern as in Figure 6.10.

One might consider string theory as an example of a dash-dot-dot path. However, it is expected that string theory might eventually be testable in the future, see [634]. It is also possible that the amount of information and evidence available is not sufficient to narrow existing theories to a single theory or is underdetermined and multiple theories will often exist to explain a given phenomenon.

Consider the case whereby experimental results lie outside the region described by the current knowledge base. Phenomena would exist that cannot be described by the use of induction based solely on current theory. These phenomena are necessarily exceptions to what is currently understood. A new theory that explains such phenomena would be expected to be initially met with skepticism and resistance, particularly by those who prefer inductive reasoning and are unskilled in deductive reasoning. Scientists that use inductive reasoning would incorrectly classify such phenomena as those which can be understood by current theory, but the detailed predictions are generally too complex.

Let us analyze several examples of scientific processes in order to more fully understand the roles of inductive and deductive reasoning.

Example 1:

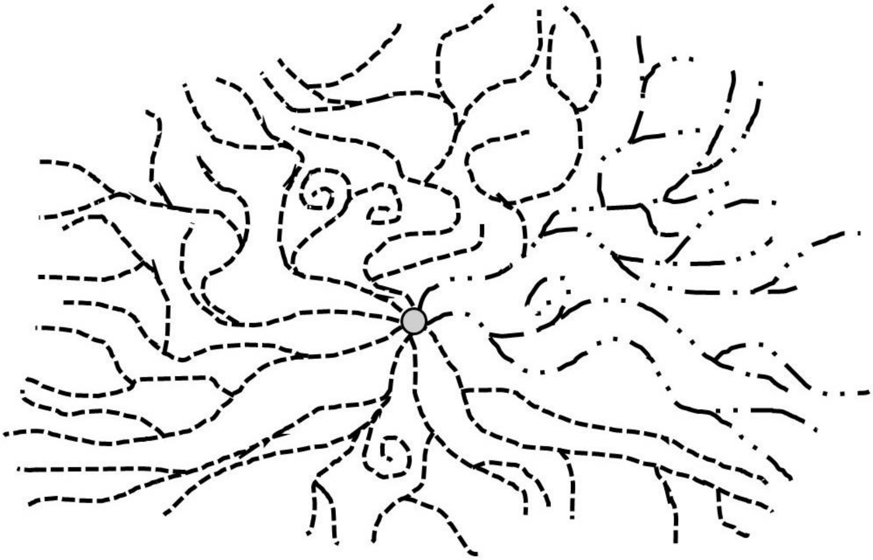

Figure 6.10: Paths are represented with the dash-dot-dot pattern when it is impossible to verify predictions either theoretically or empirically.

An engineer learns how to correctly design and accurately predict the response of the design for various electrical engineering circuits. He learns to build and test circuits in school and verifies their behavior up to a level of accuracy as shown in Figure 6.11.

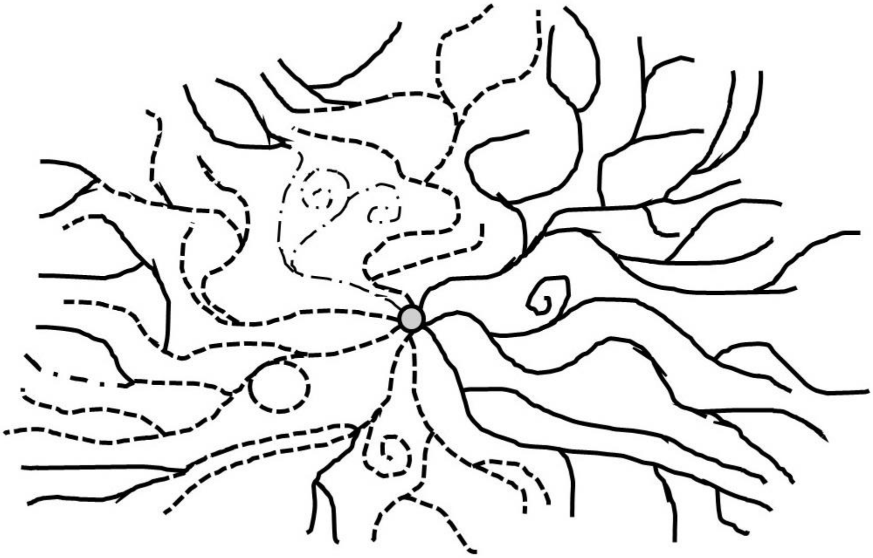

Figure 6.11: Engineer’s learned knowledge base of circuits.

