A Short Introduction to Logic

What exactly *is* logic?

Logic, judging by the way the word is used, is many different things to different people. In popular usage, the word 'logic' is most commonly used to refer to *reason* or *reasoning*. Often it is set in contrast to feeling or emotion—especially when it is described as 'cold'. Spock, a character on the original Star Trek program, frequently used 'logic' in this way. His appeals to logic were meant to reflect his emotionless side, as a half-Vulcan.[1] He often said things like, 'Captain, that is not logical'—by which he meant, roughly, 'Captain, that is not a good idea'. Or he might say, 'Logic suggests that you should shoot the Klingons'.[2] By this would be meant something along these lines: 'It would be advisable to shoot the Klingons right about now.'

Among Christians, the term is generally used in a similar way, but frequently with a negative twist, when it is identified closely with unbelieving human reasoning. It is not uncommon to hear statements such as this: 'Human logic may tell us that God's sovereignty negates human responsibility, but God's word tells us otherwise.' Here, 'human logic' refers to carnal reason—that is, to what seems reasonable to the unbelieving mind, according to which the things of God are foolishness. As such, logic is a bad thing, for it opposes divinely revealed truth. Note carefully, that the contrast here is not between logic-as-reason and emotion, but between logic-as-godless-reason and godly thinking—which may involve some logic-as-reason.[3]

When we take up the study of the academic subject logic, however, we need to understand that we are turning to something different from what is suggested by such usages.[4] Logic, as an academic discipline, is simply the science of correct reasoning. As a science, it is an organized body of knowledge and a set of methods for adding to that body of knowledge. It is the science which studies reasoning, by which I mean simply the mental process of deriving implications from facts and hypotheses. To be precise, it studies the content of reasoning (the study of the mental process itself being a topic for psychology), and it does so in a normative way. That is, logic aims to provide guidance as to what is good reasoning and what is bad—hence, the science of *correct* reasoning.

How did logic develop? It—not reasoning, but logic, as the scientific *study* of reasoning—can be said to have been invented by Aristotle, arguably the greatest of the ancient Greek philosophers. Other ancients after Aristotle, especially the Stoic philosophers, made significant contributions. The next major burst of progress in logic came in the late Middle Ages, when the scholastic theologian-philosophers of Christendom made important

[1] For the benefit of any non-Trekkies among my readers, I should explain that Vulcans do not have emotions.

[2] Again, for the non-Trekkies, Klingons are bad guys.

[3] There are other, more subtle challenges to logic which are heard in Christian circles (as in the claim, 'The doctrine of the Trinity contains contradictory statements which are nevertheless both true', for example), but I don't intend to take these up here. I expect to get to some of these issues in my Logic III course—some day. Until then, see the books by Frame in the bibliography, below.

[4] It's not that the other usages are wrong; it's just that the word 'logic' has several different (though related) meanings.

contributions. More recently, in the nineteenth and twentieth centuries, logic has flourished as never before, with dramatic progress made in all departments of logic.

How does logic function in practice? Since reasoning takes place in our heads, and the thoughts that are its content are invisible mental objects, logic, in practice, studies linguistic expressions of our reasoning. That is, instead of attempting to study thoughts as 'thoughts occurring in our minds', we can express those thoughts in words, phrases, and sentences, and let logic study the words etc. as visible or audible embodiments of the thoughts.

The most important objects of study in logic are propositions and arguments. A proposition can be identified (loosely) with an indicative sentence; for example, 'Molly and Parsnip are my cats' is a proposition. Propositions (also known as statements, assertions, and claims) are the most important units of thought for logic's purposes, as they express beliefs or claims about what is true. Arguments, on the other hand, are collections of propositions which express a process of reasoning. Starting with propositions which are believed to be true (the *premises* of the argument), an argument tries to show that a further proposition (the *conclusion*) follows from those believed-to-be-true propositions.[5]

Logic is sometimes described as the *formal* science of reasoning, and the word 'formal' in this definition expresses an important aspect of logic. To describe logic this way presupposes the important distinction between *form* and *content*. Logic has to do (mostly) with the forms of propositions and arguments, and any content arranged in a given form will have the same logical status as any other content arranged in that same form. In short, logic rarely tells us whether a given proposition is true; it focuses, rather, on forms or patterns of statements and arguments.

An example may make this distinction clearer. Logic tells us that if we know that two statements of the following *forms* are true:

If such-and-such, then blah-blah-blah (1)
Such-and-such (2)

then we may safely conclude that

Blah-blah-blah (3)

is also true. What this means is that if we replace 'such-and-such' with a meaningful statement in both places where it appears (in (1) and (2)), and 'blah-blah-blah' with a meaningful statement in both places where it appears (in (1) and (3)); and if (1) and (2) are both true after these replacements are performed; then (3) is also true.

For instance, we could replace 'such-and-such' with 'Molly is a cat', and 'blah-blah-blah' with 'Molly is a mammal', thus:

If Molly is a cat, then Molly is a mammal. (1')
Molly is a cat. (2')
Molly is a mammal. (3')

[5] There are other kinds of arguments. For example, in a *reductio ad absurdum* argument, we start with a premise and show it to be false by deriving a contradiction from it; the premise in such a case is not a proposition which we believe is true, but one which our argument shows to be false. In addition, there are hypothetical arguments, in which we postulate a premise and argue from it in order to find out what else would be true if it were true.

(1') and (2') are now both true (if 'Molly' be understood to refer to my cat). Logic then informs us, on the basis of the forms of (1') and (2'), that (3') must also be true.

The sequence of statements (1)-(3) is an example of an argument form. That is, it's a form into which we can plug propositions, and because it is a *valid* argument form, it tells us that if the premises are true, then the conclusion will also be true. Of course, logicians rarely use 'such-and-such' and the like as placeholders in argument forms, and they generally supply an indication of logical consequence before the conclusion, such as the word 'therefore'. A more normal way of setting out our argument form would be something like this:

If P, then Q. (4)
P.
Therefore, Q.

We say that this argument form is *valid*, meaning that if the premises are true, the conclusion must also be true. And because it is an argument *form*, it is, logically speaking, much of a muchness[6] what statements we plug in in place of 'P' and 'Q'.

Going back to (1')-(3'), note carefully that logic *doesn't* tell us that Molly is a mammal. Rather it, tells us that *if* it is true that if Molly is a cat, then Molly is a mammal; and *if* it is also true that Molly is a cat; *then* it will be true that Molly is a mammal. To assess the truth of the premises, we need more than logic. We need to know something about Molly, about cats, and about mammals. In short, we need factual knowledge about the way things are.

The power of logic (the science) is very great, but it is easy to be mistaken about its power. To go back to the examples with which we began, the science of logic by itself does not and cannot tell us that Captain Kirk should shoot the Klingons, or that God's sovereignty negates human responsibility. Joined to knowledge, logic can help us draw inferences from that knowledge; by itself, logic tells us very little. In fact, when it is used to draw inferences from false beliefs, it may do little more than yield further false beliefs. Logic, then, can be likened to a computer program, in that however well written and tested it may be, the old saying still applies, 'Garbage in, garbage out'. We might extend this truism to the other two possibilities: 'Nothing in, nothing out', and, 'Truth in, truth out'. It is the last of these possibilities which provides the incentive to study logic.

Note that the example we've examined in this section—argument form (4) and its instances—is just one of the many kinds of arguments that logic studies. In arguments like (4), if the premises are true, then the conclusion is certain to be true. There are many other arguments—arguments that are perfectly good and useful, I might add—whose premises don't guarantee the truth of the conclusion so much as render it likely, and logic studies those as well.

