Chapter 2

Logic: A Science and a Toolbox

A science

This is a book about logic. What is logic? The word *logic* is used in several ways. Sometimes it refers to reasoning, or to rationality; at other times it is used to refer to someone's argument, offered to support a point (in debate, for example). In computer programming, it refers to the instructions that determine which commands are executed in what order. It is also used to refer to the circuitry built into a microprocessor (such as a computer chip), which determines the behavior of the microprocessor.

In this class, however, we will be using the term in a different sense. Here is our definition:

Logic is the science of correct reasoning.

In our definition, the word 'science' means an organized body of knowledge about some subject, and the methods used to add to that knowledge (such as study, experimentation, etc.) And our definition identifies logic as the science *of correct reasoning.* As we've seen, reasoning is the process of deriving new knowledge from facts already known. More broadly, we may think of reasoning (or reason) as orderly, effective thinking. And correct reasoning is simply reasoning that works, or that is right. This is the great interest of logic.

We might wonder whether it is possible to reason without logic. It is. We can't reason without reasoning, any more than we can think without thinking. But we can reason without making any scientific effort to understand the laws or principles of reason—i.e., without the study of logic—just as we can throw a baseball without understanding the laws of physics, which our throw will obey anyway. Most people reason about many things without being able to state any principles of correct reasoning. Logic involves us in *studying* and *knowing* the principles of reason. It's possible to study logic without being very good at reasoning, and it's frequently the case that people who haven't studied logic can reason quite well.

It is not possible, however, to reason properly without obeying the laws that logic studies. For logic, after all, is the science, or organized study, of the laws by which correct reason proceeds. We call those laws the *rules* or *laws of logic*. The point here is simply that a person can obey those laws without being able to recite them.

To restate what we're saying, logic is a science, or an organized study, of certain laws. It is impossible to reason correctly without obeying those laws, but it is possible to reason correctly without studying those laws, or even necessarily knowing them well enough to state them. That is, it is impossible to reason correctly without obeying the laws of logic, but it is possible to reason correctly without knowing logic.

Let's come back to our analogy of throwing a baseball: Is it possible to throw a baseball without physics? That all depends on what we mean, doesn't it? If we mean to ask whether it is possible to throw a baseball without obeying the laws of physics (the laws that physics studies—laws of motion in this case), then the answer is, obviously not. But if we mean by our question to ask whether it is possible to throw a baseball without having engaged in the scientific study of physics, then clearly it is possible, for most of us learn to throw a baseball long before we learn any physics. In the same way, we can't reason correctly without obeying the laws of logic, and yet we *can* reason correctly without knowing and studying the laws of logic.

Why study logic?

What has just been said raises a further question: If it is possible to reason correctly without knowing or studying logic, then why bother to study it at all? Will it enable us to do anything we can't do without it?

There are several good answers to this question. Perhaps the best is that without knowing or studying the laws of logic, you can reason correctly, but you can't reason correctly about very much.

To go back to our baseball analogy, you can do something simple like throwing a baseball from second base to first without any study of physics, but you probably couldn't propel it to the moon without some knowledge of physics. To do that, you would need to build some sort of machine or rocket, and you would have to calculate how to aim it, and when to launch it so that it would actually hit the moon. It is very unlikely that you could do all of that without at some point acquiring some knowledge of physics. (Of course, you are unlikely to *want* to throw a baseball to the moon. But there are lots of things which mankind has wanted to send to the moon, or to even more hard-to-reach places, and that's where knowing the laws of physics becomes so important.)

The same thing is true in the realm of reasoning. We have a lot of *intuitions* about how to reason—which we normally refer to as common sense. *Intuitions* are things that seem to us to be obviously true. They just *feel* true. We know they're true, without having to think about it very much. For exampe, most people can tell, based on intuition, that sentences (1) and (2) can't both be true at the same time:

Socrates is dead. (1)

Socrates is not dead. (2)

That is because the law of non-contradiction is a matter of common sense. (The law of non-contradiction is the law of logic that states that a statement and its negation cannot both be true. As it happens, (2) is the negation of (1).)