The engineer builds the circuit, tests it and measures the outputs, and confirms that his

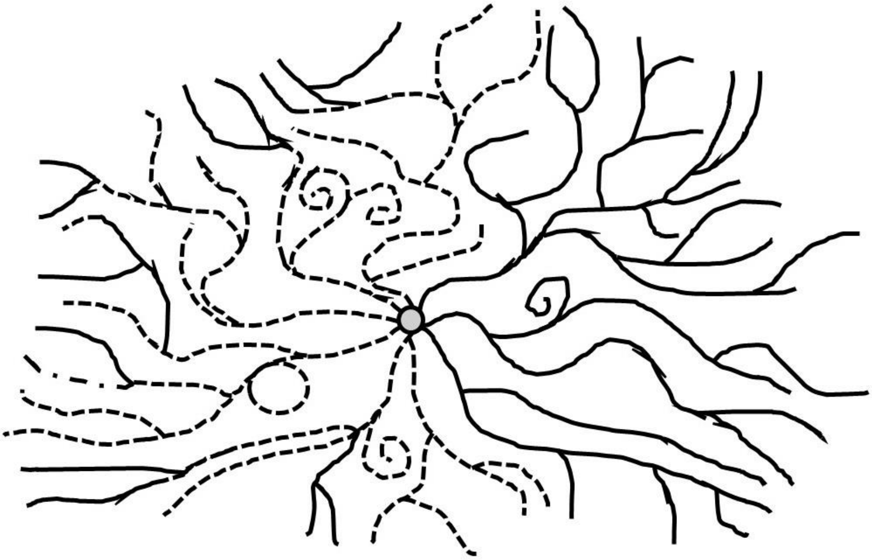

Figure 6.12: Confirmation and expansion of knowledge base when existing theory is applied to previously untested circuits and found to accurately reflect the phenomena.

predictions based on the current knowledge base are within an error ε. He is successful, and the path associated with this circuit is updated to a dashed pattern as seen in Figure 6.12.

Example 2: The same engineer is given a new circuit to design shown by the dash-dot pattern in Figure 6.13, one which has not been designed previously but is expected will work in conformity with the current knowledge base.

The engineer applies the theory and practices learned previously to design the desired circuit. It is found when the outputs of the circuit are measured, that it does not agree with expectations. These paths are changed to a double line pattern as shown in Figure 6.14.

The engineer is surprised by this finding and consults with others. They tell him that he must have done something wrong. Later, it is found that the engineer's modeling of the experiment was not sufficiently accurate. For this problem, more accurate modeling was needed and when this was done the results agreed with the theory. These paths are updated to a dashed pattern as seen in Figure 6.15. The general form of the Nexus is ultimately constrained by the principles of nature. It may be expected that a solution to the measurement problem will impose a similar structure to the physically realizable Nexus.

These examples indicate that an inductive reasoner sees the entire Nexus of Knowledge as dashed, even though it may not be. An inductive reasoner may be deceived unless the current state of knowledge is sufficiently advanced to where absolutely all phenomena can be predicted to within some error. Inductive reasoning is to largely compute or apply knowledge that one has learned.

There is generally a known methodology or approach that can be used to solve a

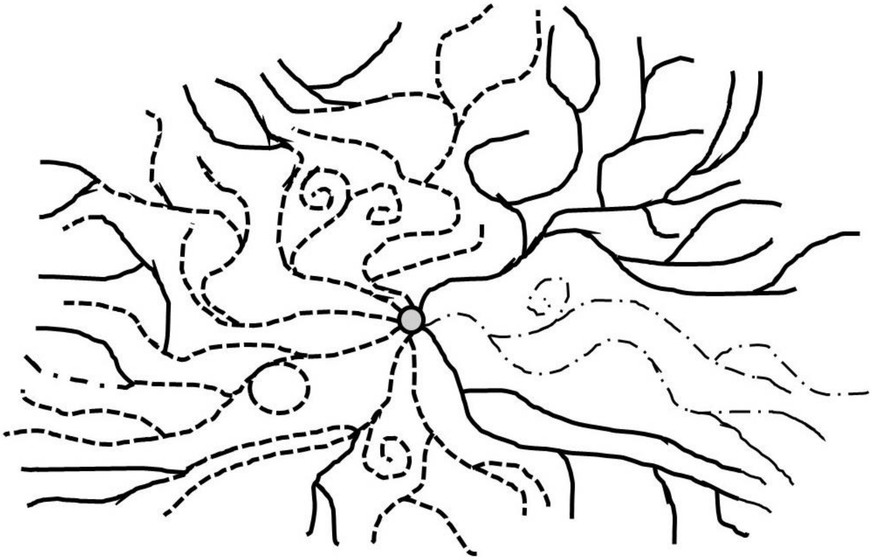

Figure 6.13: New circuit that has not been previously designed or tested is desired as shown by the dash-dot pattern.

problem inductively. Deductive reasoning can also be applied to problems that would be predicted correctly using the current knowledge base. For example, mathematical theorems are generally based on deductive reasoning and are guaranteed to be self-contained within dashed paths. In such cases, deductive reasoning will yield the same result as inductive reasoning.