This would be a good place to introduce an important bit of terminology: Arguments like (4), that have the potential to confer certainty upon their conclusions, are commonly called *deductive arguments*, whereas those that can confer only probability or likelihood are most often called *inductive arguments*. (Although this terminology is not accepted universally, I have followed it in this book.) And note that there are useful and interesting arguments that are neither deductive nor inductive.

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[6] 'Much of a muchness' means something like 'six of one, half-a-dozen of the other' or 'it makes no difference'.

What are the parts or branches of logic?

When we consider the many situations and ways in which we use our reasoning faculty, it will not surprise us that the science of reasoning is a very broad subject with many parts, dealing with many different kinds of reasoning. The following outline may be helpful as you read the discussion, below, on the various sub-fields of logic. (It isn't intended to be an exhaustive outline of logic, just an outline of the parts which I have chosen to discuss.)

I. The logic of propositions and of truth (sometimes called *theoretical logic*)
  - A. Deductive logic (sometimes called *formal logic*)
    - 1. Symbolic logics
      - a) General-purpose
        - (1) Categorical logic (often presented without symbols)
        - (2) The sentential calculus (or propositional calculus, or statement logic, or any number of other names)
        - (3) The first-order predicate calculus
      - b) Special-purpose
        - (1) Modal logics
        - (2) Temporal logics (or tense logics)
    - 2. Mathematics-oriented logic (and logic-oriented mathematics)
      - a) Axiomatic set theory
      - b) Recursion theory
      - c) Probability theory and statistics
    - 3. Linguistics-oriented logic
      - a) Formal language theory
      - b) Language analysis
      - c) The study of translation between natural languages and formalisms
  - B. Inductive (or informal) logic
    - 1. The general study of informal reasoning
    - 2. The study of fallacies
    - 3. Hermeneutics (the science of interpretation)

II. Practical logic (the logic of decision and action)
  - A. Ethical reasoning (reasoning about how to decide what is right)
  - B. Pragmatic reasoning (reasoning about how to achieve practical objectives)
    - 1. Investment management
    - 2. The study of economic decision-making
    - 3. Military decision-making principles (used mostly for training leaders)
    - 4. Decision theory

One basic distinction in logic is between logic that deals with the truth of propositions and that which addresses questions of practice or behavior. The former kind is far more fully developed as a science, but the latter has been worked out to a considerable degree in limited areas. Practical logic, however, is not considered to be in the mainstream of logic, and has tended to be more the province of mothers, preachers, ethicists, economists, and other people more practically-oriented than logicians.[7]

The propositional side of logic (the side that deals with the truth of propositions), can be divided up in a number of different ways. *Deductive* logic deals with what we could describe as 'crisp' reasoning, in which statements are either true or false, and conclusions follow either necessarily or not at all. What is sometimes called *inductive* logic, on the other hand, works with 'fuzzier' problems—areas where arguments establish probability or likelihood, but not certainty. Let us consider each of these in turn.

Deductive logic is very amenable to symbolic treatment. What is meant by this? In practice, logicians have found that a very useful way to work is to translate our reasonings from the everyday language in which we generate or encounter them into simplified symbolic languages, and then to manipulate them in the symbolism, where their logical form can be easily seen, analyzed, and tested. These languages (called *symbolic logics*, or simply *logics*) have a mathematical feel to them, and are useful because they are unambiguous and are manipulated according to unambiguous rules. Symbolic logics are also called *formalisms*, or *formalizations*, and deductive logic is often called *formal* logic because of its widespread reliance on formalisms.[8]

Symbolic, deductive logic has given us systems for general reasoning, such as Aristotle's categorical logic, the sentential calculus, and the predicate calculus. In addition, there are numerous systems of deductive logic intended for specialized purposes, such as modal logics (which try to capture such ideas as possibility, necessity, and even probability, approaching inductive logic at some points) and temporal logics (used for reasoning about things that change in time).

Deductive logic is of keen mathematical interest in many of its aspects. In fact, mathematics itself can be viewed as the application of deductive reasoning to certain fundamental intuitions about numbers. Logicians have studied math extensively and have exposed its structure and its foundational ideas in a branch of logic called *axiomatic set theory*. And *probability theory*, the mathematical development of how probability works, is a branch of mathematics with wide-ranging usefulness in logic, as is its near relative, *statistics*. Another discipline within logic with great relevance for math is *recursion theory*, which deals with the abstract limits of what can be computed. Recursion theory is of fundamental importance for computer science. Also of importance for computers is *formal language theory*, on the boundaries between logic and linguistics, which studies what can be expressed, and how succinctly, in various man-made languages.

As this last example suggests, deductive logic also has a linguistics-oriented side to it, in which problems of the logical analysis of sentences are considered. In these areas, logic meets not only the field of linguistics, but those of philosophy and theology. One of the most important subjects dealt with in connection with language is the matter of how to translate reliably between natural languages and the formal languages of logic. It is in this area that most mistakes are made when deductive logic is used outside mathematics and computer science.

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[7] That is not to say that the logic of propositions is *impractical*. The question of what follows from what is often of great practical importance, for what we believe affects what we do. But there *is* a difference between believing something and doing something; the logic of propositions has directly to do only with the former, what I'm calling practical logic with the latter.

[8] In the expression 'formal logic', 'formal' has a different sense than that used above in connection with the form-content distinction, though a not unrelated sense.

Turning now from deductive logic, we may observe that inductive logic, also known as *informal logic*[9], has begun to receive considerable attention as well in recent years. This aspect of logic has, arguably, more everyday usefulness than deductive logic, and much more relevance to theological and political discourse, but by its very nature it is harder to systematize than deductive logic. One area that has received a good bit of attention is the study of *fallacies*, or common mistakes in our reasoning. I think that *hermeneutics*, the study of interpretation, is best thought of as a branch of informal logic.

So much for the logic of propositions. What about practical logic? It tends to be broken down according to the fields in which it is employed. I think a useful distinction can be made between ethical reasoning and pragmatic reasoning. In the pragmatic realm, the most highly developed accounts of decision making have been produced by economists, investment theorists, and military thinkers, in addition to a few logicians who study an area called 'decision theory'.

How should Christians view logic?

The Christian has good warrant to accept the results that make up logic, although he will find that most logicians hold many views (having little or nothing to do with logic) which are hostile to the Christian faith. Sorting the wheat from the chaff requires discernment, but logic itself is not only something Christians *can* trust, it is something they *must* trust.

How can I make such a strong claim, especially when so many Christians distrust logic? The biblical speakers and writers make use of many forms of reasoning that cannot be understood without at least an intuitive grasp of logic. They employ inference, which is remarkable given that those who were instruments of revelation didn't need to derive their conclusions from premises, but could simply have stated that they were true, as fresh revelation. Evidently, the Holy Spirit didn't move them to do that, but to employ reasoning instead.

For example, Paul, in 1 Corinthians 15:16-20, addresses the question of whether there is a resurrection of the dead in general. Note carefully how he resolves this question, and how he expects the question to be resolved in the minds of his readers.

