INTRODUCTION

The Elements of Argument

We reason every day of our lives. All of us argue for own points of view, whether the topic be politics, the value or burden of religion, the best route to drive between Boston and New York, or any of a myriad of other subjects. We are constantly barraged by the arguments of others, seeking to convince us that they know how to build a better computer or how to prevent a serious illness or whatever. When first approaching the subject of reasoning, a student is apt to feel like Molière’s M. Jourdain, who suddenly realized that he had been speaking in prose for forty years. Just as prose can be elegant or ungrammatical, however, there are grades of reasoning, from the clear and compelling to the fallacious and sloppy. All scholars must engage in reasoning, but it is the mainstay of work in philosophy. A brief, but quite accurate, description of philosophical method is that we do not observe or experiment, we construct chains of reasoning. Because of its central role in their discipline, philosophers have tried to make their reasoning explicit and to discover the principles underlying good reasoning.

This introductory section of Reason at Work presents some basic principles of good reasoning. We hope to provide readers with some of the skills required for constructing good arguments of their own and for analyzing the reasoning of others. These two tasks—the constructive and the critical—are related. A good critic can reconstruct the best version of the argument under appraisal. Equally, a good reasoner is constantly playing critic, subjecting the developing argument to scrutiny. Besides the intrinsic value of improving the skill of reasoning, we hope that this section will also enable students to achieve a better understanding of the argumentation in the readings that follow.
Arguments

In ordinary parlance, an argument is a verbal dispute carried out with greater or less ferocity. The technical, philosophical notion is quite different. An argument is a collection of sentences consisting of premises and a conclusion. Arguments can have any number of premises, starting with as few as one. In reasoning, we often encounter a chain of argumentation, that is, a sequence of arguments. We begin with some premises and infer a conclusion. From this first conclusion, plus some other premises, we infer a second conclusion, and so on down the line until we reach the final conclusion of the entire chain of argumentation. The conclusions of the individual arguments in the chain are usually referred to as subconclusions, because although they function as premises of later arguments, they are not premises of the entire chain of argumentation. A statement functions as a premise in an argument, or in a chain of argumentation, if the truth of that statement is assumed and not established by the argumentation. Conclusions and subconclusions are the claims whose truth is supposed to be established and not assumed by the argumentation.

In the following chain of argumentation, 1, 2, and 4 are premises; 3 is a subconclusion, because it follows from 1 and 2 and because, along with 4, it supports 5; 5 is the final conclusion.

1. The people in the house would have been awakened the night the horse was stolen if the dog had barked.
2. Everyone slept peacefully the entire night the horse was stolen.
3. So, the dog must not have barked.
4. The dog would have barked if the individual or individuals leading the horse out of the stable had been strangers.
5. Therefore, the horse thief (or horse thieves) was (were) known to the dog.*

One crucial fact about philosophical arguments follows immediately from the recognition that arguments always have two basic parts: premises and conclusions. It is sometimes said that a true philosopher never assumes anything; every claim must be proved. Taken literally, this cannot be right. For if you are going to construct an argument at all, you must take some claim (or claims) as your premise(s). It would obviously be backwards to assume the truth of a very controversial claim in order to argue for something that is obvious to everyone. The direction of argumentation must always be, as above, from the more obvious to the less obvious. Ideally a reasoner will assume, as premises, claims that are very uncontroversial and argue that a much more controversial, perhaps even surprising, conclusion follows from those unproblematic assumptions.

A chain of argumentation is exactly as solid as the arguments it contains. If any link is weak, then the entire chain will break down. From a logical point

* Sherlock Holmes offers this chain of reasoning in “Silver Blaze,” in The Memoirs of Sherlock Holmes.
of view, the crucial aspect of arguments is the relationship between the premises and the conclusion. Logic is that branch of philosophy which studies the inferential relations between premises and conclusion. The task of logic is to establish rules or guidelines about which claims can be inferred from other claims. This task has been carried out with great success for deductive inference. Deductive logicians have provided clear and rich accounts of the standards of good deductive inference. Courses in deductive logic present these theories in detail. We will describe only those aspects of deductive logic that are particularly important for evaluating ordinary reasoning.

Deductive Arguments

The central concept of deductive logic is validity. An argument is valid if and only if the following relation holds between its premises and its conclusion: It is impossible for the conclusion to be false if the premises are true. Alternatively, in a valid argument, if the premises are true, that guarantees that the conclusion is also true. It is important to realize that logicians are not concerned with truth itself. Logicians will certify an argument as valid whether or not the premises are true. Their concern is only with the relation between the premises and the conclusion. Regardless of whether the premises are true, an argument is valid if, if the premises happen to be true, then the conclusion must be true. If all the arguments in a chain of argumentation are valid, then the entire chain will also be valid. Valid arguments are ideal, because if you start from true premises, true conclusions are guaranteed. Like a trolley car that is bound to follow the tracks, if you start with the truth and make only valid inferences, you will never veer away from the truth.