There are many things which it would be useful to know, however, where raw intuition or common sense is not enough to shed any real light. For example, if I want to know whether my desktop computer is capable of any fundamentally different kind of calculation from those which my HP-12C programmable pocket calculator can perform, intuition wouldn't get me very far. It certainly wouldn't give me an answer with any certainty. By studying our intuitions about reasoning, however, and building up more and more powerful tools from them to use in our reasoning, we can answer many such difficult questions with a fair likelihood of being right, and in some cases with complete certainty.[1]

Of course, there are many other problems of reasoning which we have to solve every day, for which intuition or gut feelings cannot provide adequate guidance, and that is why we study logic.

Another reason for studying logic is closely related to the first. If we relied on our intuitions for all our reasoning, we would be more prone to mistakes. As we've already seen, human reasoning can be wrong, and yet it usually seems right to the people who make a mistake. That is, their intuition tells them that their reasoning is correct. When we study logic, we discover that if some of our most basic intuitions about reasoning are right, then some of our applications of those intuitions in specific reasoning situations are wrong, and we learn how to recognize those mistakes. The more logic we study, the more we can learn to guard against mistakes of reasoning.

A third reason to study logic is that like all true sciences, it is a study of the works of God. Psalm 111:2 says, 'The works of the LORD are great, sought out of all them that have pleasure therein.' God created logic, and logic, like all of God's creation, proclaims his wisdom and glory, and so our study of logic can be an act of worship and a path to knowing our wonderful God more fully, if we approach him with faith in the Lord Jesus Christ as our Lord and Savior. In Christ 'are hid all the treasures of wisdom and knowledge', as Paul tells us in Colossians 2:3. Far from being contrary to knowledge, whether of logic or anything else, faith in and subjection to Christ bring us into living union with the one in whom all knowledge is hidden.

This has an important implication for our pursuit of the study of logic. As we sift through the various things our intuitions would tell us about correct reasoning, we can never accept anything which is contrary to the Bible, which is the word of Christ. How can something be one of the treasures of wisdom and knowledge if it is contrary to Christ, in whom all those treasures are stored? No, in our logic studies we must, like Paul, seek to bring every thought into captivity to the obedience of Christ (2 Cor. 10:5).

A toolbox

When we study logic, we acquire a great variety of principles, rules (or laws), methods, tests, and other things, which can seem miscellaneous and jumbled. It's often easier to have a clear grasp of the individual elements of logic than it is to clearly see how they all fit together.

I find it helpful to think of logic as a toolbox, filled with a great variety of tools. Some of the tools are relatively small and simple, like a carpenter's hammer, or a seamstress's seam-ripper. Others are large, powerful, and complicated, and can be used for a great many purposes, like the carpenter's radial-arm saw, or the seamstress's programmable sewing machine. Logic tools are not used for building things out of wood or sewing clothes, however, but for reasoning

[1] The answer to the question I raised, for any who are interested, is that no, my desktop computer can't compute anything fundamentally different from what my HP-12C can calculate. And we know this to be true with certainty, since logicians proved in the middle of the 20th century that all known forms of computers and calculators have the same range of computable functions, though of course they differ greatly in speed, memory capacity, and the like. This is a relatively elementary result in an advanced branch of logic called *recursion theory*. What has *not* been proven, however, is that all *possible* kinds of computers have the same range of computing ability. Can you see how the result which *has* been proven is different from the one which hasn't been?

in a clear, orderly, reliable, and God-like manner. They are *tools for thinking*.