> 16 For if the dead rise not, then is not Christ raised: 17 And if Christ be not raised, your faith is vain; ye are yet in your sins. 18 Then they also which are fallen asleep in Christ are perished. 19 If in this life only we have hope in Christ, we are of all men most miserable. 20 But now is Christ risen from the dead, and become the firstfruits of them that slept. (KJV)

Verses 16 and 20 together make up a valid deductive argument of the type called *modus tollens*. The point that we need especially to note, however, is that Paul writes as though this argument should settle the matter in the minds of his readers. (An examination of the context will bear this out.) But his readers can't even understand how what he has written relates to the question at hand without an understanding of how to reason! Much less can they assess what he's written and recognize it as being reasonable. In short, Paul uses reason to persuade his readers, and he

9 In my opinion, the term 'informal logic' is less confusing than 'inductive logic' when it comes to describing this division of logic. A better name could, perhaps, be found. I would nominate 'messy logic'—as distinguished from 'tidy logic'. (Trudy Govier uses something like the latter term for deductive logic in *A Practical Study of Argument*.)

expects them to use it, too, if they are to understand his argument and to feel its force.[10]

Consider other ways Paul could have addressed this issue. He might simply have exercised his apostolic authority in issuing a definitive pronouncement on the matter (as he does in another connection in 1 Cor. 5:3-5). Or he might have appealed to the practice of all the churches (1 Cor. 11:16). Or he might have settled the question by reference to some special revelation he had received (Acts 20:23). Instead, he reasons with his readers, and he appears to think that is sufficient.

The New Testament places a high premium on reasoning from the Scriptures, which seems to imply that there must be ways to distinguish good reasoning from bad. See, for example, the innumerable appeals of Jesus and the apostles to the Scriptures, or the explicit reference to reasoning in Acts 17:2.

In summary, the Bible seems to take the realities studied by logic for granted in much the same way as it takes the realities studied by mathematics for granted.

Turning from the issue of the trustworthiness of logic, another question that confronts us is that of the relation of logic to God. A simple answer, which leaves room for much that is mysterious, is that God created the realities which logic studies, that he ensures by his providence that the creation 'obeys' the laws of logic, and that the laws of logic reflect something very significant about his own nature and ways of thinking. When we consider that the God of the Bible is the God of truth, and not of falsehood, that he gave us our ability to speak and to reason, and that he upholds all things according to his own orderly ways, it should give us a high degree of confidence that he has made the universe to obey the laws of truth or reason (studied by logic), and that he will keep it that way. In short, logic studies a phenomenon (reasoning) that was created by God, and one which reflects his nature as the God of truth and the nature of the universe that he has created.

For subject matter for our reasoning (our body of propositions which we regard as true), we must go first to God's word and then to other sources of knowledge that are consistent with his verbal revelation. When we rely on those other sources of knowledge, we must return constantly to the Scriptures to test our conclusions, for though logic can improve our reasoning, it will not make it foolproof (simply because we make mistakes all the time, and also because what we think we know from Scripture may represent a mistaken interpretation of it). And we must realize that the Bible tells us quite clearly that there are things about God that our logic and reason will never comprehend. Logic may help us to get as far out into the sea of his greatness as his word will permit, but we must eventually stop, able to go no further, and there we must worship, and recognize the smallness and creatureliness of our minds and our logic before the almighty, transcendent God of truth. It is for this reason that we must never treat the teachings of the Bible as a formal deductive system, like mathematics, which can be thoroughly and reliably explored with complete reliance upon reasoning ability, and upon nothing else. Logic alone will never suffice for our coming to know God (or much of anything else), although it may be helpful when joined with other resources; for the knowledge of God, godly character and wisdom (rooted in the fear of God) is required—and these are conferred upon us at conversion and cultivated by us thereafter.

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[10] Of course, Paul relies on more than mere logic. His argument has premises, and in order to accept those premises as true, his reader must assess the claims of the witnesses to Christ's resurrection. My point is not that logic is the *only* persuasive tool used by Paul here, but that it is one of the tools he uses, such that we cannot understand or assess his argument without some knowledge of it.

Why should we study logic?

Logic takes, as its starting point, many very obvious, common-sense intuitions which nearly all of us seem to have. For example, it strikes most people as quite obvious that if P is true, not-P will be false. (If it is true that Molly is one of my cats, it will be false that Molly is not one of my cats.)

Of course, if logic went no further than that sort of thing, it wouldn't be worth our studying. It *is* worth studying because it does go much further. The tools logic gives us can enable us to reason accurately about much more difficult questions than those for which raw intuition is sufficient. And the study of logic can make our use of reason less error-prone.

There are more general developmental benefits from the study of logic. It strengthens the mind and improves its efficiency, which is useful in any area which requires thinking. It also helps us to cultivate precision and clarity of thought and expression, good habits in their own right.

Christians must be determined to shape all their thinking, speech, and action to conform to God's word and its many implications. For this, we must reason from the Bible, and must be able to identify error and falsehood. In these fundamental and critical aspects of the Christian life, logic can help us.

Logic is especially useful in certain fields of activity. Disciplines in which logic is constantly useful include theology and preaching; philosophy; law; computer science; and business systems analysis. Moreover, I am hard-pressed to think of *any* calling in which the ability to think and reason clearly would not be of some benefit. (That is not to say that one couldn't subsist in some callings without these abilities. Many do. I'm only claiming that logic would be *helpful* in any calling—that is, that it would enable one to excel and advance in any calling.)

What parts of logic are commonly covered in textbooks?

There is a bewildering variety of logic textbooks available. Many of them address specialized uses of logic, but when we narrow our focus to the general-purpose logic texts, the variety becomes only slightly less bewildering. How can one make any sense of the range of books out there?

When I've examined introductory, general-purpose texts—I've probably looked at some twenty or thirty of them—it has struck me that most of them seem to spend most of their time on this or that subset of a fairly small portion of logic. In this section, I'll give you a very brief overview of what those parts are—with some unsolicited advice on their importance and on the best ways of teaching them—as it will help you to orient yourself when examining textbooks.

Most introductory textbooks take up one or more of the three major systems for testing deductive arguments for validity. Many, in fact, go no further than this. I'll describe the three systems in the order in which they were invented.

Three preliminaries are in order to our discussion of the three main systems of deductive validity. First, you will want to recall what an *argument* is. It's a set of statements—one called the *conclusion*, and one or more others called *premises*—in which the premises are meant to persuade someone to accept the conclusion. (That's a slightly oversimplified definition, but it will do for now.) Second, you need to remember that for an argument to be *valid*, its form must ensure that when the premises are true, the conclusion will also be true. Third, you should understand that my purpose in what follows is to teach you not how to use these systems for assessing validity, but how to recognize them. So don't be concerned if you don't understand every detail.

The first of the 'big three' validity-testing systems was *Aristotelian logic*—also called *traditional logic*, *categorical logic*, *the logic of terms*, and (part of it, at least) *syllogistics*, *syllogistic*, or *the syllogistic*. It was developed, as the first of these names suggests, by Aristotle. That puts its origin in the fourth century B.C.

Aristotelian logic is called categorical logic because it deals exclusively with *categorical statements*, or *categoricals*. There are four kinds of categoricals. Here is one example of each, drawn from Aristotle's favorite field, biology:

All whales are mammals. (5)
No sharks are mammals.
Some dolphins are fish.
Some dolphins are not fish.

A fair bit of attention is paid in Aristotelian logic to describing and analyzing statements of the four kinds illustrated above. Considerable effort is also expended on translating statements that don't appear in obvious categorical form into some sort of standard form. Statement (6), for example, translates into (7), if we are following one particular set of standardization rules.

Some whales have teeth. (6)

Some whales are things-that-have-teeth. (7)

Even odder are translations like the following:

Freddy the Goldfish died yesterday. (8)

becomes

All members-of-the-set-whose-only-member-is-Freddy-the-Goldfish are things-that-died-yesterday. (9)

As you can see, this sort of thing can be strangely entertaining.