It is somewhat unfortunate that, in ordinary English, “valid” and “true” are often used as synonyms. Their technical, philosophical meanings are quite distinct. In the primary philosophical use of “valid,” it makes no sense to say that a statement is “valid,” for validity is a relation among statements. Statements can be true, but not valid; arguments can be valid, but not true. “True” and “valid” have distinct meanings, and truth and validity are independent properties; that is, each property can occur without the other. Arguments whose premises are all true can still be invalid and valid arguments can have false premises. Thus, a valid argument can have (i) true premises and a true conclusion, as in (1); (ii) one or more false premises and a false conclusion, as in (2); or (iii) one or more false premises and a true conclusion, as in (3). The only possibility ruled out by validity is that the argument have true premises and a false conclusion.

(1) \( P_1 \) Wombats belong to the order of marsupials.
\( P_2 \) Koalas belong to the order of marsupials.
\( C \) Wombats and Koalas belong to the same order.

(2) \( P_1 \) All philosophers lived in Ancient Greece. (false)
\( P_2 \) Bertrand Russell was a philosopher.
\( C \) Bertrand Russell lived in Ancient Greece. (false)
Finally, an argument can have true premises and a true conclusion and still be invalid, as in (4).

(4)  \( P_1 \) Some roses are red.  
     \( P_2 \) Some violets are blue.  
     \( C \) Some flowers give some people hay fever.

The problem with argument (4) is that, while all the claims are true, the fact that \( P_1 \) and \( P_2 \) are true gives us no reason whatsoever to believe that \( C \) is true.

So far, we have been assuming that the reader can simply "see" when an argument is valid or invalid. But how can we actually test for deductive validity? In one sense, the test for validity comes right out of the definition of validity: A valid argument is one whose conclusion cannot be false if its premises are true. To test for validity, try negating the conclusion while assuming the truth of the premises.

(5)  \( P_1 \) All Englishmen love the Queen. (false)  
     \( P_2 \) Henry is English.  
     \( C \) Henry loves the Queen.

In (5) we would negate the conclusion, yielding "Henry does not love the Queen." Now the question is, can we still maintain the truth of the premises? Obviously not, for if we try to claim that Henry does not love the Queen, while holding to the truth of \( P_2 \), "Henry is English," then we shall have to give up the truth of \( P_1 \), "All Englishmen love the Queen." Conversely, if we claim that Henry does not love the Queen and try to maintain \( P_1 \) as well, then we will have to give up \( P_2 \). Since we cannot maintain the truth of both (or all) premises while negating the conclusion, this argument is valid. If it is possible to preserve the truth of the premises, while denying the conclusion, as in (6), then the argument is invalid.

(6)  \( P_1 \) Only U.S. citizens vote in American elections.  
     \( P_2 \) Jones is a U.S. citizen  
     \( C \) Jones votes in American elections.

Even though \( P_1 \) and \( P_2 \) are true, \( C \) could be false, if Jones is one of the citizens who does not bother to vote.

While the test just described is always sufficient to determine validity, sometimes it is difficult to tell whether an argument passes or fails this test, for example, argument (7).
THE ELEMENTS OF ARGUMENT

(7) P₁ All Republicans are happy or handsome.
P₂ No Republican is silly.
P₃ All happy people are silly or hardworking.
Sub C All Republicans are hardworking or handsome.
P₄ All hardworking people are silly or handsome.
C All Republicans are handsome.

To simplify and systematize the task of determining validity, logicians have appealed to the notion of logical form. Since classical antiquity, philosophers have recognized that different arguments could share the same form. For example, arguments (8) and (9) have a common form.

(8) P₁ Either the Yankees or the Red Sox will win the pennant.
P₂ The Yankees cannot win the pennant.
C Therefore, the Red Sox will win the pennant.

(9) P₁ With the new Congress, taxes will either go down or up.
P₂ Taxes never go down.
C Therefore, taxes will go up.

This common form can be seen more clearly if we represent the claims contained in the arguments by letter variables. Both arguments have the following form:

F₁ P₁ A or B.
P₂ Not A.
C B.

Clearly, any argument of this form must be valid. For the first premise asserts that either A or B is true and the second premise claims that A is not true. Thus B must be true.

There are many, many valid argument forms. We list some of the more common forms alongside an example of each form.

(10) P₁ The 1960s were not a time of peace.
C Therefore, the 1960s were not a time of peace and prosperity.

(11) P₁ If interest rates come down, the stock market goes up.
P₂ Interest rates have come down.
C The stock market is going up.
(12) \( P_1 \) All Mozart compositions are melodious.
\( P_2 \) The "Window" aria was composed by Mozart.
\( C \) The "Window" aria is melodious.

(13) \( P_1 \) Jones was an honest politician.
\( C \) Some politicians are honest.

Finally, argument (7) above has the following form:

\( F_6 \)  
\( P_1 \) All A's are B or C.
\( P_2 \) No A is a D.
\( P_3 \) All B's are D or E.
\( \text{Sub} \)  
\( C \) All A's are E or C.
\( P_4 \) All E's are D or C.
\( C \) Therefore, all A's are C.

