An Altogether Too Brief Introduction to Logic  
for Students of Rhetoric

At the opening of his book on rhetoric, Aristotle claimed that "Rhetoric is the counterpart of Dialectic," thus both drawing a distinction and making a connection between pure logic (dialectic) and the art of persuasion (rhetoric). Other rhetoricians and philosophers have drawn similar distinctions, yet almost all have agreed that no clear line can be drawn between the two studies. It is certainly true that rhetoricians have recognized "logos" as a major element (if not the most significant element) in all persuasive discourse. Traditionally they have followed the lead of Aristotle in holding that rationality is humanity's essential characteristic, holding that, although individuals are often motivated by passions and prejudices, they are usually disposed to follow to the dictates of reason when presented with "reasonable" arguments. We should, therefore, attempt to grasp a few of the basic principles of logic so that, whenever necessary, we may employ this "available means of persuasion" and so that whenever we are presented with an argument that employs logic we will be in a position to evaluate it fairly.

The Question of Definition

First of all, definition is a fundamental principle of exposition and argumentation. In the *Topicae*, one of the works in the *Organon*, Aristotle laid down a method of definition that has remained in use ever since. We put the "thing to be defined" (known as the *species* or *definiendum*) into a larger general class (known as the *genus*) and then separate it from all other members of that class by drawing essential distinctions that set it off from the other members. Such distinctions are called *differentiae*. If we have done all of this correctly and our *differentiae* have distinguished the "thing" completely, we have arrived at an essential definition, that is, a definition that spells out a thing's fundamental nature. For example, Aristotle proposed the definition "man is a rational animal." Man (the thing being defined) is placed in a larger class of things of which he is a member (animals) and then is distinguished from all other animals by the characteristic of "rationality." While the structure to the definition is the same if we say, "man is a bipedal animal," since two-footedness is a quality humans share with other animals, the definition is not essential. Sometimes the *differentiae* can get quite complex.

The Aristotelian definition structure:

- *Definiendum* (or *Species*): the Thing to be defined
- *Genus*: the larger or general class
- *Differentiae*: the specific differences that distinguish this thing from all other members of the genus

Example

- *Definiendum*: screwdriver
- *Genus*: handtool
- *Differentiae*: consisting of a bladed metal shaft affixed to a handle, used for inserting and removing screws
The Question of Cause

Often the differentiae can involve an issue of cause. Up until the modern age, people tended to see four types of causes of a thing: the material cause, the formal cause, the efficient cause, and the final cause. For example, one might define a table as a piece of furniture (genus) made by a carpenter (efficient cause) from wood (material cause), with a broad, flat top resting horizontally on four legs (formal cause) on which one places objects such as dinner dishes (final cause, or purpose of the thing). All of the causes make up the differentiae.

Definition by causation

- Species: Table
- Genus: an item of furniture
- Differentiae:
  - Formal cause—consisting of a flat, horizontal surface
  - Material cause—made of wood, glue, screws, paint, etc.
  - Efficient cause—by a carpenter
  - Final cause—for the purpose of holding objects such as papers, book, dishes, etc.

*However, since "final cause" implies intelligent purpose, many people question the application of these causes to anything other than human-created objects (what exactly is the final cause of an oak tree?). In such cases, many people use a different system of causal analysis, involving necessary cause (that without which an effect cannot under any circumstances occur), sufficient cause (that which makes it possible for a necessary cause to work), proximate cause (agent or circumstance responsible for the sufficient cause), and remote cause or causes (circumstances that explain why the proximate cause acted as it did).

Necessary Cause—That cause without which a given phenomenon cannot, under any circumstances, occur

Example: a child drowned at the beach while playing in the surf.

Necessary Cause of death: Water

Sufficient Cause—the agent or circumstance which made it possible for the Necessary Cause to work

Example: the action of breathing while under water.

Sufficient Cause: the action of breathing while under water.