Moving along, we might wonder what Aristotelian logic does with all of these strange and wonderful categoricals. Simply put, it provides tools for assessing the validity of arguments that are made up of categoricals. There are two fundamental kinds of arguments that can be assessed—'fundamental' because other arguments can be reduced to combinations of them.

The first of these classes of categorical arguments is the *immediate inferences*. These amount to single-premise categorical arguments. Here's a valid immediate inference:

No sharks are mammals. (10)

Therefore, no mammals are sharks.

And here's an invalid example:

No sharks are mammals. (11)
Therefore, some dolphins are not mammals.

The second and more important kind of categorical argument is the *categorical syllogism*, which is an argument consisting of three categorical statements—two premises and a conclusion. (It has to satisfy a few other requirements, as well, if it's to be considered a categorical syllogism, but those need not detain us now.) The following is a valid categorical syllogism:

No sharks are mammals. (12)
All whales are mammals.
Therefore, no whales are sharks.

The next one, on the other hand, is not valid.

No sharks are mammals. (13)
No elasmobranchs are mammals.
Therefore, no elasmobranchs are sharks.

Without any knowledge of Aristotelian logic—though with a little knowledge of marine zoology—we can see that (13) must be invalid, since its premises are both true but its conclusion is false. (Most elasmobranchs are sharks. Recall that for an argument to be valid, its form must ensure that when the premises are true, the conclusion will also be true. The form of (13) evidently ensures no such thing.)

A slightly trickier example of categorical invalidity is (14):

No sharks are mammals. (14)
No elasmobranchs are mammals.
Therefore, some elasmobranchs are sharks.

In this case, the conclusion happens to be true, but the argument is invalid nonetheless. That's because its *form* doesn't *guarantee* that true premises will give you a true conclusion. Here's another argument with the same form that makes this clear, because its conclusion is false while its premises are true:

No sharks are mammals. (15)
No turtles are mammals.
Therefore, some turtles are sharks.

If (14) had been valid, then its form—shared by (15)—would have guaranteed the truth of the conclusion of (15), given that the latter argument's premises are true.

It remains to be said that categorical logic gives us several distinct systems for testing categorical syllogisms for validity—and for remembering the tests. They all give exactly the same results. A couple of them are frightfully complicated[11], while at least one is relatively simple. I teach my students just one relatively simple method (in Logic II)—an approach that makes sense to me—but for some reason, many books that present categorical logic insist on using one of the really complicated validity-testing schemes—and they often add insult to injury by presenting *multiple* validity tests. Perhaps the authors of such books want their students to be sure to learn Aristotle's Own Method—it's a predecessor of one of the more hideously complex validity-testing systems—out of an elevated esteem for Aristotle. If so, I think that's misguided, as it seems much more in keeping with Aristotle's example to teach our students as quickly and easily as possible how to assess syllogisms for validity, and then use the time we've saved to teach them other skills and knowledge. But then I'm not an Aristotelian[12], so I probably can't understand the appeal of testing syllogisms for validity the way Aristotle did it. And I want to move my students along to other subjects besides Aristotelian logic, so I seem to lack the instinct that leads some authors to teach multiple validity-testing schemes that all yield the same results.

That brings us to the second of the three main systems for testing deductive arguments for validity. It, like the first, has several names. My favorite among them is *the sentential calculus*, or *SC* for short. It also goes by *the propositional calculus*, *propositional logic*, *statement logic*, *sentence logic*, and other names. Since all of these names are rather unwieldy, many authors invent their own shorter names for this system. One book I have calls it *Sentential*, for example.[13] I have dubbed it *Moleculan*, for reasons that I explain in the text. In the present section, I'll call it SC.

SC was developed by the logicians of the ancient Stoic school of philosophy, most notably Chrysippus (c. 280-208 B.C.). The symbols used in SC today are a modern innovation.

SC deals with what are called *molecular statements*. These are, roughly, statements that are made of simple statements (called *atomic* statements) held together by *logical operators*. There are five common logical operators, although SC can be constructed with fewer than that without any loss of power. The standard five are *negation* (commonly expressed in English by 'not' and its variants), *conjunction* ('and'), *disjunction* ('or'), *implication* ('if … then'), and *equivalence* ('if and only if').

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[11] One involves memorizing the following 'poem', which encodes the validity rules for syllogisms according to a scheme that I've never grasped:

Barbara Celarent Darii Ferio Baralipton
Celantes Dabitis Fapesmo Frisesomorum;
Cesare Campestres Festino Baroco; Darapti
Felapton Disamis Datisi Bocardo Ferison.

Note that the words are nonsensical; they're just codes. When I am told to memorize something like that, I am strongly inclined to run away, screaming in terror. (I subscribe to the rather simple-minded view that mnemonic devices should be easier to remember than the information that they're supposed to remind us of.) But some people go in for that sort of thing, and they'll love Aristotelian logic—even at its most convoluted.

[12] I'm only an admirer of Aristotle, which is different from being an Aristotelian. Aristotelians aren't followers—or necessarily admirers—of Aristotle. Rather, they follow a certain interpretation of Aristotle—almost certainly a serious misinterpretation—concocted and handed down by Medieval Muslim, Jewish, and Christian thinkers, and codified by Thomas Aquinas.

[13] Tom Tymoczko and Jim Henle, *Sweet Reason: A Field Guide to Modern Logic* (New York: W.H. Freeman and Company, 1995).

Molecular statements can be expressed or represented in a number of different ways. We are all accustomed to garden-variety English molecular statements, such as the following:

> If the cat doesn't stop getting onto the dinner table, then I'm going to incarcerate him in the bathroom. (16)

This sentence consists of two atomic statements and two operators—negation and implication. We could express it like this if we wanted to make this structure more obvious:

> If not [the cat stops getting onto the dinner table], then [I'm going to incarcerate him in the bathrooom]. (16′)

We can take a further step toward a purely symbolic expression of this sentence by assigning meanings to letters that will stand for the atomic statements, as follows:

> <u>Interpretation</u>: (17)
> A: The cat stops getting onto the dinner table.
> B: I'm going to incarcerate him [i.e., the cat] in the bathroom.

Using these letters for the atomic statements, we can rewrite (16′):

> If not A, then B. (16″)

Finally, SC gives us symbols for the logical operators, which allow us to translate the sentence into purely symbolic form. Each dialect of SC has a slightly different set of symbols. Here's the translation of (16″) into the dialect that I favor:

$$(\sim A) \to B \qquad (16''')$$

Logics that enable us to express statements entirely in symbols are called symbolic logics. While it is true that some people like these simply because they like symbols, symbolisms have a much more important value. Symbolic logics allow us to perform calculations on sentences with mathematical precision. That is, it is possible—fairly easy, in fact—to carry out operations on symbolic sentences without making mistakes. Many symbolic operations, in fact, can be checked by computers. The same cannot be said of the same operations performed on sentences in English—or any other natural language.

I must add an important qualification at this point. Symbolic operations can generally be carried out free of errors, but we can't conclude that our use of symbolic logic will be equally free of errors. Most mistakes in logic—and this is especially true of the mistakes that are hard to catch—are made not when we're manipulating symbols, but when we're translating from the natural language into the symbols. For this reason, I believe strongly that any logic course that will be worth anything *must* give considerable explicit attention to the translation step. Sadly, many logic texts entirely fail to do this—and that's a serious problem whether a text is teaching SC, Aristotelian logic, or any other formal system.