In an older tradition in logic, students would be expected to memorize numerous valid argument forms, many of which have special names. \( F_1 \) is called "constructive dilemma," \( F_3 \) "modus ponens," and \( F_4 \), a "syllogism in Barbara." A serious drawback of this system—aside from the archaic names—is that students simply cannot memorize all the valid forms, because there are too many of them. We suggest, instead, that students think of logical form as a tool to use in determining validity. When presented with an argument, it is extremely helpful to schematize that argument by using letter variables. Care must be taken in figuring out the correct schematic presentation of an argument. The first point to realize is that one sentence will often contain two claims. For example, (8) \( P_1 \), "Either the Yankees will win the pennant or the Red Sox will win the pennant" actually involves two distinct claims, "the Yankees will win the pennant" and "the Red Sox will win the pennant." It asserts a relation between these claims, namely, the relation that one of these two claims is true, so it should be represented as "Either A or B." Sometimes it is possible to schematize an argument adequately just by using letter variables to stand for claims. Of course, the same claim should always be represented by the same letter and each distinct claim must be represented by a different letter.

Other arguments have a more complex structure, because distinct claims share a common part and the shared part plays a role in the inference. In example (12), "All Mozart compositions are melodious" and "The 'Window' aria was composed by Mozart" share a common idea, "being composed by Mozart." Further, the fact that these two premises share this part is crucial in
allowing us to infer the conclusion. In such cases, distinct letters must be used for elements within claims. Otherwise, the schema would mask rather than reveal the logical interrelations between the claims. The standard procedure for assigning letter variables to elements within claims, is to replace attributes that different individuals can share—“being red,” or “being composed by Mozart,” for example—by capital letters, and names of individuals by lower case letters. So argument (12) should be represented as above:

\[
\begin{align*}
F_4 & \quad P_1 \quad \text{All A's are B's.} \\
    & \quad P_2 \quad a \text{ is an A.} \\
    & \quad C \quad a \text{ is a B.}
\end{align*}
\]

To sum up: Where possible, schematize arguments by assigning letter variables only to distinct claims. When the inferential structure of the argument is hidden by this procedure, assign letter variables to elements within claims.

A compelling deductive argument should be valid. Otherwise, the premises should not lead us to accept the conclusion. However, validity is not enough. Even if the truth of a conclusion may be validly inferred from the truth of certain premises, that gives us no reason at all to accept the conclusion, unless we have good reason to believe that the premises are, in fact, true. Fortunately, there is no magical device we can use to determine truth. For philosophers, as for anyone else, establishing the truth of claims is often a complex, difficult, and uncertain project. Still, through their explicit study of argumentation, philosophers have recognized that there is a general method that can be used to assess the worth of premises, even in the absence of a test of truth.

In analyzing arguments, philosophers noticed that the key terms in some premises were either so vague or so ambiguous that the premise ought to be rejected out of hand. For example,

\[\begin{align*}
P_1 & \quad \text{The Constitution requires that public education be theologically neutral.} \\
P_2 & \quad \text{The theory of evolution is really just a religious doctrine.} \\
C & \quad \text{Therefore, since evolution is taught in schools, the Biblical account of creation should also be taught in order to ensure theological neutrality.}
\end{align*}\]

While \(P_2\) is also highly questionable, we will just consider the terminology employed in \(P_1\) and the conclusion. What is the key expression “theologically neutral” supposed to mean? Given a standard interpretation of the Constitutional doctrine of the separation of Church and State, if \(P_1\) is to be true, then “theologically neutral” must be read as something like “devoid of theology.” Notice, however, that this cannot be the intended reading of “theologically neutral” in the conclusion, or the conclusion would be self-contradictory, asserting that the way to make public education devoid of theology is to start teaching the Biblical account of creation. There, “theologically neutral” must
be interpreted to mean something like "theologically balanced." In this example, the ambiguous terminology completely vitiates the argument. The only reason the premises even appear to support the conclusion is that the same phrase occurs in both P_1 and C. That connection is illusory, however, because the phrase is used ambiguously. In cases like this, the argument may be dismissed without trying to determine the truth of the premises. In fact, when a key term in a premise is either ambiguous or vague, there is no way to figure out whether the premise is true or not. For, if we are unsure about what the premise asserts, we are in no position to find out whether what the premise asserts is true.

Thus, when philosophers move from assessing the validity of an argument to assessing the plausibility of its premises, they make a preliminary inquiry into the clarity of the premises. Their two questions are: Are key terms used ambiguously? Is any key term too vague to be assigned a meaning? Sometimes, vagueness is very easy to spot as, for example, in the popular advertising claim, "Lipton tea is brisk." Here we are given no idea at all about what "brisk" is supposed to mean when applied to tea, as opposed to, say, a "brisk" walk. So we are in no position to weigh the plausibility, let alone the truth, of the claim. In other cases, it requires considerable practice and serious thought to figure out whether the claim made by a premise (or a conclusion) is acceptably clear. To take a contemporary example, most people believe in equality of opportunity for all. This superficial consensus can mask deep differences, however, because "equal opportunity" can mean many different things. To give just three possibilities, "equal opportunity" can mean "a right to equal consideration for all jobs," or "a right to equal education or training in the skills required by more prestigious jobs," or "a right to proportionate distribution of the actual jobs available." It will be easier or more difficult to defend the claim that the "equal opportunity" is correct, depending on which of these meanings is used. So when trying to assess the plausibility of a premise, the first step is to try to assign some clear meaning to its key terms. Often, different assignments will have to be tried, before it is possible to determine the best reading for the term or phrase in the argument. For, as we saw in (14), while one reading may work well in one premise, that reading may be disastrous in other parts of the argument. To avoid trading on any ambiguities, the same reading must be used for every occurrence of the term. As the example of "equal opportunity" suggests, thinking carefully about what the terms in argument mean is just as important for constructing sound arguments as it is for criticizing the arguments of others.

