LOGIC

THE ESSENTIALS

PATRICK J. HURLEY

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To my mother, Maggie Hurley,
in celebration of her 105th birthday

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Preface

The most immediate benefit derived from the study of logic is the skill needed to construct sound arguments of one's own and to evaluate the arguments of others. In accomplishing this goal, logic instills a sensitivity for the formal component in language, a thorough command of which is indispensable to clear, effective, and meaningful communication. On a broader scale, by focusing attention on the requirement for reasons or evidence to support our views, logic provides a fundamental defense against the prejudiced and uncivilized attitudes that threaten the foundations of our democratic society. Finally, through its attention to inconsistency as a fatal flaw in any theory or point of view, logic proves a useful device in disclosing ill-conceived policies in the political sphere and, ultimately, in distinguishing the rational from the irrational, the sane from the insane.

About *Logic: The Essentials*

Logic: The Essentials concentrates on the essentials of introductory logic. It is practical in orientation and content, and is loaded with class-tested, proven practice exercises. The book is tailored to address the needs of many of today's instructors who are challenged by time constraints but yet want to instill in their students a solid grasp of basic logical principles and the requisite skill to apply them in everyday life. This new text is based on the classic and best-selling textbook *A Concise Introduction to Logic*, and nearly all of the exercises in the correlative chapters, so central to the effectiveness of that text, have been retained to ensure more than enough practice for students to master the central concepts. The text focuses largely on deductive logic, but it contains sufficient treatment of induction to provide a solid footing for informal fallacies. The result is a contemporary approach—more focused, more practical, less theoretical—built on a tradition of precise, elegant, and clear presentation of the subject matter of logic, both formal and informal.

The text pedagogy is designed to make sure the main points are always presented up front so students cannot miss them, the prose is clear and uncomplicated, and excess verbiage and peripheral subject matter are avoided. To accomplish these and other related goals, the following pedagogical devices are used in the text:

- Section-opening Previews induce students to start thinking about the material that follows by connecting the section content to real-life scenarios pertinent to students' lives.
- Important terms, principles, and bits of advice are stated in marginal boxes.
- Chapters are organized so that earlier sections provide the foundation for later ones. Later sections can be skipped by instructors opting to do so.
- Relevant and up-to-date examples are used extensively.
- Key terms are introduced in boldface type and defined in the Glossary/Index.
- Central concepts are illustrated in graphic boxes.
- Numerous exercises, many drawn from real-life sources such as newspapers, textbooks, and magazines, are included to perfect student skills.
- Biographical vignettes of prominent logicians are included to give logic a human face.
- Dialogue exercises illustrate the application of logical principles to real-life situations.
- Venn diagrams for syllogisms are presented in a novel and more effective way, using color to identify the relevant areas.
- End-of-chapter summaries facilitate student review.
- Every third exercise is answered in the back of the book so students can check their work.
- Important rules and tables are printed on the inside covers for ready access, and are also presented on a tear-out card.

Digital Solutions for Students and Instructors

MindTap™ MindTap is a personalized digital learning platform that offers an interactive eBook, a tutorial program, and homework all in one place. Specifically, MindTap includes the MindTap Reader™ (the interactive eBook), *Learning Logic* (the tutorial program), Aplia™ (which provides robust homework assignments), and video lectures (devoted to conceptually difficult topics). For more details about this new digital solution, see the Note to the Student, Note to the Instructor, and Digital Options sections later in this preface.

On our Instructor Companion Website, instructors will find all the tools they need to teach a rich and successful introductory logic course. The protected teaching materials include an **Instructor's Manual**, which contains answers to all textbook exercises; **Lecture Slides**, customizable to fit your particular needs; and a set of image slides that contains all of the photos and art from the text. Also included is the extensive author-created **Test Bank**. The multiple-choice tests, which are

machine-gradable, can be a great time saver, and they match the Practice Tests available to the students in MindTap in length and format. The Test Bank, named Cengage Learning Testing, is powered by Cognero®, an online testing system that allows you to author, edit, and manage Test-Bank content. You can create multiple test versions and instantly deliver them through your Learning Management System (LMS) from your classroom, or wherever you may be, with no special installations or downloads required.

Note to the Student

Imagine that you are interviewing for a job. The person across the desk asks about your strengths, and you reply that you are energetic, enthusiastic, and willing to work long hours. Also, you are creative and innovative, and you have good leadership skills. Then the interviewer asks about your weaknesses. You hadn't anticipated this question, but after a moment's thought you reply that your reasoning skills have never been very good.