Back to SC. SC has a lot to say about molecular statements. It gives us methods for figuring out whether a given molecular statement is true, for instance. It also enables us to determine whether a molecular statement is a tautology—a statement which is true by virtue of its logical structure. Here's an example of a tautology:

If Karissa and Jillian are coming, then Karissa is coming. (18)

As is characteristic of tautologies, this one isn't all that interesting. It seems obvious, in fact. But it turns out that tautologies are very valuable things in logic, and so it's quite useful that SC gives us a test for tautology.

Building on its treatment of molecular statements, SC gives us a test for validity that we can apply to many arguments—most of those we meet every day that consist of a mix of molecular and atomic statements. Here's an example of the most common of all SC arguments, a valid one called *Modus Ponens*:

If Jared said it, it must be true. (19)
Jared said it.
Therefore, it must be true.

In symbols, this argument looks like this:

$A \rightarrow B$ (19′)
$\underline{A\quad\quad}$
$\therefore B$

SC can assess the validity of arguments of considerable complexity. Here's a three-premise SC argument, first in English, and then in symbols:

Either Priscilla told her, or Esther told her. (20)
If it was Priscilla, then she would have told Alissa, too.
She didn't tell Alissa (since Alissa didn't know).
Therefore, Esther told her.

$A \vee B$ (20′)
$A \rightarrow C$
$\underline{\sim C\quad\quad}$
$\therefore B$

That happens to be a valid argument.

There are several methods in SC for testing molecular statements for truth or for tautology, and for assessing the validity of arguments. My favorite is *truth tables*, but you will also see *truth trees* and other methods. I like truth tables because they can be used to test statements for truth and for tautology, to test arguments for validity, and even to test sets of statements for consistency—and students seem to find them pretty easy to learn. By teaching students one technique (truth table construction), then, I can give them quite a lot of logical power, which strikes me as very efficient and thus desirable.

We've covered Aristotelian logic and SC, two of the three big systems for validity testing. (Note that they can be used for some other things, as well.) These first two have something very important in common. Given an argument of the right kind, each system can guarantee us that in a finite number of mechanical steps, we will know for certain whether the argument is valid. In the lingo of advanced logic, validity in both systems is formally decidable. Between them, the two systems cover a very large number of the arguments that we meet in everyday life. The only major drawback they have is that they are two. They bear almost no resemblance to each other, and each operates on a different set of statements and arguments.

The third system for validity testing combines the first two, and its power extends to many arguments that neither of the first two can assess—including most of the arguments used in mathematics. That sounds pretty wonderful, no doubt—and it is—but there's a cost. This third system is not formally decidable. That is, it doesn't give us a set of rules to apply to an argument that will ensure we get the answer 'valid' or 'invalid' in some finite amount of time. Instead, it requires us to try to produce a proof of the validity of the argument. If the argument is valid, then we might succeed in proving it (if we know what we're doing), but if at any point we haven't succeeded in proving it, we can't thereby be sure the argument is not valid. For all we know, if we try a little harder, we'll hit on the right proof. In some cases, we can prove that an argument is invalid, but, again, failure to do so doesn't prove that it's not invalid.

Note that proofs can be used with SC. This strikes me as useful if you're trying to get students ready for proofs in the third, more advanced system that we're discussing now. But any discussion of proofs ought to make the point that I made in the paragraph before this one—that proof systems are formally undecidable, whereas truth tables and the like are formally decidable. This, it seems to me, is one of the most important distinctions in all of logic—and I'm referring here to importance for everyday life. (My treatment of questions here in Logic I and in Logic II is aimed at developing this distinction and applying it to life.)

This third system that I've been introducing so gradually into the discussion was developed by Gottlob Frege (1848-1925) and promoted avidly by Bertrand Russell (1872-1970). It's most often called *predicate logic* or *the predicate calculus*, but also goes by such names as *the functional calculus* (or *calculus of functions*), *quantificational logic* (or *logic of quantification*), and the *logic* (or *calculus*) *of relations*. For reasons too technical to go into here, it should be described as 'first-order', to distinguish it from other 'higher-order' variants. I will refer to it as FOPC (rhymes with 'flopsy'), an abbreviation of *first-order predicate calculus*.

FOPC can be used on the stuff of Aristotelian logic and of SC—namely categorical statements and molecular statements. It can also be used on statements that combine features of both. It would be difficult here to give you even the remotest idea of how FOPC works, but I will give a few examples of statements with their FOPC translations, to aid you in recognizing FOPC when you meet it in books. I'll start by translating the categorical statements in list (5) into FOPC. I'll repeat the original sentences here, give an interpretation of the FOPC elements that I'm using, and then give the FOPC translations in the same order:

All whales are mammals. (5)
No sharks are mammals.
Some dolphins are fish.
Some dolphins are not fish.

<u>Interpretation</u>: (21)
Universe: real marine organisms
$D\phi$: ϕ is a dolphin.
$F\phi$: ϕ is a fish.
$M\phi$: ϕ is a mammal.
$S\phi$: ϕ is a shark.
$W\phi$: ϕ is a whale.

$(\forall x)\ (\ Wx \rightarrow Mx\ )$ (5′)
$\sim (\ (\exists x)\ (\ Sx \ \&\ Mx\ )\ )$ or $(\forall x)\ (\ \sim (\ Sx \ \&\ Mx\ )\ )$
$(\exists x)\ (\ Dx \ \&\ Fx\ )$
$(\exists x)\ (\ Dx \ \&\ (\ \sim Fx\ )\ )$

The way you read these FOPC sentences is along these lines—I'll give 'pronunciations' of the first and third:

For all x, Wx implies Mx.

There exists an x such that Dx and Fx.

What the first of these means is that for every 'thing' in the universe of discourse (in this case, marine organisms), if that thing is a whale, then it will also be a mammal. The second says that there exists at least one thing in the universe of discourse which is both a dolphin and a fish.

When you translate a molecular sentence into FOPC, it often ends up looking the same as it did in SC, so I won't bother with any of those here. But I will illustrate FOPC's treatment of a statement that combines features of molecular and categorical statements. Here it is:

All dolphins are either fish or mammals. (22)

And here's its translation into FOPC under interpretation (21):

$(\forall x)\ (\ Dx \rightarrow (\ Fx \vee Mx\ )\ )$ (22′)

The only symbol here that you've not seen before is '$\vee$', which means 'or'.

To illustrate a valid FOPC argument that can't be analyzed successfully using Aristotelian logic or SC, we'll use the following:

All dolphins are either fish or mammals. (23)
The creature we just pulled out of the water is not a fish.
Nor is it a mammal.
Therefore, it's not a dolphin.

To translate this into FOPC, we'll have to augment interpretation (21), thus:

<u>Interpretation</u>: (continued) (21, continued)
c: the creature we just pulled out of the water

The translation of argument (23) under our augmented interpretation comes out as follows:

$(\forall x) (Dx \rightarrow (Fx \vee Mx))$ (23′)
$\sim Fc$
$\underline{\sim Mc}$
$\therefore \sim Dc$

I have very mixed feelings about FOPC. It's of great value for the study of calculus and more advanced mathematics, and for important aspects of computer software design, but it's tricky and unwieldy. I currently teach it in Logic II (grade 9), but I must admit it's pretty rough going for some students—though there are some who love it. My own goal is to identify a minimal subset of the subject that will yield optimal intellectual and practical benefit without bogging us down in technicalities. I don't know of any existing logic curriculum aimed at a schools audience that takes on FOPC, so I suppose I'm defying conventional wisdom in trying to teach it. For that matter, a good many first-semester college logic textbooks don't teach it. Time will tell whether I ought to have listened to the conventional wisdom! But I believe there is real value in FOPC, and I'm determined to find a subset of the system that can be taught in high school. In the meantime, if you find a logic book that presents FOPC, then chances are either it's not meant (or suitable) for schools use—i.e., it's a college text, probably in fact geared toward the philosophy and math majors—or it presents some small, simple subset of FOPC. (A few schools textbooks do say a little bit about quantification fallacies, which amounts to scratching the surface of FOPC in a very small way. That's a good place to start, but I think we can and should do more.)