Non-Deductive Arguments

We have looked briefly at one type of inferential relation between premises and conclusions—the relation of deductive validity. As noted above, the science of deductive logic has been worked out in great detail and with impressive precision. As we turn from deductive arguments to non-deductive arguments,
matters look very different. Current theorizing about non-deductive inference is much less certain, much less clear-cut than its counterpart in deductive reasoning. For reasons that we will touch on below, it may turn out that a rigorous and complete theory of non-deductive logic is not possible! Nevertheless, we must try to deal with non-deductive reasoning, because there are many good, but non-deductive inferences that we encounter in everyday and scientific discussions. Suppose, for example, that a particular drug is given 100,000 trials across a wide variety of people and it never produces serious side effects. Even the most scrupulous researcher would conclude that the drug is safe. Still, this conclusion cannot be validly inferred from the data.

(15) \[ P_1 \text{ In 100,000 trials, drug X produced no serious side effects.} \]
\[ C \text{ Drug X does not have any serious side effects.} \]

We can use our regular method of testing validity to show that this argument is invalid (see p. 4). Assuming the negation of the conclusion—drug X has a serious side effect—can we preserve the truth of premise \( P_1 \)? It could turn out that a serious side effect only shows up on the 100,001st trial. Thus the premise, \( P_1 \), could be true, even though \( C \) is false, so the argument is invalid.

There are many more good, but invalid arguments. Here is a mundane example.

(16) \[ P_1 \text{ The dining room window is shattered.} \]
\[ P_2 \text{ There is a baseball lying in the middle of the glass on the dining room floor.} \]
\[ P_3 \text{ There is a baseball bat lying on the ground in the yard outside the dining room.} \]
\[ C \text{ The dining room window was shattered by being hit with a baseball.} \]

Here is an example from a current scientific debate.

(17) \[ P_1 \text{ The evolution of organisms depends on particular facts about environment and competitors.} \]
\[ P_2 \text{ Among many other facts, the development of mammals (and so, of human beings) probably depended on the accidental extinction of the dinosaurs, who had dominated the mammals.} \]
\[ C \text{ Since it is very unlikely that the sequence of facts which permitted the rise of human beings will ever be repeated, it is unlikely that we will encounter humanoid creatures on other planets.} \]

* Stephen Jay Gould offers this argument in Discover (March, 1983). Gould’s main point is that while evolutionary considerations make the discovery of other humanoids unlikely, they do not tell against the possibility of discovering other forms of intelligent life.
If we cling to the standard of deductive validity, then all three of the above arguments—and all other arguments like these—will have to be dismissed as bad reasoning. That constraint on argumentation is unacceptable for three reasons. First, these arguments appear to be perfectly reasonable, at least at first glance. Second, it is hard to see how we could get by without engaging in the sorts of reasoning represented by these examples. Finally, and perhaps most critically, it seems unreasonable to demand that the truth of the premises must guarantee the truth of the conclusion. Very often it is reasonable to believe something that is merely very probable, given the evidence. To take a different example, given the number of traffic lights in Manhattan, it is reasonable to believe that, if you drive the entire length of the island in normal traffic, you will have to stop at some traffic light or other (and probably at several). At least, we would be willing to make a small wager on this point.

Logic has, therefore, a second task. It needs to provide criteria for evaluating good, but non-deductive, inferences. This work may never be carried out with the precision and detail found in theories of deductive inference. Still, philosophers have distinguished various types of non-deductive arguments and have offered suggestions about standards for evaluating these sorts of arguments.

**Induction**

Without any detailed knowledge of combustion, we know that if we place a dry piece of paper into the flame of a candle, the paper will burn. We know this because we have witnessed or heard about many similar events in the past. In the past, the paper has always burned, so we infer that the paper will burn in the present case. This common type of reasoning is called induction. In induction, one relies on similar, observed cases, to infer that the same event or property will recur in as yet unobserved cases. We reason that since paper has always burned when placed in a flame, the same thing will happen in the present case. In this example, we are using previous experience to make a single prediction. Inductive reasoning can also warrant general conclusions. Having determined that, in all the carbon atoms that have been tested, the atomic weight is 12, we infer that all atoms of carbon have an atomic weight of 12. As the reader can easily verify, neither a single-case induction nor inductive generalizations can be validly inferred from their premises.