> The interviewer quickly responds that this weakness could create big problems.
>
> "Why is that?" you ask.
>
> "Because reasoning skills are essential to good judgment. And without good judgment your creativity will lead to projects that make no sense. Your leadership skills will direct our other employees in circles. Your enthusiasm will undermine everything we have accomplished up until now. And your working long hours will make things even worse."
>
> "But don't you think there is some position in your company that is right for me?" you ask.
>
> The interviewer thinks for a moment and then replies, "We have a competitor on the other side of town. I hear they are hiring right now. Why don't you apply with them?"

The point of this brief dialogue is that good reasoning skills are essential to doing anything right. The business person uses reasoning skills in writing a report or preparing a presentation; the scientist uses them in designing an experiment or clinical trial; the department manager uses them in maximizing worker efficiency; the lawyer uses them in composing an argument to a judge or jury. And that's where logic comes in. The chief purpose of logic is to develop good reasoning skills. In fact, logic is so important that when the liberal arts program of studies was formulated fifteen hundred years ago, logic was selected as one of the original seven liberal arts. Logic remains to this day a central component of a college or university education.

From a more pragmatic angle, logic is important to earning a good score on any of the several tests required for admission to graduate professional schools—the LSAT, GMAT, MCAT, and GRE. Obviously, the designers of these tests recognize that the ability to reason logically is a prerequisite to success in these fields. Also, logic is a useful tool in relieving what has come to be called math anxiety. For whatever reason, countless students today are terrified of any form of reasoning that involves abstract symbols. If you happen to be one of these students, you should find it relatively easy to master the use of logical symbols, and your newly found comfort with these symbols will carry over into the other, more difficult fields.

Before commencing your study of logic, be sure to check out MindTap (www.cengage.com/mindtap). This highly robust Internet platform supports all of the supplements

that accompany your textbook. It has the advantage of being able to play on any Internet-enabled device including desktops, laptops, and mobile devices, which allows you to learn anywhere, at any time, and on your terms. Some of the products offered on MindTap are *Learning Logic*, a set of video lectures that presents challenging subjects in logic, an eBook (MindTap Reader) containing everything in the textbook, and practice tests for every chapter. Also available is a supplement called Logic and Graduate-Level Admission Tests, which shows how the principles you will learn in studying logic can be used to answer questions on the LSAT, GMAT, MCAT, and GRE.

Among the MindTap offerings that I would especially urge you to investigate is *Learning Logic*. This is an interactive tutorial program that virtually teaches the entire course in a very user-friendly way. It tracks the textbook chapter by chapter, but your computer must be equipped with speakers or headphones, because the audio component is essential.

Because proficiency in logic involves developing a skill, it helps to work through the practice problems in *Learning Logic* and the exercises in the textbook more than once. This will help you see that good reasoning (and bad reasoning, too) follows certain patterns whose identification is crucial to success in logic. As you progress, I think you will find that learning logic can be lots of fun, and working with the online resources of MindTap should enhance your overall learning experience.

Note to the Instructor

Logic: The Essentials is in part an abridged version of *A Concise Introduction to Logic*. The approach taken in writing *Logic: The Essentials* was to cut material that, for lack of time, is often skipped over in class, but to retain material devoted to central topics and nearly all the correlative exercises. Also retained are the successful pedagogical features such as the biographical vignettes of prominent logicians and the section-opening "previews," which instructors can use as springboards for class discussion. The goal was to focus on the *essential* content most often covered in standard introductory logic courses.

For those of you familiar with my original text, topics that I have removed for the purposes of this new presentation include diagramming extended arguments, meaning and definition, the last two sections of predicate logic, and all the final chapters on induction. Also eliminated are certain redundant techniques including the two-circle Venn method for testing immediate inferences (which back up the two squares of opposition), and the Venn method for testing sorites (which backs up the far-simpler rules method). But two-circle Venn diagrams are retained for many purposes related to categorical propositions, and, of course, three-circle Venn diagrams are retained for categorical syllogisms.

A second group of materials not included in this new volume are topics of chiefly peripheral or theoretical interest. These include the use of conversion, obversion, and contraposition in multistep proofs, the use of Venn diagrams to prove the traditional square of opposition, the section related to proving the rules for categorical syllogisms, and several of the paragraphs comparing the meaning of the propositional operators with ordinary language.