So much for the deductive argument-assessment systems that commonly turn up in general-purpose logic textbooks. The only other parts of logic that appear fairly frequently are some inductive arguments and the fallacies.

Inductive arguments are arguments that aim to lend probability to their conclusions. An inductive argument can have true premises and a proper form, and yet it is *possible* for its conclusion to be false—it just isn't very *likely*. (The degree of this non-likelihood varies with the strength of the argument.) There are many kinds of inductive arguments (I introduce three in the present book), but I'll illustrate the whole lot of them with just one example:

75% of the Americans we spoke to said they supported the President's policy. (24)
Therefore, we think a strong majority of the American public supports him.

Argument (24) is an example of the *inductive generalization*. Its form is unimpeachable. Let's suppose the premise is true. Is the conclusion necessarily true? No. It's probably true, but it might not be. Suppose, for example, that the Americans 'we' spoke to weren't typical of the populace as a whole; then the conclusion might be false.

The most common kinds of inductive arguments besides the inductive generalization are the appeal to authority and the argument from analogy. You'll find the occasional introductory logic textbook that describes these, but most don't. I happen to think that the inductive arguments are extremely important.

The other topic that seems to appear pretty often in introductory texts is the *fallacies*. There is debate about how best to define 'fallacy', but I'll go with this fairly mainstream definition: A fallacy is a common mistake of reasoning. It follows from that definition that fallacies can be deductive or inductive fallacies, since mistakes are something we mortals make pretty indiscriminately. For that matter, it's hard to classify mistakes of reasoning as deductive or inductive, since those categories are defined in what kind of support is given to the conclusion if no mistakes are made.

I'm all for teaching the fallacies, but I have some reservations about how it's commonly done. There's a traditional, 'standard' list of fallacies that show up in logic book after logic book when it's time to deal with the fallacies.[14] Unfortunately, it's a seriously flawed list. Some of the 'fallacies' listed in many books aren't fallacies at all. The appeal to authority, for example, is a perfectly legitimate inductive argument, but it's on the standard list as a fallacy. There are fallacious appeals to authority, but the same could be said of any other argument type. The *ad hominem* argument is similar. While many *ad hominem* arguments are fallacious, many are not. Another problem with the standard list is that some of the 'fallacies' on it aren't reasoning mistakes at all—or, at any rate, they're not reasoning mistakes that anyone in his right mind would make. (Amphibology is a good example. It refers to phrases that can be construed two different ways, as in the headline, 'Congressman Backs Train through Iowa'. I'm not sure how one would use such a device for reasoning at all.) And some of the standard fallacies can arise only in the context of a debate—which is why I teach most of the fallacies in Rhetoric class rather than in Logic. (The clearest example of this last point is 'begging the question'.)

If I were assessing a book's treatment of the fallacies, I would check its discussions of the four that I just mentioned, and make sure they were balanced and made the points that I just made about them. (Of course, if it omitted any of them, most notably amphibology, I wouldn't necessarily regard that as a defect. It would probably be a strength.) I would also think very critically about whether the discussions of the fallacies made sense.

To summarize, then: Three deductive systems, inductive arguments, and the fallacies, together make up a large part of the material covered in most introductory, general-purpose logic books. All five topics are valuable (though they're by no means the only parts of logic that are), but I would give priority among them to the sentential calculus, inductive arguments, and Aristotelian logic (in descending order of importance).

As for my main beefs with the way books tend to treat these subjects, I would summarize them as follows:

1. When presenting SC, too little attention is paid to translation between English and the SC symbolism.

2. Inductive arguments are neglected—or, worse yet, may be listed as fallacies.

3. Too much attention is paid to Aristotelian logic. In many cases, Aristotelian logic is all that's presented. And then some books (the same ones or others) often insist on presenting the more complicated methods for checking the validity of syllogisms. Further, some present

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[14] The list is traceable to good old Aristotle.

more than one method for assessing validity, even though all the methods are equivalent.

A short, annotated bibliography for teachers of logic

Eventually, I hope to produce a fuller bibliography covering logic, rhetoric, and hermeneutics, but the following brief list should be useful to any teacher of logic who wants to expand his understanding.

Items marked with an asterisk should be regarded as the places to start within each category, but I do want to draw your attention to two books up front. If you are planning to teach logic and are new to the subject, or if your background is limited to this or that branch of logic (usually deductive logic, whether sentential or categorical) and you want to broaden your knowledge, there are two books you should consider obtaining (in addition to mine, of course!): Read Trudy Govier's *Practical Study of Arguments*, and have Thomas Mautner's *Penguin Dictionary of Philosophy* available for reference. Govier is superb, and Mautner is the most useful reference I've found for logical terminology.

Like any annotated bibliography that is meant to be useful, this one is highly opinionated. If you disagree with any of my assessments, or if you know of books that I ought to add to the list, I'd be glad to hear from you. (See the Feedback Form located at the back of this *Teacher's Manual*.)

Logic Textbooks for Schools (college texts are listed in the next section)

Please note that some of the books listed here have videotaped lectures and web resources available for use with them. I have not examined any of these support materials, and I haven't attempted to list them below. Please contact the publishers or their distributors for information on such ancillaries.

Bluedorn, Nathaniel, and Hans Bluedorn. *The Fallacy Detective*. Muscatine, Iowa: Trivium Pursuit, 2002. An entertaining book, and not a bad treatment of the fallacies. I believe the authors were in high school when they wrote it (or not far out of high school), making the book a tribute to the renaissance going on in Christian education—in their case, Christian homeschooling. May their tribe increase! Teachers should make use of this book if they want to 'teach the fallacies', but I would recommend they approach it with a mildly critically attitude. The more serious flaws of standard-list fallacy treatements seem to have been avoided, but there are subtle problems here and there. For example, the discussion of circular reasoning fails to distinguish between viciously circular reasoning and virtuously circular reasoning, which is a point of enormous importance in refuting skepticism. Summary assessment: Every teacher who teaches 'the fallacies' will find something of value here.

*Cothran, Martin. *Traditional Logic: Book I, An Introduction to Formal Logic*. Danville, Kentucky: Memoria Press, 1998. Intended for high-school students; also claims to be usable in seventh and eighth grades. Attractively presented. Lots of exercises. Presents the basics of categorical logic at length and in detail; a good choice of coverage, hitting on most of what's useful in categorical logic, and not too much of what isn't. The validity-testing method for syllogisms is the one I like. Quite a lot of terminology, some of which seems unnecessary to me. The order of presentation is confusing in places. For example, the immediate inferences (not identified as such) are presented before the notion of inference is introduced. The discussion of distribution of terms is very involved; I found it unenlightening. (To be fair, I should add that I've never read an *enlightening* account of distribution, other than several that assert that distribution cannot be explained.) Summary assessment: A lot of work for a narrow scope, but not a bad choice if you want an in-depth introduction to Aristotelian logic. If you need a book to use for a second logic course after using my *Logic I*, this is the one I recommend.