(18) \( P_1 \) In all observed cases, paper burns when placed in a flame.
\[ \text{C If the piece of paper in front of us is placed in a flame, it will burn.} \]

(19) \( P_1 \) All the carbon atoms which have been tested have an atomic weight of 12.
\[ \text{C All carbon atoms have an atomic weight of 12.} \]

For different cases, we will have different amounts of evidence on which to draw. If only ten instances of a disease have been observed, then we will have much less confidence in predicting the course of the disease than if we had
observed 10,000 occurrences. Philosophers usually describe our “confidence” in a claim as our “strength of belief” in that claim. The obvious suggestion is that our strength of belief in a claim should vary with the amount of evidence supporting the claim. More precisely, our strength of belief should increase with the number of positive instances of the claim. In other words, the degree of rational belief does increase as positive instances increase. So, for example, if you arrive in a new town and notice that all the buses you see on your first day are green, then as the days pass and you continue to observe nothing but green buses, the degree of your rational belief in the claim that all the buses in town are green will continually go up. Each new instance of a green bus is said to “confirm” the generalization that all the buses are green. Another way to state this relationship is that the degree of rational belief in an inductive generalization should vary with the amount of confirmation that the generalization has received.

Positive instances gradually confirm an inductive generalization, making it more and more reasonable to accept the generalization. By contrast, a negative instance defeats the generalization in a single stroke. To take a dramatic twentieth-century example, with the splitting of the first atom, the long-standing claim that atoms are indivisible particles of matter had to be given up. Besides the sheer number of positive instances, another criterion for good inductive reasoning is that the evidence be varied. If you have observed buses in many different parts of town, then you are more justified in claiming that the town’s buses are all green than if you only considered the buses on your street.

**Hypothesis Testing**

It is a commonplace that people—most notably scientists and detectives—test hypotheses and accept those hypotheses that pass the tests they have devised. The process of hypothesis testing (with consequent acceptance or rejection) is very similar to the process of inductive reasoning. For example, imagine that a problem has developed in a small rural town. Residents are falling sick, complaining of severe nausea, abdominal pains, and other symptoms. The local doctor hypothesizes that the trouble has been caused by the opening of a new chemical plant that is emptying waste within a mile of one of the lakes that yield the town’s supply of drinking water. The hypothesis can be tested in a number of different ways. The residents might check the consequences of only drinking water from lakes that are not close to the chemical plant. Or they might examine the effects on laboratory animals of drinking water obtained shortly after large amounts of waste had been ejected from the plant. It is relatively easy to see how the doctor’s hypothesis might fail such tests. The residents might find that using water from different lakes achieved nothing, and that the sickness continued to spread. Equally, it is evident how the hypothesis could pass the tests. One might discover, for example, that the health of laboratory animals was dramatically affected by providing them with water obtained shortly after an episode of waste disposal.
The case just described indicates the general way in which a hypothesis might be tested. Frequently we advance a claim—a hypothesis—whose truth or falsity we are unable to ascertain by relatively direct observation. We cannot just look and see what causes the sickness in the rural town (or what causes various forms of cancer); we cannot just look and see if the earth moves, or if the continents were once part of a single land mass, or if the butler committed the crime. In evaluating such hypotheses, we consider what things we would expect to observe if the hypothesis were true. Then we investigate to see if these expectations are or are not borne out. If they are, then the hypothesis passes the test, and its success counts in its favor. If they are not, then the failure counts against the hypothesis.

We can make our description of the process of hypothesis testing more precise as follows. For any hypothesis $H$, an observational consequence of $H$ is a statement that meets two conditions: first, it must be possible to ascertain the truth or falsity of the statement by using observation; second, the statement must follow deductively from $H$. Then we can represent cases of success and failure with tests as follows. Suppose that $O$ is an observational consequence of $H$. Then, as a matter of deductive logic, it is true that,

$$\text{If } H \text{ then } O$$

If we are fortunate to observe the truth of $O$, then we give the following argument:

$$\begin{align*}
F_7 & \quad \text{If } H \text{ then } O \\
& \quad O \\
& \quad H
\end{align*}$$

If experience is unkind to $H$, and we observe that $O$ is false, we give the different argument:

$$\begin{align*}
F_8 & \quad \text{If } H \text{ then } O \\
& \quad \neg O \\
& \quad \neg H.
\end{align*}$$

There is an important asymmetry between $F_7$ and $F_8$. The latter is conclusive in a way that the former is not. Notice that $F_8$ is a deductively valid form of argument. Hence, if we know that the premises are true, we have a guarantee that the conclusion is true. However, $F_7$ is not deductively valid: it is possible that the premises should be true and the conclusion false. Moreover, there are many instances of the form $F_7$ that we would not want to accept. However, as in the case of inductive generalization, we become ever more justified in accepting a hypothesis as we find that a numerous and varied collection of its observational consequences prove true. Although we may (reasonably) balk at accepting an argument of the form $F_7$, we find it hard to resist more elaborate arguments, taking such forms as
where \( n \) is a large number and the \( O \) statements \( O_1, \ldots, O_n \) form a varied collection of claims about what might be observed. For example, if Sherlock Holmes infers from the hypothesis that Moriarty was the culprit, observational consequences to the effect that the grandfather clock should have stopped at midnight, that a single goblet should be missing from the curio cabinet, that the rug in the hallway should show traces of clay on its underside \( \ldots \), and if we discover that all of these effects are to be found, then we may justifiably conclude that the hypothesis is correct. Here again, arguments of form \( F_9 \), like those of form \( F_7 \), are deductively invalid.