As noted earlier, an important digital asset that accompanies this book is MindTap, a personalized digital learning platform that offers an interactive eBook, a tutorial

program, and homework all in one place. See the Digital Options section for help in deciding which digital assets you want your students to access.

One of the more noteworthy offerings on MindTap is *Learning Logic*. This tutorial program virtually teaches the course, and it is especially helpful for students who have difficulty mastering logical principles directly from the textbook or from classroom lectures alone. *Learning Logic* contains over two thousand practice problems not contained in the textbook, and students get immediate feedback for correct and incorrect answers.

Another great product available on MindTap is Aplia™, an online homework program that improves student comprehension by increasing effort and engagement. Students get immediate feedback on their work—not only what they got right or wrong—but *why*; and they can choose to see another set of related problems if they want further practice. Aplia's simple-to-use course management interface allows instructors to post announcements, host student discussions, e-mail students, and manage the grade book. Personalized help is available from a knowledgeable and friendly support team. To learn more, ask your Cengage Learning sales representative for a demonstration, or view a specific demonstration for this book at www.aplia.com.

Another highly useful digital asset is the Instructor Companion Website, which contains the Instructor's Manual and the very substantial Test Bank (Cengage Learning Testing, powered by Cognero) composed by the author. It also includes "Existential Import: Historical Background," a paper written by the author, which provides further explanation of the Aristotelian/Boolean distinction.

While *Logic: The Essentials* is designed to be shorter than many other logic textbooks, it still offers considerable flexibility to the instructor in designing a course. Chapters are organized so that later sections can be skipped by those wishing to do so. For example, the last section of Chapter 2 (Informal Fallacies) can be skipped, those wanting to treat categorical propositions only as an introduction to predicate logic can cover just the first three sections of Chapter 3, and any of the last four sections of Chapter 4 (Categorical Syllogisms) can be skipped. The last two sections of Chapter 5 (Propositional Logic) can be skipped, and those instructors desiring only a touch of predicate logic can skip any of the last three sections of Chapter 7. The restrictions on natural deduction in predicate logic are designed to allow precisely such a treatment.

Digital Options

Logic: The Essentials is available in multiple formats and can be combined with digital solutions in a variety of ways.

1. **Textbook + MindTap.** Includes, in addition to the printed textbook, access to the MindTap course, with *Learning Logic* (the tutorial), Aplia assignments (automatically graded and featuring detailed, immediate feedback on every question), newly reworked videos (covering difficult-to-master topics in logic), chapter learning-path activities, automatically graded quizzes for almost every end-of-section problem in the book, and the full-text interactive eBook (MindTap Reader).

2. **Textbook + Aplia.** Includes, in addition to the printed textbook, access to the Aplia course (with automatically graded assignments featuring detailed, immediate feedback on every question), the course management interface (which allows instructors to post announcements, upload course materials, host student discussions, e-mail students, and manage the grade book), and the full-text interactive eBook (MindTap Reader).
3. **MindTap (alone).** Available with the interactive eBook (MindTap Reader), this option includes everything in Option 1 except the printed textbook. Available only at www.cengagebrain.com, this option can be a cost-saving choice for students.
4. **Aplia (alone).** Available with the interactive eBook (MindTap Reader), this option includes everything in Option 2 except the printed textbook. Available only at www.cengagebrain.com, this option can be a cost-saving choice for students.
5. **Instructor Companion Site.** This password-protected website for instructors features all of the Instructor's Manual, Lecture Slides, and Test Bank delivered via Cognero. Access all of your instructor resources by logging into your account at www.cengage.com/login.
6. **Custom Options.** Cengage Learning offers custom solutions for your course—whether it's making a small modification to *Logic: The Essentials* to match your syllabus or combining multiple sources to create something truly unique. You can also pair your custom text with our digital solutions such as MindTap and Aplia. For more information, visit www.cengage.com/custom.
7. **CengageBrain.** Let this be your students' online source for an à la carte offering of all of the products they need for a successful logic course. Visit www.cengagebrain.com.

Contact your personal Learning Consultant, sites.cengage.com/RepFinder/, for more information about all available options, pricing, and assistance in selecting the best solutions for your students and your course.