Proximate Cause—the agent or circumstance responsible of the Sufficient Cause

Example: a strong riptide

Proximate Cause: a strong riptide

Remote Causes—the agents or circumstances explaining the Proximate Cause

Example: an inadequate number of Lifeguards, caused by a budget reduction, caused by an economic recession, caused by …

Remote Causes: an inadequate number of Lifeguards, caused by a budget reduction, caused by an economic recession, caused by …

For example, it is fairly obvious that the necessary cause of a bullet hole is a bullet. Generally we assume that a gun is a sufficient cause, while someone pulling the trigger is responsible for that sufficient cause. Remote causes of a bullet hole may be many: robbery, accident, rage, etc. The advantage of this system is that it tends to be a little more scientific about causes; its disadvantages are rather philosophical and harder to see: it tends to reduce all things (including
human values such as love, altruism, and integrity) to mechanism, removing purpose as a meaningless word in a strictly material universe governed solely by laws of physics.

Whenever we seek to determine cause, we must be careful about what kind we mean. Consider what a coroner would say about the cause of death as opposed to a policeman investigating the crime. What cause would a prosecuting attorney focus on? What causes would a senator or congressman focus on when considering legislation about crime? Each would look at a different level of causation, and each would be, from that perspective, correct.

Logic of a special type underlies arguments about causation: inductive logic. Inductive logic is the use of specific empirical data to reach a conclusion. Usually we refer to this as reasoning from specific to general. Inductive logic can be used to form either generalizations or hypotheses. Generalizations are conclusions drawn after seeing a number of specific examples of the same kind. Examples are a strong form of evidence; since their use is a form of induction, they constitute an appeal to logic, or logos. Aristotle claimed that the use of example was rhetoric's counterpart to "full induction" in formal logic. In truth, absolutely full induction is rarely possible, so even the most scientifically formal arguments will use the persuasive power of multiple examples (usually given in the form of statistics) to make a point. The other use of induction, to form hypotheses, involves using specific empirical data of different kinds to reach a conclusion. A detective might look at items on a desk, an open window, and the location of bloodstains to reach a conclusion. An electronics technician will look at a radar's display, take some voltage and power measurements, and check some switch settings to determine the cause of a problem. Both of these are using forms of induction, yet they are forming hypotheses rather than generalizations.

**Scientific Method**

The real power of inductive reasoning, however, comes when it is combined with deductive reasoning, known as reasoning from general to specific. Deductive reasoning begins with accepted laws and definitions and then applies them to specific instances. We will discuss deductive reasoning in greater depth later, but first let's examine the use of induction and deduction together.

One of the clearest explanations of this combination is found in Robert Pirsig's *Zen and the Art of Motorcycle Maintenance.*

Mechanic's Logic
by
Robert Pirsig

Two kinds of logic are used [in motorcycle maintenance], inductive and deductive. Inductive inferences start with observations of the machine and arrive at general conclusions. For example, if the cycle goes over a bump and the engine misfires, and then goes over another bump and the engine misfires, and goes over another bump and the engine misfires, and then goes over a long stretch of smooth road and there is no misfiring, and then goes over a fourth bump and the engine misfires again, one can logically infer that the misfiring is caused by the bumps. That is induction: reasoning from particular experiences to general truths.

Deductive inferences do the reverse. They start with general knowledge and predict a specific observation. For example, if, from reading the hierarchy of facts about the machine, the mechanic knows the horn of the cycle is powered exclusively by electricity from the battery, then he can logically infer that if the battery is dead the horn will not work. That is deduction.