When hypotheses pass tests, we find ourselves in a very similar situation to that of inductive generalization. The test results do not guarantee that the hypothesis is true, but the larger the number of cases and the more varied they are, the higher is our rational confidence in the hypothesis. Moreover, as in the inductive case, a single failure spells doom. One observational consequence that is not borne out shows us that the hypothesis is wrong. However strikingly successful Holmes’s hypothesis about Moriarty may have been, we must abandon it if it implies an effect we find to be absent. Suppose that it follows from the hypothesis that there should be a size 12A footprint in the flowerbed beneath the kitchen window. Then, for all the success with the grandfather clock, the missing goblet, and the hallway rug, the absence of that footprint defeats Holmes’s hypothesis.

At this stage we ought to acknowledge a point that may have bothered readers. Observational consequences of a single hypothesis are hard to come by. Indeed, it should have been clear that our discussion of Holmes’s hypothesis about Moriarty is extremely fanciful. By itself, that hypothesis does not imply any such results about observation as those that we have ascribed to it. To make predictions about clocks, clay, and curios we have to appeal (tacitly) to all sorts of other premises, unspoken auxiliary assumptions. When our predictions go awry we can always lay the blame on one of these auxiliary assumptions. Saving the central hypothesis, we choose to reject some other statement that is used in deriving from it the observational result that has proved faulty.
What this means is that the simple argument form $F_8$, while deductively valid, does not often provide us with a realistic account of what goes on in abortive tests. The following form of argument is much more widely applicable:

$$F_{10} \quad \text{If } H \text{ and } (A_1 \text{ and } A_2 \text{ and } \ldots \text{ and } A_n) \text{ then } O$$

$$\quad \text{Not } O$$

$$\text{Not } H \text{ or not } (A_1 \text{ and } A_2 \text{ and } \ldots \text{ and } A_n)$$

$F_{10}$, like $F_8$, is deductively valid. However, it lacks the bite of $F_8$, for it leaves open the possibility that, given uncomfortable observational findings, we may lay the blame on some auxiliary assumption (i.e. $A_1$ or $A_2$ or $\ldots$ or $A_n$).

In the abstract, it may be hard to understand how this could ever work, or how the rejection of auxiliary assumptions could ever be justified. So we shall conclude our discussion of hypothesis testing by describing a classic case. In 1543, Nicolaus Copernicus published an astronomical treatise, claiming that the earth revolves annually about the sun. Orthodox astronomers pointed out that, if Copernicus were right, then, at different times of the year, we should observe the fixed stars from different angles. (Compare: As you run around a running track, the objects you see are seen at different angles from different points of the track.) Yet we do not observe any change in the angle at which we see the fixed stars. So Copernicus is instantly refuted! However, the alleged refutation is too quick. As Galileo (and other Copernicans) pointed out, the prediction that the fixed stars should be seen at different angles at different times of the year does not follow from the claim that the earth revolves annually about the sun. One must also assume that the stars are relatively close, for if they are very distant, the shifts in angle will not be big enough for us to detect. Thus Galileo rejected an auxiliary assumption, and maintained that the universe is much bigger than his predecessors had supposed. He was vindicated in the nineteenth century, when minute differences in the angles at which the fixed stars appear were finally detected.

*Inference to Best Explanation*

Another common and indispensable type of non-deductive inference should be familiar to readers of both scientific essays and detective stories. Sherlock Holmes uses this type of reasoning in his first encounter with Dr. Watson in *A Study in Scarlet*:

“I knew you came from Afghanistan. From long habit the train of thoughts ran so swiftly through my mind that I arrived at the conclusion without being conscious of intermediate steps. There were such steps, however. The train of reasoning ran, ‘Here is a gentleman of a medical type, but with the air of a military man. Clearly an army doctor, then. He has just come from the tropics, for his face is dark, and that is not the natural tint of his skin, for his wrists are fair. He has undergone hardship and sickness, as his haggard face says clearly. His left arm has been injured. He holds it in a stiff and unnatural manner. Where in the
tropics could an English army doctor have seen much hardship and got his arm wounded? Clearly in Afghanistan.' The whole train of thought did not occupy a second. I then remarked that you came from Afghanistan, and you were astonished."