To know how to use a set of tools, you have to know three things: *what the tools are that you have available*; *what each tool is good for* (what it does, and what materials you can use it on); and *how to use each tool*. If you've ever watched a skilled craftsman using his tools, you've probably noticed that he has a great many tools to choose from but always seems to know which one to use when he wants to achieve something. On the other hand, if you've ever tried to do a repair job around your house using the wrong tool (either because you don't have or can't find the right one), you will appreciate that there is all the difference in the world between the right tool and the wrong one when it comes to effectiveness.

So it is with logic. As we learn logic, we will acquire a toolbox full of tools, each of which is useful for some specific range of jobs. In addition, we will learn how to decide which tool to use. And of course we'll learn how to use the tools.

Before we start picking up individual tools and examining them, however, we should think some more about tools in general. Probably the hardest thing when it comes to learning about logical tools is that you can't see them. The carpenter's tools, or those of the mechanic or tailor or shoe-repair man, are all physical tools, for use on physical materials. You can see them, pick them up (the smaller ones, at least), feel them in your hands, and often practice with them on scrap material. But the tools of logic are conceptual. You can't see them or touch them. You can only think about them. This can make it hard to understand exactly what they are, since most of us are much better at taking in what we can see than at apprehending abstract ideas.

Raw materials for logic's tools to work on

We've seen that logic gives us tools for reasoning. What materials can we use these tools on? If we consider a carpenter and his tools, we know that he uses those tools on wood (most of the time). Or if we look at the tools a cake decorator uses, we'll see that they're used on icing and other sugary things. What, then, is the raw material on which we will use our logical tools?

We might answer this by saying, 'We use logic on thoughts, or on reasoning.' This is correct, and follows immediately from what logic is. It's not especially useful, however. Can you see why not? Thoughts and reasoning are things that we cannot see. They're things or processes that live inside our minds. When you have a thought in your head, not even you can see that thought. (The thought might consist in your visualizing—'seeing'—something. But then you are 'seeing' the something, not the thought.) No one else can see it, either. Others might not even be aware of its existence, since it's hidden inside your mind.

The good news, however, is that thoughts can be expressed in a form in which we can see them and work with them. What do you think that form is?

Let's look at two examples: First, suppose you were thinking that you would very much like to go out to your favorite pizza place for your upcoming birthday. How would you express this to your parents? You might try to express it by some kind of action. Perhaps you could leave a copy of the restaurant's take-out menu lying around in the kitchen, hoping that this would make your parents think of taking you there. Of course, this might not work. The result might only be to get the menu thrown into the recycling bin as unnecessary clutter. You could hope that someone might ask you whether you wanted to go to the pizza place for your birthday, in which case you could nod vigorously with a big smile on your face. That might not happen, however, so you wouldn't want to count on that as a way of expressing your desire. Instead, you would probably *say* something to one of your parents. That would make it quite clear what you were thinking, and would have much less chance of failing to convey the information you wanted to convey. That's why we normally use speech to express our thoughts to the people around us.

Second, notice that in this logic book, I have various thoughts about logic and related subjects, and I'm trying to express them in a way that will reach you and will be understandable to you. How am I doing that? By *writing* this text. Everything in this text is the result of my attempting to express my thoughts about logic in a way that you may be able to follow.

From these examples, we see that we can express thoughts by *saying* something or by *writing* something. What do these two activities have in common? They both involve our using *words*, or *language*.

God, in making us in his image, has made us so that we can communicate our thoughts by using language. We can *speak* (utter words with our mouths) when we want to convey our thoughts to someone else, or we can *write* our thoughts down (in language) to convey them.

Of these two forms of language, which do you think would be easier for logic to work with? We can't see spoken language, though at least we can hear it. But we can *see* written language, and for this reason, we generally apply the tools of logic to written language—that is, to words and sentences which have been written down. This gives us raw material to work with that we can see and manipulate in front of us. With practice, we may eventually be able to apply logic's tools to spoken language, but it will be much easier to gain that practice on written material.