When applying deductive reasoning to physical problems outside the knowledge base, the deductive solution may require rigor well beyond any inductive argument. One needs to be assured that the experimental conditions are correct to within the desired error ε needed to differentiate whether the problem is outside the current knowledge base or within the current knowledge base, but the modeling was not sufficient.

A new theoretical basis may be needed to explain the phenomena beyond anything known previously. It is necessary to verify experimentally that the new proposed theory is correct and explain why the previous theory was inadequate.

Inductive reasoning is successful when a problem can be solved or accurately approximated based on building upon existing theory and techniques. Deductive reasoning must be considered when a problem cannot be solved via induction using the current knowledge base. One can make additional assumptions but cannot be sure that the assumptions are correct. The use of deductive reasoning for cases for which the current knowledge base is insufficient, will necessarily yield a different result than what is predicted by current theory and thereby be initially considered improbable, surprising, and in certain cases even mystical.

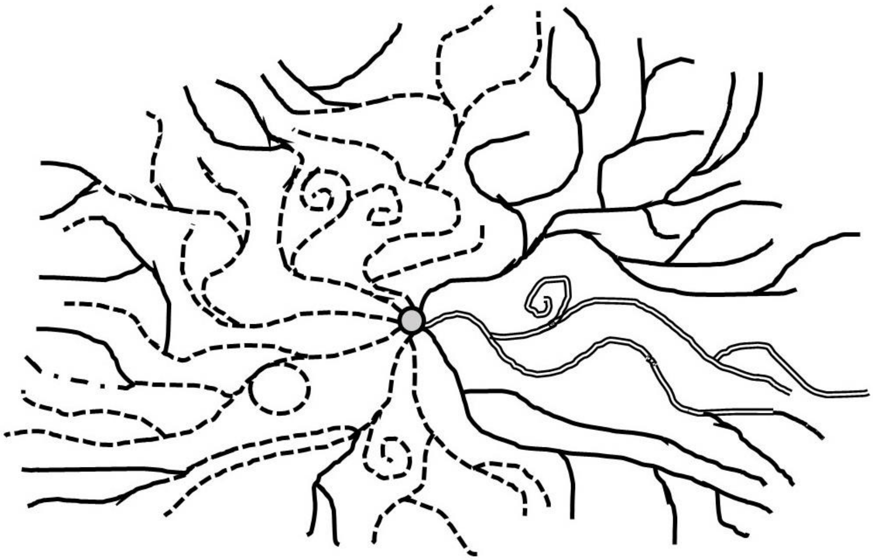

Figure 6.14 An engineer’s perspective of the Nexus when it is found that a circuit has failed to produce the predicted outcome.

Deductive reasoning requires an approach in which many potential solutions are considered. Only the theory that cannot be eliminated is the correct answer. Any idea must remain “on the table” until eliminated. In this case, the issues of consciousness and free will must be considered in any serious deductive attempt to solve the measurement problem.

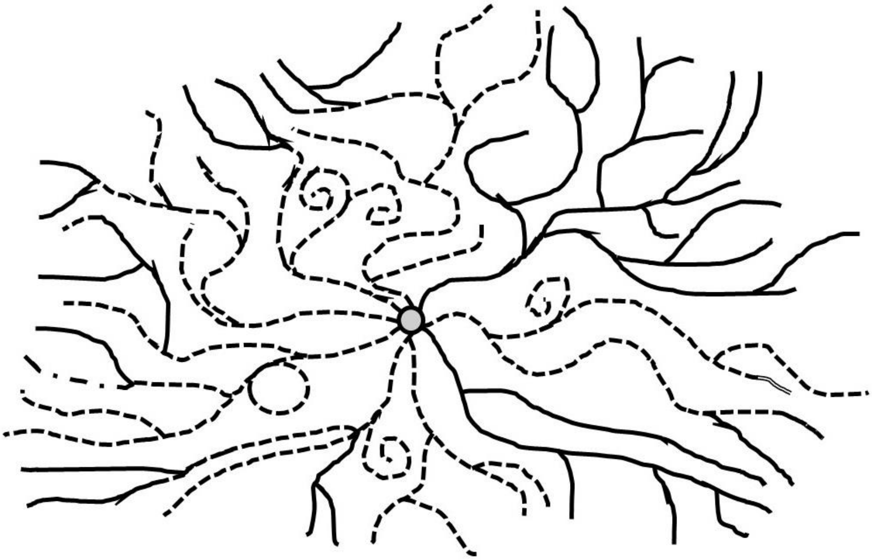

Figure 6.15: Final knowledge base of engineer after taking into account more accurate modeling.