It is no help to students of reasoning that Sir Arthur Conan Doyle consistently misdescribes Holmes's reasoning as "deduction." Holmes's argument is obviously invalid. Even though Watson has a deep tan and a wounded arm, it is still entirely possible that he has never been in Afghanistan. He could have obtained the tan in Florida and the wound in a knife fight in Soho. Still, Holmes's argument does provide considerable support for his claim that Watson had been in Afghanistan. This is the way Holmes's reasoning (here and in most other places) actually works. He lists a number of facts: the military bearing, the medical bag, the tan, the wounded arm. Then he uses those facts to infer a conclusion, on the grounds that the claim made by the conclusion would explain all the facts presented. In this case, if Watson is, in fact, a military doctor who has just returned from active service in Afghanistan, that would explain why he has a medical bag, a tan, and so forth. The correct, if clumsy, name for this type of reasoning is argument by inference to the best explanation. Argument (16) about the dining room window and the baseball is also an argument by inference to the best explanation. If the baseball was hit through the window, that would explain why the window was broken, why there is a baseball in the middle of the room and why there is a baseball bat out in the yard.

Inference to best explanation is related to hypothesis testing. In hypothesis testing, a hypothesis is supported when observations which can be deduced from that hypothesis are borne out by observation. In inference to best explanation, the relation between the conclusion—the explanation—and the observed facts is looser. For example, the fact that Watson was in Afghanistan does not deductively imply that his face was tanned. (He could have worn a large hat to protect his face from the sun.) Still, the conclusion, that he was in Afghanistan, makes it likely that, other things being equal, he would be deeply tanned. So, in argument by inference to the best explanation, the premises support the conclusion because, if the conclusions were true, that would give us good reason to expect that the premises would be true, and the premises are true.

Inference to best explanation is a mainstay of scientific reasoning. A classic example is Alfred Wegener's defense of the hypothesis of continental drift (1915). One striking observation that led Wegener to endorse continental drift was the shape of the continents. If you look at a globe, you will be able to see a remarkable correlation between the shapes of South America and Africa: it looks as if you could move Africa next to South America and the two continents would fit together like pieces of a jigsaw puzzle. This observation, and various other considerations, led Wegener to hypothesize that all the continents had once been part of a supercontinent, "Pan-gaia," and had reached their present locations by drifting apart. Wegener reasoned that the hypothesis of continental drift was the best explanation of the observed facts, and so the hypothesis
was probably true. This case provides a useful illustration of how arguments by inference to the best explanation may be evaluated. Wegener’s argument for continental drift was largely dismissed by the scientific community and for good reason. The complaint was that Wegener had not really explained anything, because he had not provided any explanation of how the continents could drift. This weakness in his case was disastrous. An argument by inference to best explanation is acceptable only if the conclusion actually offers an explanation for the observed data. Wegener’s hypothesis was confirmed many years later by the theory of plate tectonics. This defense for Wegener’s claim succeeded precisely because it offered an explanation for how the continents could move.

The case of continental drift also illustrates the difficulties—perhaps insuperable difficulties—of providing a complete and precise account of inference to best explanation on a par with the theory of deductive logic. On a superficial level, the criteria for evaluating inferences to best explanation are easy to state: the conclusion should explain the observed facts; the conclusion should provide a better explanation of those facts than any of its rivals. These criteria would permit the development of a rigorous science of inference to best explanation, however, only if we could develop a tight (and defensible) system of rules for evaluating explanations. While philosophers of science have made some suggestions on this topic, no such set of rules has ever been developed.

This same problem afflicts other types of non-deductive inference we have examined, induction and hypothesis testing. To have a real science of induction, we need to know, for example, what kinds of factors contribute to a genuine diversity in a sample population. A theory of hypothesis testing would require a precise account of when auxiliary assumptions are reasonable, as opposed to ad hoc, and many other canons of sound scientific practice as well. In general, a science of non-deductive inference would need, as a prerequisite to its full development, a precise and complete set of rules for good science, a complete philosophy of science. It is not clear that this ideal can ever be achieved. Nevertheless, we can appeal to our current understanding of good scientific practice in evaluating non-deductive arguments. Often, it will be fairly clear that an argument by inference to best explanation fails, because superior alternative explanations are available, or that an inductive generalization rests on a biased sample.

Argument Analysis

We have examined various types of inference. Now we will consider how this information may be used in analyzing reasoning. The basic task of argument analysis is to provide a clear formulation of the chain of argumentation presented in a piece of prose. It is important to realize that arguments do not come neatly packaged, with labels clearly identifying the premises and the conclusion. A critic needs to be careful and sympathetic. The best critic works hard at finding the optimal version of the argumentation contained in a passage before evaluating it.
While it may seem surprising, the first step in evaluating a piece of reasoning is to find the conclusion. The conclusion may occur at the beginning, or at the end, or in the middle of the passage. Often the conclusion will not be stated at all! To find the conclusion, you need to ask yourself, What is the author trying to get us to believe? If you encounter difficulty in locating the conclusion, one technique is simply to examine each claim in the passage and ask, Is it a premise or a (sub)-conclusion? All of the claims will have to be assigned to one of three categories: premise, conclusion, or rhetorical fluff. Sometimes you can find the conclusion by elimination: If a claim cannot be regarded either as a premise or as a mere rhetorical flourish, then it must be some sort of conclusion. Of course, for some arguments, all the stated claims will be premises, as in (20).

(20) The only legitimate reason to own a handgun is self-defense. But statistics show that a person who owns a handgun is six times more likely to injure himself or a member of his family than any potential attacker.