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After several conversations with colleagues and Cengage Learning editors, I decided that the time was right for a more focused and less theoretical textbook that addresses the challenges faced by many instructors in the current teaching environment. Crafting a new book requires help on several fronts. Accordingly, I want to thank the following reviewers for their comments and suggestions:

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1 Basic Concepts

1.1 Arguments, Premises, and Conclusions

PREVIEW

Suppose a student with whom you are in a long-term relationship happens to see you sitting close to someone else in the library. The person you have been dating for months now accuses you of cheating and threatens to break off the relationship. You, in turn, try to prove that the event in the library was perfectly innocent and amounted to nothing. To do this, you need an argument. In this section you will learn about arguments and their basic components—premises and conclusions.

1

logic: The organized body of knowledge (science) that evaluates arguments.

Logic may be defined as the organized body of knowledge, or science, that evaluates arguments. All of us encounter arguments in our day-to-day experience. We read them in books and newspapers, hear them on television, and formulate them when communicating with friends and associates. The aim of logic is to develop a system of methods and principles that we may use as criteria for evaluating the arguments of others and as guides in constructing arguments of our own. Among the benefits to be expected from the study of logic is an increase in confidence that we are making sense when we criticize the arguments of others and when we advance arguments of our own.

argument: A group of statements, one or more of which (the premises) are claimed to provide support for, or reasons to believe, one of the others (the conclusion).

An **argument**, in its simplest form, is a group of statements, one or more of which (the premises) are claimed to provide support for, or reasons to believe, one of the others (the conclusion). Every argument may be placed in either of two basic groups: those in which the premises really do support the conclusion and those in which they do not, even though they are claimed to. The former are said to be good arguments (at least to that extent), the latter bad arguments. The purpose of logic, as the science that evaluates arguments, is thus to develop methods and techniques that allow us to distinguish good arguments from bad.

As is apparent from the given definition, the term *argument* has a very specific meaning in logic. It does not mean, for example, a mere verbal fight, as one might have with one's parent, spouse, or friend. Let us examine the features of this definition in greater detail. First of all, an argument is a group of statements. A **statement** is a sentence that is either true or false—in other words, typically a declarative sentence or a sentence component that could stand as a declarative sentence. The following sentences are statements:

statement: A sentence that is either true or false.

Chocolate truffles are loaded with calories.
Melatonin helps relieve jet lag.
Political candidates always tell the complete truth.
No wives ever cheat on their husbands.
Tiger Woods plays golf and Maria Sharapova plays tennis.

truth value: The attribute by which a statement is either true or false.

The first two statements are true, the second two false. The last one expresses two statements, both of which are true. Truth and falsity are called the two possible **truth values** of a statement. Thus, the truth value of the first two statements is true, the truth value of the second two is false, and the truth value of the last statement, as well as that of its components, is true.

Unlike statements, many sentences cannot be said to be either true or false. Questions, proposals, suggestions, commands, and exclamations usually cannot, and so are not usually classified as statements. The following sentences are not statements:

Where is Khartoum?	(question)
Let's go to a movie tonight.	(proposal)
I suggest you get contact lenses.	(suggestion)
Turn off the TV right now.	(command)
Fantastic!	(exclamation)

premises: The statements that set forth the reasons or evidence.

conclusion: The statement that the premises are claimed to support or imply.

The statements that make up an argument are divided into one or more premises and exactly one conclusion. The **premises** are the statements that set forth the reasons or evidence, and the **conclusion** is the statement that the evidence is claimed to support

or imply. In other words, the conclusion is the statement that is claimed to follow from the premises. Here is an example of an argument:

> All film stars are celebrities.
> Halle Berry is a film star.
> Therefore, Halle Berry is a celebrity.

The first two statements are the premises; the third is the conclusion. (The claim that the premises support or imply the conclusion is indicated by the word "therefore.") In this argument the premises really do support the conclusion, and so the argument is a good one. But consider this argument:

> Some film stars are men.
> Cameron Diaz is a film star.
> Therefore, Cameron Diaz is a man.

In this argument the premises do not support the conclusion, even though they are claimed to, and so the argument is not a good one.