Solutions of problems too complicated for common sense to solve is achieved by long strings of mixed inductive and deductive inferences that weave back and forth between the observed machine and the mental
hierarchy of the machine found in the manuals. The correct program for this interweaving is formalized as
scientific method.
Actually, I've never seen a cycle-maintenance problem complex enough really to require full-scale formal scientific method. Repair problems are not that hard. When I think of formal scientific method an image sometimes come to mind of an enormous juggernaut, a huge bulldozer-slow, tedious, lumbering, laborious, but invincible. It takes twice as long, five times as long, maybe a dozen times as long as informal mechanic's techniques, but you know in the end you're going to get it. There's no fault isolation problem in motorcycle maintenance that can stand up to it. When you've hit a really tough one, tried everything, racked your brain and nothing works, and you know that this time Nature has really decided to be difficult, you say, "Okay, Nature, that's the end of the nice guy," and you crank up the formal scientific method.
For this you keep a lab notebook. Everything gets written down, formally, so that you know at all times where you are, where you've been, where you're going, and where you want to get. In scientific work and electronics technology this is necessary because otherwise the problems get so complex you get lost in them and confused and forget what you know and what you don't know and have to give up. In cycle maintenance things are not that involved, but when confusion starts, it's a good idea to hold it down by making everything formal and exact. Sometimes just the act of writing down the problems straightens out your head as to what they really are.
The logical statements entered into the notebook are broken down into six categories: (1) statement of the problem, (2) hypotheses as to the cause of the problem, (3) experiments designed to test each hypothesis, (4) predicted results of the experiments, (5) observed results of the experiments, and (6) conclusions from the results of the experiments. This is not different from the formal arrangement of many college and high-school lab notebooks, but the purpose here is no longer just busywork. The purpose now is precise guidance of thoughts that will fail if they are not accurate.
The real purpose of scientific method is to make sure Nature hasn't misled you into thinking you know something you don't actually know. There's not a mechanic or scientist or technician alive who hasn't suffered from that one so much that he's not instinctively on guard. That's the main reason why so much scientific and mechanical information sounds so dull and so cautious. If you get careless or go romanticizing scientific information, giving it a flourish here and there, Nature will soon make a complete fool out of you. It does it often enough anyway even when you don't give it opportunities. One must be extremely careful and rigidly logical when dealing with Nature: one logical slip and an entire scientific edifice comes tumbling down. One false deduction about the machine and you can get hung up indefinitely.
In Part One of formal scientific method, which is the statement of the problem, the main skill is in stating absolutely no more than you are positive you know. It is much better to enter a statement "Solve Problem: why doesn't cycle work?" which sounds dumb but is correct, than it is to enter a statement "Solve problem: What is wrong with the electrical system?" when you don't absolutely know the trouble is in the electrical system. What you should state is "Solve Problem: what is wrong with cycle?" and then state as the first entry of Part Two: "Hypothesis Number One: The trouble is in the electrical system." You think of as many hypotheses as you can; then you design experiments to test them to see which are true and which are false.
This careful approach to the beginning questions keeps you from taking a major wrong turn which might cause you weeks of extra work or can even hang you up completely. Scientific questions often have a surface appearance of dullness for this reason. They are asked in order to prevent dumb mistakes later on.
Part Three, that part of the formal scientific method, called experimentation, is sometimes thought of by romantics as all of science itself because that's the only part with much visual surface. They see lots of test tubes and bizarre equipment and people running around making discoveries. They do not see the experiment as part of a larger intellectual process and so they often confuse experiments with demonstrations, which look the same. A man conducting a gee-whiz science show with fifty-thousand dollars' worth of Frankenstein equipment is not doing anything scientific if he knows beforehand what the results of his efforts are going to be. A motorcycle mechanic, on the other hand, who honks the horn to see if the battery works is informally conducting a true scientific experiment. He is testing a hypothesis by putting the question to Nature. The TV scientist who mutters sadly, "The experiment is a failure; we have failed to achieve what we had hoped for," is suffering mainly from a bad scriptwriter. An experiment is never a failure solely because it fails to achieve predicted results. An experiment is a failure only when it also fails adequately to test the hypothesis in question, when the data it provides doesn't produce anything one way or the other.
Skill at this point consists of using experiments that test only the hypothesis in question, nothing less, nothing more. If the horn honks, and the mechanic concludes that the whole electrical system is working, he is in deep trouble. He has reached an illogical conclusion. The honking horn only tells him that the battery and
horn are working. To design an experiment properly he has to think very rigidly in terms of what directly causes what. This you know from the hierarchy. The horn doesn't make the cycle go. Neither does the battery, except in a very distinct way. The point at which the electrical system directly causes the engine to fire is at the spark plugs, and if you don't test here, at the output of the electrical system, you will never really know whether the failure is electrical or not.