————. *Traditional Logic: Book II, Advanced Formal Logic*. Louisville, Kentucky: Memoria Press, 2000. Contains much that is valuable, but illustrates many of the limitations and complications of Aristotelian logic. Chapters 1-4 cover material that is unnecessary if you've studied Cothran's *Book I*, and is of only slight historical interest. (These chapters present one of the more horrible systems for testing the validity of categorical syllogisms.) Chapters 5 and 6 cover ordinary-language arguments—a good thing. Chapters 7-9 cover some extremely elementary but useful bits of the sentential calculus. Note that no general validity-testing scheme for the sentential calculus is presented; nor is symbolism. This is sentential calculus as it was taught in the Middle Ages. Chapters 10-14 take us back to categorical logic, and some of the more complex arguments treated by it. Summary: Contains some potentially useful background reading for teachers, but as for teaching it, if you've covered Cothran's *Book I* and want to do another year of logic, you'll get more knowledge for your money and effort by using my book instead.

Harnadek, Anita. *Critical Thinking*. Books One and Two. Pacific Grove, California: Critical Thinking Books & Software, 1981. Teachers' manuals also available. Useful at middle- and high-school levels. Reasonably good presentation, but not as good as Cothran's. Very broad scope, including fallacies, thinking habits, a little sentential calculus, and a short discussion of quantification. Lots of useful exposition and examples, although I think it's easy to get lost in the verbiage. Lacks cohesiveness; reads like a collection of isolated rules for thinking. (Book Two is better in this respect than Book One.) Talks down to the students too much, in my opinion. I do suspect this series would be useful for logic teachers to read, as it is contains some good teaching ideas. Summary: Scattered and shallow, and written in dumbed-down language, but has some creative ideas.

Nance, James B. *Intermediate Logic*. Moscow, Idaho: Canon Press, 1996. Exercise key also available. Intended for eighth grade. Presents definitions, and then the sentential calculus (here called propositional logic), with no obvious connection between the two sections. (There isn't any, but the reader is left to figure that out on his own.) The section on definitions seems out of place in a logic book—at any rate, it seems out of place in this particular logic book. The treatment of the sentential calculus is solid, with

truth tables, proofs, and truth trees presented, along with some technicalities ('metatheory', for the cognoscenti). I don't like the fact that redundant methods are covered for no apparent pedagogical reason, but at least they are covered competently. On the other hand, Nance does present consistency-checking methods, which I don't do in the present book. Expensive for a workbook, though it would be easy not to use it as a workbook. Summary: A lot of work and expense for a relatively narrow scope. I like my book a lot more. (I admit it, though—I'm biased.)

*Tagliapietra, Ron. *Better Thinking & Reasoning*. Greenville, South Carolina: Bob Jones University Press, 1995. Intended for high school. The best organized of these books. Covers a wide range of subjects—the only one with a wider scope is Harnadek—yet the presentation is cohesive, giving the reader an understanding of how the various parts fit together. Useful reading for the logic teacher with little or no background in the subject. Occasionally oversimplifies a subject, making it just a bit too neat and tidy. (The author is a math teacher.) Introduces the sentential calculus (with truth tables for validity-testing), gives a fairly clean though philosophically slanted method for testing categorical syllogisms for validity, deals tolerably well with inductive arguments (at least he deals with them!), and covers fallacies moderately well. The treatment of the Bible, on the other hand, is exegetically sloppy and theologically shallow, and the biographical vignettes of logicians are irrelevant. (I suspect they're included for alleged motivational value.) There are quite a few errors, some of them substantive. Summary: Useful for getting an overview of the subject, but not useful for the details; needs a once-over by a competent editor, and some of the logic needs to be taken with a grain of salt.

Wilson, Douglas J., and James B. Nance. *Introductory Logic*. 3rd ed. Moscow, Idaho: Canon Press, 1997. Exercise key also available. Intended for seventh grade. Spends most of its time on the logic of categoricals, and touches on a smattering of other subjects. Workbook format. Easy to read, but the exposition is weak, the exercises inadequate, and the structure hard to follow. The treatment of categoricals is cluttered with details which serve no useful purpose (such as the modes and figures of syllogisms). The third edition (which added Nance as co-author) represented a vast improvement over the second, but it still has a long way to go. Expensive for a workbook. Summary: Hard to follow, lacking in cohesiveness, and expensive. This book pioneered the teaching of logic in schools as part of the current rebirth of 'classical Christian education', and its authors and publisher deserve our gratitude, but as a textbook, it has been superseded.

Logic Textbooks for Colleges

There are dozens, probably hundreds, of logic textbooks available for college use. Most of them are undistinguished presentations of a conventional set of (mostly deductive) tools—Irving Copi's book seems to be the mother of all such logic books—but a surprising number manage to be quite good. The following are my favorites out of my constantly growing collection, which currently stands at about twenty general-purpose logic textbooks (i.e., not counting specialized texts and scholarly works).

Allen, Colin, and Michael Hand. *Logic Primer*. Second edition. Cambridge, Massachusetts: Massachusetts Institute of Technology Press, 2001. Very elegant, minimalist presentation of sentential and predicate logic. You have to like symbols and mathematically pithiness to use this book; if you do, you'll love it.

Fogelin, Robert J., and Walter Sinnott-Armstrong. *Understanding Arguments: An Introduction to Informal Logic*. 5th ed. Fort Worth: Harcourt Brace College Publishers. An elegant book, which I've not yet had time to read thoroughly. I'm finding it quite useful to dip into, however. Takes language as the starting point, and keeps the linguistic aspect of logic in view throughout (an approach I favor). Covers the sentential calculus, categorical logic, the predicate calculus, inductive and other informal arguments, probability, and fallacies. Has chapters on legal arguments, moral arguments, scientific reasoning, and philosophical arguments. It isn't clear to me just how well integrated the various parts are; that is, it may lack cohesiveness.

*Govier, Trudy. *A Practical Study of Argument*. 4th ed. Belmont, California: Wadsworth, 1997. A model logic book, and not just because its author is Canadian! (I must admit, however, it's nice reading a textbook written by someone who has heard of my homeland.) Flows very well. Presents argument analysis in the context of everyday discourse (news articles, editorials, etc.) Covers categorical logic, the sentential calculus, inductive arguments, analogies, and conductive arguments. *Every logic teacher should read this book.* It will be very clarifying and helpful—and if you read my book, you'll notice lots of ways in which Govier has influenced my presentation.

*Kahane, Howard, and Nancy Cavender. *Logic and Contemporary Rhetoric: The Use of Reason in Everyday Life*. 8th ed. Belmont, California: Wadsworth, 1998. Covers a wide range of subjects in logic, media, and rhetoric, and does so in a generally entertaining, frequently obnoxious manner. A new edition comes out every few years so that the examples and exercises can be kept current (i.e., so that current politicians can be skewered). A very useful book, especially for the rhetoric teacher, or for those who enjoy political controversy, but don't expect the New Right or Christian Right to be exempt from the authors' barbs. If anything, I think they come in for more than their fair share.

Mates, Benson. *Elementary Logic*. 2nd ed. New York: Oxford University Press, 1972. A ruthlessly rigorous and philosophically sophisticated presentation of sentential and predicate logic. Not for those who dislike symbols. This is the book from which I learned elementary logic, and I still find it the most satisfying when I want rigor, for the subjects it covers. But if you suffer from the slightest hint of math anxiety, stay away from this book.