One of the most important tasks in the analysis of arguments is being able to distinguish premises from conclusions. If what is thought to be a conclusion is really a premise, and vice versa, the subsequent analysis cannot possibly be correct. Many arguments contain indicator words that provide clues. Some typical **conclusion indicators** are

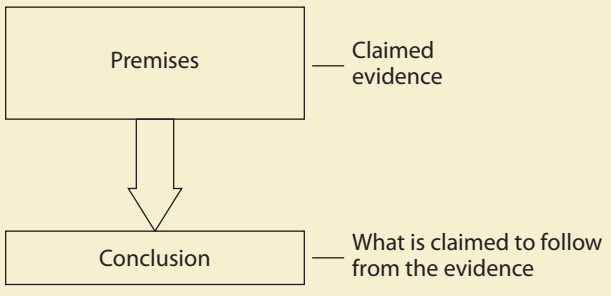
conclusion indicator: A word or phrase that provides a clue for identifying a conclusion.

therefore	accordingly	entails that
wherefore	we may conclude	hence
thus	it must be that	it follows that
consequently	for this reason	implies that
we may infer	so	as a result

Whenever a statement follows one of these indicators, it can usually be identified as the conclusion. By process of elimination the other statements in the argument are the premises. Example:

> Tortured prisoners will say anything just to relieve the pain. Consequently, torture is not a reliable method of interrogation.

The conclusion of this argument is "Torture is not a reliable method of interrogation," and the premise is "Tortured prisoners will say anything just to relieve the pain."



1 **premise indicator**: A word that provides a clue for identifying a premise.

If an argument does not contain a conclusion indicator, it may contain a premise indicator. Some typical **premise indicators** are

since	in that	seeing that
as indicated by	may be inferred from	for the reason that
because	as	in as much as
for	given that	owing to

Any statement following one of these indicators can usually be identified as a premise. Example:

> Expectant mothers should never use recreational drugs, since the use of these drugs can jeopardize the development of the fetus.

The premise of this argument is "The use of these drugs can jeopardize the development of the fetus," and the conclusion is "Expectant mothers should never use recreational drugs."

In reviewing the list of indicators, note that "for this reason" is a conclusion indicator, whereas "for the reason that" is a premise indicator. "For this reason" (except when followed by a colon) means for the reason (premise) that was just given, so what follows is the conclusion. On the other hand, "for the reason that" announces that a premise is about to be stated.

Sometimes a single indicator can be used to identify more than one premise. Consider the following argument:

> It is vitally important that wilderness areas be preserved, for wilderness provides essential habitat for wildlife, including endangered species, and it is a natural retreat from the stress of daily life.

The premise indicator "for" goes with both "Wilderness provides essential habitat for wildlife, including endangered species," and "It is a natural retreat from the stress of daily life." These are the premises. By method of elimination, "It is vitally important that wilderness areas be preserved" is the conclusion.

Some arguments contain no indicators. With these, the reader/listener must ask such questions as: What single statement is claimed (implicitly) to follow from the others? What is the arguer trying to prove? What is the main point in the passage? The answers to these questions should point to the conclusion. Example:

> The space program deserves increased expenditures in the years ahead. Not only does the national defense depend on it, but the program will more than pay for itself in terms of technological spin-offs. Furthermore, at current funding levels the program cannot fulfill its anticipated potential.

The conclusion of this argument is the first statement, and all of the other statements are premises. The argument illustrates the pattern found in most arguments that lack indicator words: The intended conclusion is stated first, and the remaining statements are then offered in support of this first statement. When the argument is restructured according to logical principles, however, the conclusion is always listed *after* the premises:

P_1: The national defense is dependent on the space program.
P_2: The space program will more than pay for itself in terms of technological spin-offs.
P_3: At current funding levels the space program cannot fulfill its anticipated potential.
C: The space program deserves increased expenditures in the years ahead.

When restructuring arguments such as this, one should remain as close as possible to the original version, while at the same time attending to the requirement that

premises and conclusion be complete sentences that are meaningful in the order in which they are listed.

Note that the first two premises are included within the scope of a single sentence in the original argument. For the purposes of this chapter, compound arrangements of statements in which the various components are all claimed to be true will be considered as separate statements.

Passages that contain arguments sometimes contain statements that are neither premises nor conclusions. Only statements that are actually intended to support the conclusion should be included in the list of premises. If, for example, a statement serves merely to introduce the general topic, or merely makes a passing comment, it should not be taken as part of the argument. Examples:

> The claim is often made that malpractice lawsuits drive up the cost of health care. But if such suits were outlawed or severely restricted, then patients would have no means of recovery for injuries caused by negligent doctors. Hence, the availability of malpractice litigation should be maintained intact.