To test properly the mechanic removes the plug and lays it against the engine so that the base of the plug is electrically grounded, kicks the starter lever, and watches the spark-plug gap for a blue spark. If there isn't any, he can conclude one of two things: (a) there is an electrical failure or (b) his experiment is sloppy. If he is experienced he will try it a few more times, checking connections, trying every way he can think of to get that plug to fire. Then, if he can't get it to fire, he finally concludes that (a) is correct, there's an electrical failure, and the experiment is over. He has proved that his hypothesis is correct.

In the final category, conclusions, skill comes in stating no more than the experiment has proved. It hasn't proved that when he fixes the electrical system the motorcycle will start. There may be other things wrong. But he does know that the motorcycle isn't going to run until the electrical system is working and he sets up the next formal question: "Solve problem: what is wrong with the electrical system?"

He then sets up hypotheses for these and tests them. By asking the right questions and choosing the right tests and drawing the right conclusions the mechanic works his way down the echelons of the motorcycle hierarchy until he has found the exact specific cause or causes of the engine failure, and then he changes them so that they can no longer cause the failure.

An untrained observer will see only physical labor and often get the idea that physical labor is mainly what the mechanic does. Actually the physical labor is the smallest and easiest part of what the mechanic does. By far the greatest part of his work is careful observation and precise thinking. That is why mechanics sometimes seem so taciturn and withdrawn when performing tests. They don't like it when you talk to them because they are concentrating on mental images, hierarchies, and not really looking at you or the physical motorcycle at all. They are using the experiment as part of a program to expand their hierarchy of knowledge of the faulty motorcycle and compare it to the correct hierarchy in their mind. They are looking at underlying form.

Clearly, deductive logic and inductive logic are powerful tools of thought, and therefore powerful tools of persuasion.

**Fallacies**

It is also true that just the appearance of logic has a powerful persuasive effect, even when the logic itself is skewed. As a result, we must be on the alert for errors in reasoning in our own arguments and in the arguments of others. In logic errors are known as fallacies. Generally speaking, there are two main categories of fallacies: material (or informal) fallacies and formal fallacies.

**Material Logic: Questions of Definitions and Facts**

Consider the following argument:

**All men are mortal.**  
**No women are men.**  
**Therefore, no women are mortal.**

It is fairly obvious that, among other things, the argument has a major error involving the word "men." In the first statement, the arguer seems to use the term to mean "human beings," while in the second it seems to indicate males. Shifting definitions of a term in the middle of an argument has long been a source of fallacious reasoning. It has a special name: *equivocation*.
greater when terms like democracy, fascism, liberty, theoretical, scientific, and duty are used. Such terms are, first of all, very hard to define to begin with. Second, they are often loaded with emotional connotations. As a result, arguments involving these terms frequently degenerate into parallel monologues and the resulting failure to communicate leads to hostility.

Further, equivocation is just one type of "informal" fallacy. A glance at almost any rhetorical handbook will reveal such errors as begging the question, ad hominen, post hoc, and false dilemma. Here is a short list and some examples

(1) **Ad hominem** is a personal attack on an opponent that draws attention away from the issues under consideration.
**Faulty** We should not vote for the governor's proposed tax reform because he drank too much when he was a college student. [Whether or not the governor drank too much when he was young may reveal something about his character, but that fact says little about the value of the tax reform proposal. It may not even say much about the governor today.]