We include two further examples, one with the conclusion at the beginning (21), the other with the conclusion tucked into the middle of the passage (22).

(21) Intelligence must be determined largely by genetic factors. For, how else could we explain the significant correlation between the scores of parents and children on IQ tests?

(22) Although Edward Kennedy claimed that he withdrew from the 1984 presidential race for "personal reasons," many pundits claimed that Kennedy's reasons were actually political. The pollsters had told him that he could not win. However, there is a third possibility. Kennedy may have withdrawn for both sorts of reasons [C]. If Kennedy had run, it is inevitable that people would have raised questions about his moral character. And, while those questions would have hurt him politically, they would also have been painful for his family.

After locating the conclusion, the next step in analyzing an argument is to list the stated premises. To find the stated premises of an argument, you need to ask about the author’s starting place. What claims is the author assuming, without argument? Once you have found the conclusion and found the stated premises (and eliminated any other apparent claims as rhetorical fluff), then you are ready to move to the most difficult stage in argument analysis. You need to trace a plausible route from the premises to the conclusion. This stage is difficult for two reasons. The first reason is that authors will very rarely tell you what kind of argument they are trying to make—deductive, inductive, or whatever. Sometimes, the authors themselves may not fully understand how their arguments are supposed to work. However, it is absolutely critical for
appraising an argument that you determine how the premises are supposed to support the conclusion. Consider argument (23), for example.

(23) The spread of Legionnaire's disease in Hospital X was probably caused by the virus getting into the air cooling system. For that is the only hypothesis that can explain how the disease was dispersed so widely in the hospital.

If this argument is regarded as deductive, then it must be dismissed immediately as invalid. Whatever the pattern of the disease's spread through the hospital, it is still possible that the conclusion about the air cooling system may be false. This argument would also be a very poor inductive argument, since the conclusion that the fault lay with the air cooling system would be based on a single case, namely, the spread of the disease at this particular hospital. However, if we understand this argument correctly—as inference to best explanation—then it may be a perfectly good argument, depending on the details of the disease's spread and the difficulty of finding good alternative explanations.

Another reason why reconstructing an argument may be difficult is that most arguments make tacit assumptions in addition to those stated explicitly in the text. An example is argument (24).

(24) The minimum drinking age should be raised. For statistics have shown that when the drinking age is lowered, traffic fatalities go up, and when the drinking age is raised, traffic fatalities go down.

The opening sentence in this passage contains the conclusion. The next sentence offers two premises: when the drinking age is lowered, traffic fatalities go up; when the drinking age is raised, traffic fatalities go down. Our question is, How are these premises supposed to lead to that conclusion? The first point to realize is that the premises would provide no support at all for the conclusion unless we assume that high traffic fatalities are bad, and lower fatalities are better. Of course, even though these premises are unstated, they are completely uncontroversial, so the author may legitimately assume them. Indeed, an argument that took explicit account of such obvious assumptions would be both tedious and overly long. Even if we add these uncontroversial premises to the stated premises, however, we are still a long way from the conclusion. Some stronger tacit premise has to be added, like P₃ below.

(24) P₁ When the drinking age is lowered, traffic fatalities go up.  
    P₂ When the drinking age is raised, traffic fatalities go down.  
    P₃ The number of lives saved by raising the drinking age fully justifies the loss of liberty imposed on young people.  
    C Therefore, the minimum drinking age should be raised.

When P₃ is added, the argument becomes deductively valid. It is no longer possible to deny C while maintaining that traffic fatalities vary with the drink-
ing age \((P_1 \text{ and } P_2)\) and that the number of lives saved justifies the restriction on liberty. However, \(P_3\) is a fairly controversial assumption; some parties to this debate would want to deny it. This argument also illustrates how the two constraints on reconstructing an argument may conflict. A successful reconstruction must both trace a path from the premises to the conclusion that shows how the premises are supposed to support the conclusion, and fill out the reasoning by adding only uncontroversial unstated assumptions. In a case of uncompelling reasoning such as (24), it will be impossible to meet both constraints at once. For the only ways to move from the premises to the conclusion will involve the assumption of one or another controversial unstated assumption, showing that important matters have been swept under the rug.

To sum up: The last stage of reconstructing an argument—tracing a plausible route from the stated premises to the conclusion—is frequently the most difficult. Authors do not tell us what kinds of arguments they are making, nor (obviously) do they tell us their unstated assumptions. Often it will be necessary to try several alternative reconstructions before you are satisfied that you have found the argument buried in the prose. Besides adding needed unstated assumptions and deleting any unnecessary rhetorical flourishes, you will often have to clarify the meanings of key terms, as we noted above. Once you have reconstructed the argument, so that you know how it is supposed to work, then you can appraise its success or failure. This step employs the criteria for evaluating different types of inferences, some of which are presented above.

Evaluating reasoning is a complex task, because human language is rich and fluid, and because we are able to see a large number of subtle connections among the facts we confront. While the task is difficult, the alternative is unacceptable. For if we give up trying to understand reasoning, then we must either naively accept the arguments of others, as if we were children, or play the cynic, and forswear the possibility of learning from the insights of others.