> Massive federal deficits push up interest rates for everyone. Servicing the debt gobbles up a huge portion of the federal budget, which lowers our standard of living. And big deficits also weaken the value of the dollar. For these reasons, Congress must make a determined effort to cut overall spending and raise taxes. Politicians who ignore this reality imperil the future of the nation.

In the first argument, the opening statement serves merely to introduce the topic, so it is not part of the argument. The premise is the second statement, and the conclusion is the last statement. In the second argument, the final statement merely makes a passing comment, so it is not part of the argument. The premises are the first three statements, and the statement following "for these reasons" is the conclusion.

Closely related to the concepts of argument and statement are those of inference and proposition. An **inference**, in the narrow sense of the term, is the reasoning process expressed by an argument. In the broad sense of the term, "inference" is used interchangeably with "argument." Analogously, a **proposition**, in the narrow sense, is the meaning or information content of a statement. For the purposes of this book, however, "proposition" and "statement" are used interchangeably.

Note on the History of Logic

The person who is generally credited as the father of logic is the ancient Greek philosopher Aristotle (384–322 B.C.). Aristotle's predecessors had been interested in the art of constructing persuasive arguments and in techniques for refuting the arguments of others, but it was Aristotle who first devised systematic criteria for analyzing and evaluating arguments.

Aristotle's chief accomplishment is called **syllogistic logic**, a kind of logic in which the fundamental elements are *terms,* and arguments are evaluated as good or bad depending on how the terms are arranged in the argument. Chapters 3 and 4 of this textbook are devoted mainly to syllogistic logic. But Aristotle also deserves credit for originating **modal logic**, a kind of logic that involves such concepts as possibility, necessity, belief, and doubt. In addition, Aristotle catalogued several informal fallacies, a topic treated in Chapter 2 of this book.

After Aristotle's death, another Greek philosopher, Chrysippus (280–206 B.C.), one of the founders of the Stoic school, developed a logic in which the fundamental elements

were *whole propositions.* Chrysippus treated every proposition as either true or false and developed rules for determining the truth or falsity of compound propositions from the truth or falsity of their components. In the course of doing so, he laid the foundation for the truth functional interpretation of the logical connectives presented in Chapter 5 of this book and introduced the notion of natural deduction, treated in Chapter 6.

For thirteen hundred years after the death of Chrysippus, relatively little creative work was done in logic. The physician Galen (A.D. 129–ca. 199) developed the theory of the compound categorical syllogism, but for the most part philosophers confined themselves to writing commentaries on the works of Aristotle and Chrysippus. Boethius (ca. 480–524) is a noteworthy example.

The first major logician of the Middle Ages was Peter Abelard (1079–1142). Abelard reconstructed and refined the logic of Aristotle and Chrysippus as communicated by Boethius, and he originated a theory of universals that traced the universal character of general terms to concepts in the mind rather than to "natures" existing outside the mind, as Aristotle had held. In addition, Abelard distinguished arguments that are valid because of their form from those that are valid because of their content, but he held that only formal validity is the "perfect" or conclusive variety. This textbook follows Abelard on this point.

After Abelard, the study of logic during the Middle Ages flourished through the work of numerous philosophers. A logical treatise by William of Sherwood (ca. 1200–1271) contains the first expression of the "Barbara, Celarent . . ." poem quoted in Section 4.1 of this book, and the *Summulae Logicales* of Peter of Spain (ca. 1205–1277) became the standard textbook in logic for three hundred years. However, the most original contributions from this period were made by William of Ockham (ca. 1285–1347). Ockham extended the theory of modal logic, conducted an exhaustive study of the forms of valid and invalid syllogisms, and further developed the idea of a metalanguage, a higher-level language used to discuss linguistic entities such as words, terms, and propositions.

Toward the middle of the fifteenth century, a reaction set in against the logic of the Middle Ages. Rhetoric largely displaced logic as the primary focus of attention; the logic of Chrysippus, which had already begun to lose its unique identity in the Middle Ages, was ignored altogether, and the logic of Aristotle was studied only in highly simplistic presentations. A reawakening did not occur until two hundred years later through the work of Gottfried Wilhelm Leibniz (1646–1716).

Leibniz, a genius in numerous fields, attempted to develop a symbolic language or "calculus" that could be used to settle all forms of disputes, whether in theology, philosophy, or international relations. As a result of this work, Leibniz is sometimes credited with being the father of symbolic logic. Leibniz's efforts to symbolize logic were carried into the nineteenth century by Bernard Bolzano (1781–1848).