Nolt, John. *Logics*. Belmont, California: Wadsworth, 1997. The most accessible of the rigorous books. For each system covered, starts with an intuitive account, and then moves to the formalizations and metatheory. Deals with classical sentential and predicate logics, as well as a range of more specialized or advanced logics, such as modal logics, higher-order logics, non-bivalent logics, fuzzy logics, etc. Very useful for the teacher who wants to take a peek into the more rigorous or the more advanced aspects of logic.

Suppes, Patrick. *Introduction to Logic*. New York: D. Van Nostrand Company, 1957. The best that I've seen of the old, conventional books. Strong mathematical affinities. Good exercises, though not enough of them. Presentation (typography etc.) now looks rather dated.

Tymoczko, Tom, and Jim Henle. *Sweet Reason: A Field Guide to Modern Logic*. New York: W. H. Freeman and Company, 1995. Massive. Useful to the logic teacher for its numerous puzzles and its other inventive approaches to the material. Certainly one of the most entertaining logic texts out there, and not at all dumbed-down. Covers an impressive range of subjects. (With 600+ pages, it certainly ought to!)

Useful Background Reading

This is a very large area. The following are a few books I've come across which will be useful and accessible to those teaching logic:

*Carroll, Lewis. *The Complete Illustrated Works*. Reprint ed., New York: Gramercy Books, 1995. Lewis Carroll (Charles Dodgson) was a mathematician and logician, and his works contain many amusing illustrations of logical points. Students love Lewis Carroll. (I do too.) Use him whenever you can.

Grayling, A.C. An Introduction to Philosophical Logic. Third edition. Oxford: Blackwell, 1997. This is not an easy book, but it is the best I know of for leading the person who knows introductory logic into the philosophical ramifications of the subject. You could ease your way into this book by reading to two articles listed under Grayling's other entry.

Grayling, A.C., ed. *Philosophy 1: A Guide through the Subject*. Oxford: Oxford University Press, 1998. The following articles are useful, with their bibliographies: Mark Sainsbury, 'Philosophical Logic' and David Papineau, 'Methodology: The Elements of the Philosophy of Science'.

Hamblin, C.L. *Fallacies*. Reprint ed. with new preface and bibliography. Newport News, Virginia: Vale Press. A classic, which seems to have had a seminal influence on what could be called the 'informal logic movement'. Anyone who wants to understand the fallacies as they are commonly presented, or who wants to figure out why the standard presentation is so unsatisfying, should read this book. It can be hard going, as it's quite scholarly and philosophical, but it's worth the trouble if you want to understand the fallacies. The bibliography is also useful for those who have not tapped the literature on informal logic. Be forewarned, however, that the literature on informal logic includes vast amounts of worthless material along with much that is excellent. See also *Informal Logic*, below.

Heuer, Richards J., Jr. *Psychology of Intelligence Analysis*. [Washington, D.C.]: Center for the Study of Intelligence, Central Intelligence Agency, 1999. Available at http://www.cia.gov/csi/books (February 18, 2003). Very interesting example of applied logic, with extensive discussion of cognitive biases.

*Huff, Darrell. *How to Lie with Statistics*. Reprint of 1954 ed., New York: W.W. Norton & Company, 1993. This is a classic, and should be read by all logic and rhetoric teachers. It's short and entertaining, and is available in numerous editions, having been in print continuously since its original publication.

Informal Logic. Journal published by the University of Windsor, Ontario, Canada. For information, see http://www.uwindsor.ca/faculty/arts/philosophy/IL (early 2003). While some of the articles are over my head, I find much that is of value in this journal. There is a Teaching Supplement in each issue that often contains useful ideas for teachers.

Piattelli-Palmarini, Massimo. *Inevitable Illusions: How Mistakes of Reason Rule Our Minds.* Trans. by Massimo Piattelli-Palmarini and Keith Botsford. New York: John Wiley & Sons, 1994. Highly entertaining and thought-provoking, though poorly written. The student of logic must take into account the psychological factors which tend to cause reasoning errors, and this book is as good a place to start studying them as any I know. (See also Heuer, above.)

Reference Works

I've found the following works quite useful, as they touch on many aspects of logic. The two marked '*' have been the most useful to me.[15]

Audi, Robert, ed. *The Cambridge Dictionary of Philosophy.* 2nd ed. Cambridge: Cambridge University Press, 1999.

Blackburn, Simon. *The Oxford Dictionary of Philosophy.* Oxford: Oxford University Press, 1996.

Crystal, David. *A Dictionary of Linguistics and Phonetics.* 3rd ed. Oxford: Blackwell, 1991.

Dettlefsen, Michael, David Charles McCarty, and John B. Bacon. *Logic from A to Z.* London: Routledge, 1999. A short reference work focused on formal logic and some fairly hifalutin mathematical logic. Very good for the parts of logic that it covers.[16]

[15] Please note that there are quite a few other dictionaries and encyclopedias of philosophy out there. I suspect that any of them would be helpful to the logic teacher. Those listed in this section are all that I possess. They're all useful; one never knows which one will hit the nail on the head for any particular question.

[16] I am grateful to Marla Perkins for bringing this volume to my attention.

*Honderich, Ted, ed. *The Oxford Companion to Philosophy.* Oxford: Oxford University Press, 1995.

Lacey, A. R. *A Dictionary of Philosophy.* 3rd ed. London: Routledge, 1996. Particularly useful on formal logic and on the philosophy of language.

*Mautner, Thomas, ed. *The Penguin Dictionary of Philosophy.* London: Penguin Books, 1997.

CHRISTIAN VIEWS OF LOGIC

Clark, Gordon H. *Logic.* 2nd ed. Jefferson, Maryland: Trinity Foundation, 1988. This book appears to have been intended as a textbook, although I cannot imagine for what group of students. It contains a curious mix of accurate and sometimes useful points along with frequently misguided axe-grinding.[17] Clark, who often reminds me of Don Quixote, is greatly enamored of categorical logic, along with the most unwieldy of the medieval expositions of it. Clarity just doesn't seem to be on the agenda here. And the symbols are obsolete, if not idiosyncratic. In fact, the only reason I mention this book here is that so many Christians ask me about it. My answer, in a nutshell, is that while this book is not altogether without value, it is definitely not the place to start. (Also available from the publishers is an accompanying *Logic Workbook*, by Elihu Carranza, with separate answer key. I have not yet attempted to work through this.)

*Frame, John. *Cornelius Van Til: An Analysis of His Thought.* Phillipsburg, New Jersey: Presbyterian and Reformed Publishing Company, 1995. Chapters 11-13 are thought-provoking, and make useful reading for the Christian who wants to know what to make of logic.

*----------. *The Doctrine of the Knowledge of God.* Phillipsburg, New Jersey: Presbyterian and Reformed Publishing Company, 1987. Chapters 7 and (especially) 8 have a lot of useful things to say about logic.

Watts, Isaac. *Logic: The Right Use of Reason in the Inquiry After Truth.* London, 1724; reprint ed., Morgan, Pennsylvania: Soli Deo Gloria Publications, 1996. This book is of interest primarily to historians of logic and of theology, as it was very influential in its day as a textbook. Its day ended a long time ago, however, and I don't see a lot of value in it for today's readers, most of whom would find it pretty hard going. Symbols, for instance, were a very helpful invention for logic books, and Watts predated the extensive use of symbolism. Leave this one for the historians.

[17] I'm not against all axe-grinding, as you have probably observed, but I do think a lot of the axe-grinding that goes on is misguided, if not pointless, and it appears to me that Clark specialized in that kind.