(2) **Appeal to tradition** is an argument that says something should be done a certain way simply because it has been done that way in the past.
**Faulty** We should not allow women to join this club because we have never let women join before. [Times change; what was acceptable in the past is not necessarily acceptable in the present.]

(3) **Bandwagon** is an argument saying, in effect, “Everyone’s doing or saying or thinking this, so you should too.”
**Faulty** Everyone cheats on exams, so why shouldn’t you? [The majority is not always right.]

(4) **Begging the question** is a statement that assumes what needs to be proved.
**Faulty** We need to fire the thieves in the police department. [Are there thieves working in the police department? This point needs to be established before the rest of the argument can even be considered.]

(5) **Equivocation** is an assertion that falsely relies on the use of a term in two different senses.
**Faulty** We know this is a natural law because it feels natural. [When first used, natural means principles derived from nature or reason; when used again, it means easy or simple because of being in accord with one’s own nature.]

(6) **False analogy** is the assumption that because two things are alike in some ways, they must be alike in others.
**Faulty** Fred Johnson will be a good U.S. President because he used to be a good quarterback. [The differences between playing football and serving as President are greater than the similarities.]

(7) **False authority** is the assumption that an expert in one field can be a credible expert in another.
**Faulty** The U.S. defense budget must be cut, as the country’s leading pediatrician has shown. [Pediatric medicine is unrelated to economics or political science.]
(8) **False cause** is the assumption that because one event follows another, the first is the cause of the second—sometimes called *post hoc, ergo propter hoc* ("after this, so because of this").

**Faulty** Our new school superintendent took office last January, and crime has increased 14 percent. [The assumption is that the school superintendent is responsible for the increase in crime, an assumption unlikely to be true. Last week I noticed many people coming to work carrying umbrellas. Later that day it started raining. So, carrying umbrellas causes rain.]

(9) **False dilemma** means stating that only two alternatives exist when in fact there are more than two (sometimes called the *either/or* fallacy).

**Faulty** We have only two choices: to build more nuclear power plants or to be completely dependent on foreign oil. [Other possibilities exist.]

Another source of material error is simply incorrect facts. It does little good to use a correct reasoning process if your definitions or data are incorrect. Therefore, there are always two issues: the correctness of the reasoning process (*form* of the argument) and the correctness of the statements, including the definitions implied (*material* aspects)—**formal logic and material logic**. Consider the following arguments:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cats are animals</td>
<td>All cats are animals</td>
</tr>
<tr>
<td>All tigers are animals</td>
<td>All pigs are animals</td>
</tr>
<tr>
<td>therefore: all tigers are cats</td>
<td>therefore: all pigs are cats</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cats are mammals</td>
<td>All pigs are wine bottles</td>
</tr>
<tr>
<td>All tigers are cats</td>
<td>All cabbages are pigs</td>
</tr>
<tr>
<td>Therefore: all tigers are mammals</td>
<td>Therefore: all cabbages are wine bottles</td>
</tr>
</tbody>
</table>

In each of the first two arguments (expressed in a form called a syllogism) we find the first two statements (called premises or propositions) seem true, yet the conclusion of B is clearly ridiculous. Yet that conclusion is in truth no more ridiculous than the conclusion of A. The two arguments have exactly the same structure or form; they both exhibit a common error in structure known as "undistributed middle term" (more on this later). Notice that C and D have the same basic form or structure (in this case a correct one). The premises of D, however, are simply not factually (materially) true and therefore its conclusion is meaningless. Formal logic tells us that arguments A and B are invalid because an incorrect reasoning process has been applied. Material logic tells us that D is bad because non-factual data has been applied. Thus the only "good" argument is C.

**Material logic**, establishing facts and definitions, focuses on the truth of propositions. It often requires a close examination of language itself as well as a good us of inductive logic. It has advanced considerably over the years as general scientific knowledge has advanced.