In the middle of the nineteenth century, logic commenced an extremely rapid period of development that has continued to this day. Work in symbolic logic was done by many philosophers and mathematicians, including Augustus De Morgan (1806–1871), George Boole (1815–1864), William Stanley Jevons (1835–1882), and John Venn (1834–1923). The rule bearing De Morgan's name is used in Chapter 6 of this book. Boole's interpretation of categorical propositions and Venn's method for diagramming them are covered in Chapters 3 and 4. At the same time a revival in inductive logic was initiated by the British philosopher John Stuart Mill (1806–1873), whose methods of induction have now become classic.

Across the Atlantic, the American philosopher Charles Sanders Peirce (1839–1914) developed a logic of relations, invented symbolic quantifiers, and suggested the

truth-table method for formulas in propositional logic. These topics are covered in Chapters 5 and 7 of this book. The truth-table method was completed independently by Emil Post (1897–1954) and Ludwig Wittgenstein (1889–1951).

Toward the end of the nineteenth century, the foundations of modern mathematical logic were laid by Gottlob Frege (1848–1925). His *Begriffsschrift* sets forth the theory of quantification presented in Chapter 7 of this text. Frege's work was continued into the twentieth century by Alfred North Whitehead (1861–1947) and Bertrand Russell (1872–1970), whose monumental *Principia Mathematica* attempted to reduce the whole of pure mathematics to logic. The *Principia* is the source of much of the symbolism that appears in Chapters 5, 6, and 7 of this text.

During the twentieth century, much of the work in logic has focused on the formalization of logical systems and on questions dealing with the completeness and consistency of such systems. A now-famous theorem proved by Kurt Gödel (1906–1978) states that in any formal system adequate for number theory there exists an undecidable formula—that is, a formula such that neither it nor its negation is derivable from the axioms of the system. Other developments include multivalued logics and the formalization of modal logic. Most recently, logic has made a major contribution to technology by providing the conceptual foundation for the electronic circuitry of digital computers.

EXERCISE **1.1**

I. Each of the following passages contains a single argument. Using the letters "P" and "C," identify the premises and conclusion of each argument, writing premises first and conclusion last. List the premises in the order in which they make the most sense (usually the order in which they occur), and write both premises and conclusion in the form of separate declarative sentences. Indicator words may be eliminated once premises and conclusion have been appropriately labeled. The exercises marked with a star are answered in the back of the book.

★**1.** Carbon monoxide molecules happen to be just the right size and shape, and happen to have just the right chemical properties, to fit neatly into cavities within hemoglobin molecules in blood that are normally reserved for oxygen molecules. Consequently, carbon monoxide diminishes the oxygen-carrying capacity of blood.

(Nivaldo J. Tro, *Chemistry: A Molecular Approach,* 2nd ed.)

2. Since the good, according to Plato, is that which furthers a person's real interests, it follows that in any given case when the good is known, men will seek it.

(Avrum Stroll and Richard Popkin, *Philosophy and the Human Spirit*)

3. As the denial or perversion of justice by the sentences of courts, as well as in any other manner, is with reason classed among the just causes of war, it will follow that the federal judiciary ought to have cognizance of all causes in which the citizens of other countries are concerned.

(Alexander Hamilton, *Federalist Papers,* No. 80)

★**4.** When individuals voluntarily abandon property, they forfeit any expectation of privacy in it that they might have had. Therefore, a warrantless search or seizure of abandoned property is not unreasonable under the Fourth Amendment.

(Judge Stephanie Kulp Seymour, *United States v. Jones*)

5. Artists and poets look at the world and seek relationships and order. But they translate their ideas to canvas, or to marble, or into poetic images. Scientists try to find relationships between different objects and events. To express the order they find, they create hypotheses and theories. Thus the great scientific theories are easily compared to great art and great literature.

(Douglas C. Giancoli, *The Ideas of Physics,* 3rd ed.)

6. The fact that there was never a land bridge between Australia and mainland Asia is evidenced by the fact that the animal species in the two areas are very different. Asian placental mammals and Australian marsupial mammals have not been in contact in the last several million years.