In this class, we're going to treat language expressions (words, phrases, sentences, etc.) as being the same thing as the thoughts they express. If we wanted to be very precise, we would never say that words and sentences *are themselves* thoughts, but that they *express* thoughts. There's no need for us to be so precise, however, so we'll treat written language as the same thing as the thoughts it expresses.[2]

If we express our thoughts in language, then there must be a very close connection between our ability to think and our understanding of how to use language. For if we can't use language effectively, then we can't express our thoughts effectively, which is pretty likely to mean we can't think effectively.

It is for this reason that in order to study logic we have to devote quite a bit of attention to *grammar*, the science of the correct use of language. If we don't know grammar, then we will have trouble using language correctly and effectively, and we will find it difficult to study the

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[2] The distinction I'm making here is pretty fine and might be hard to grasp. Here's an example that might help. Consider the following English sentence:

The cat is on the mat. (A)

Clearly, (A) expresses the thought that the cat is on the mat. Now ask yourself, "Is (A) *the same thing as* the thought that the cat is on the mat?" And ask yourself, "Where is the thought?" Obviously, it's in someone's mind. (In fact, at the moment, because you're reading about it, it might be in *your* mind, even though you don't know which cat and which mat is being referred to.) Where, on the other hand, is sentence (A)? It's printed on a piece of paper. Is the piece of paper someone's mind? Obviously not. So sentence (A) and the thought expressed by sentence (A) exist in two different places. For this reason, we say that (A) and its thought are not identical (the very same thing), even though they are clearly very closely related, in that (A) expresses the thought. The good news, however, is that we don't need to be too concerned about the distinction between sentences and the thoughts they express, and we can speak loosely as though they *are* the same thing for practical purposes.

ways in which we express our thoughts with language.

As you shall see, you won't get very far in logic if you can't identify the subject and predicate of a sentence, among other grammatical concepts. So if your background in English grammar is weak, you will do well to study up on it if you want to learn logic. (Perhaps I will begin to work my way back into your English teacher's good graces by saying things like that.)

I'll close this section by pointing out the great power of logic. Its tools can be used on ideas or thoughts (or concepts or whatever you want to call them). The power of logic is that it can be used on *any* ideas or thoughts, regardless of what subject they have to do with. Note carefully that I didn't say that every one of logic's tools can be used on any subject. Some logical tools, like the tools of a carpenter, are specialized; they are used for some very specific purpose, which in some cases means that they can only be used on the ideas of certain subjects. But most of logic's tools work well with any subject, as we shall see.

Terms and concepts discussed in this chapter

logic
definition of 'logic'
science
rules (laws) of logic
reasoning with or without logic
reasons to study logic
intuition
common sense
the law of non-contradiction
relationship of logic to Christ
tools of logic
knowledge required to use a set of tools
raw materials for logic's tools
the difficulty of working directly with thoughts
expressing thoughts
speaking and writing
words and language
the importance of grammar

Exercises

1. Outline Chapter 2, following the same guidelines as you used in outlining Chapter 1.

2. List five sciences and indicate for each what kind of thing(s) it studies.

3. Can you think of any other reasons to study logic?

4. Find someone who has a lot of tools, and make a list of ten tools. Make your list as varied as possible. (Don't list five kinds of screwdrivers, for instance.) By each tool,

write down what it is used for. Think about whether it is good for one thing or for many. Also write down what materials it is used on.

5. Suppose that each of the following is something you are thinking. Give five different sentences by which you could express the thought, other than the one in which the thought is expressed here.
    a) I am happy.
    b) I like Logic class.
    c) Mount Everest is the tallest mountain in the world.
    d) My sister has been on the phone for a *very* long time.

Study suggestions

1. Begin to compile a study sheet, on which you should write the most important definitions and rules from each chapter. At this point, you will have two definitions from Chapter 1, and one from Chapter 2. If you're in any doubt about which definitions to include, think about the central theme of each chapter, and about which definitions are most closely and obviously related to that theme.

2. Make sure you have the definitions on your study sheet memorized, 'word perfect'.