(T. Douglas Price and Gary M. Feinman, *Images of the Past*)

★7. It really does matter if you get enough sleep. We need sleep to think clearly, react quickly, and create memories. Studies show that people who are taught mentally challenging tasks do better after a good night's sleep. Other research suggests that sleep is needed for creative problem solving.

(U.S. National Institutes of Health, "Your Guide to Healthy Sleep")

8. The classroom teacher is crucial to the development and academic success of the average student, and administrators simply are ancillary to this effort. For this reason, classroom teachers ought to be paid at least the equivalent of administrators at all levels, including the superintendent.

(Peter F. Falstrup, letter to the editor)

9. An agreement cannot bind unless both parties to the agreement know what they are doing and freely choose to do it. This implies that the seller who intends to enter a contract with a customer has a duty to disclose exactly what the customer is buying and what the terms of the sale are.

(Manuel G. Velasquez, "The Ethics of Consumer Production")

★10. Punishment, when speedy and specific, may suppress undesirable behavior, but it cannot teach or encourage desirable alternatives. Therefore, it is crucial to use positive techniques to model and reinforce appropriate behavior that the person can use in place of the unacceptable response that has to be suppressed.

(Walter Mischel and Harriet Mischel, *Essentials of Psychology*)

11. Profit serves a very crucial function in a free-enterprise economy, such as our own. High profits are the signal that consumers want more of the output of the industry. High profits provide the incentive for firms to expand output and for more firms to enter the industry in the long run. For a firm of above-average efficiency, profits represent the reward for greater efficiency.

(Dominic Salvatore, *Managerial Economics,* 3rd ed.)

12. Cats can think circles around dogs! My cat regularly used to close and lock the door to my neighbor's doghouse, trapping their sleeping Doberman inside. Try telling a cat what to do, or putting a leash on him—he'll glare at you and say, "I don't think so. You should have gotten a dog."

(Kevin Purkiser, letter to the editor)

★13. Since private property helps people define themselves, since it frees people from mundane cares of daily subsistence, and since it is finite, no individual

should accumulate so much property that others are prevented from accumulating the necessities of life.

(Leon P. Baradat, *Political Ideologies, Their Origins and Impact*)

14. To every existing thing God wills some good. Hence, since to love any thing is nothing else than to will good to that thing, it is manifest that God loves everything that exists.

(Thomas Aquinas, *Summa Theologica*)

15. Women of the working class, especially wage workers, should not have more than two children at most. The average working man can support no more and the average working woman can take care of no more in decent fashion.

(Margaret Sanger, *Family Limitations*)

★**16.** Radioactive fallout isn't the only concern in the aftermath of nuclear explosions. The nations of planet Earth have acquired nuclear weapons with an explosive power equal to more than a million Hiroshima bombs. Studies suggest that explosion of only half these weapons would produce enough soot, smoke, and dust to blanket the Earth, block out the sun, and bring on a nuclear winter that would threaten the survival of the human race.

(John W. Hill and Doris K. Kolb, *Chemistry for Changing Times,* 7th ed.)

17. An ant releases a chemical when it dies, and its fellows then carry it away to the compost heap. Apparently the communication is highly effective; a healthy ant painted with the death chemical will be dragged to the funeral heap again and again.

(Carol R. Ember and Melvin Ember, *Cultural Anthropology,* 7th ed.)

18. Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good; and for this reason the good has rightly been declared to be that at which all things aim.

(Aristotle, *Nicomachean Ethics*)

★**19.** Poverty offers numerous benefits to the nonpoor. Antipoverty programs provide jobs for middle-class professionals in social work, penology, and public health. Such workers' future advancement is tied to the continued growth of bureaucracies dependent on the existence of poverty.

(J. John Palen, *Social Problems*)

20. Corn is an annual crop. Butcher's meat, a crop which requires four or five years to grow. As an acre of land, therefore, will produce a much smaller quantity of the one species of food than the other, the inferiority of the quantity must be compensated by the superiority of the price.

(Adam Smith, *The Wealth of Nations*)

21. Neither a borrower nor lender be
For loan oft loses both itself and friend,
And borrowing dulls the edge of husbandry.

(William Shakespeare, *Hamlet* I, 3)

★**22.** The stakes in whistleblowing are high. Take the nurse who alleges that physicians enrich themselves in her hospital through unnecessary surgery; the engineer who discloses safety defects in the braking systems of a fleet of new rapid-transit vehicles; the Defense Department official who alerts Congress to military graft