**Formal logic**, however, has changed little since Aristotle apart from some improvements in notation systems.
Formal Deductive Logic

Formal deductive logic is the process of using premises (propositions established as true through material logic) to derive previously unknown truths. The premises tend to be general in nature (definitions, generalized claims about classes of things, or generalized claims about specific things). Since deductive logic uses propositions, we must first examine these. Remember, that formal logic is not concerned with the truth of the propositions (that's the function of material logic).

Propositions: Parts, Types, and Representations

We shall begin with the categorical syllogism, a type of argument whose premises involve categories, or classes of things. There are four types of propositions involved in categorical syllogisms: universal affirmative (a statement affirming something about all members of a class), universal negative (a statement denying something about all members of a class), particular affirmative (a statement affirming something about at least one member of a class), and particular negative (a statement denying something about at least one member of a class).

In an effort to help students memorize these types of propositions, teachers of the Middle Ages developed some mnemonic devices. Using the first two vowels from the Latin verb AFFIRM (meaning "I affirm"), they labeled the two affirmative propositions type A and type I. Similarly, they used the Latin verb NEGO ("I deny") to label the two negative statements as type E and type O.

Further, over the years many methods of representing the statements have been developed. First there is a propositional form that has been around for quite some time. Second, there is a Boolean algebra form that makes handling logical propositions as straightforward as mathematics. In fact, Boolean algebra is the basis for computer circuitry. Finally, there is a visual form known as a Venn diagram. There are some other forms, but these are the main ones and most of the others are variations of these. All the forms make handling the propositions easier, especially in complex arguments involving formal logic. Although such forms are rarely necessary in rhetoric, an introduction to them is helpful.

Universal Affirmative (type A)

All Scientists are Philosopers

The first term is the Subject (S) term. The second term is the Predicate (P) term. The statement affirms that all the things in the class of things known as scientists are are also in the larger class of things known as philosophers.
The diagram, called a Venn diagram, is a simplified way of visualizing the statement. The circle on the left is thought of as containing every possible thing that could be called a scientist, while the circle on the right contains everything which is a philosophers. Thus there are four possible areas:

1. Things that are Scientists, but not Philosophers
2. Things that are Scientists and Philosophers
3. Things that are Not Scientists but are Philosophers
4. Things that are neither Scientists not Philosophers
5. Things that are neither Scientists nor Philosophers

The small line above a letter indicates "not." "Not S" is the Complement of S, that is, everything which is not an S. "Not Dog" is everything not a dog: televisions, chocolate, pencils, kite string, lawn clippings, etc.

\[ S \setminus P \]

Then the statement "All Scientists are Philosophers" (or "All S are P") is expressed by shading out the area that would be "Things that are Scientists but not Philosophers," indicating that there is no such thing. Remember, the shaded area is being defined out of existence.

This Proposition can be expressed in several ways, all meaning the same thing:

- All S are P [standard form]
- Each S is a P
- Any S is a P
- Every S is a P
- If a thing is an S, then it is a P
- An S must be a P
- Only a P can be an S

\[ S \setminus P = \emptyset \]

One advantage of the Boolean expression is that it reduces the statement to a form of mathematics that enables logicians to evaluate long chains of statements in a symbolic fashion. Further, this math forms the basis of all computer circuitry. Imagine an electronic switch that has two inputs and one output. When one input is "on" and the other is "off" the circuit turns itself off and gives no output.
A modern computer is composed of billions (literally) of such switches whose outputs, in patterns of on and off, form a code, not unlike Morse Code.

Thus there is an unbroken chain between Aristotle, who first named and classified the different types of propositions, and the Internet.

**Universal Negative (Type E)**
No Scientists are Philosophers

The statement denies that any of the things in the class known as Scientists are at the same time members of the class of things known as philosophers, meaning that scientists and philosophers are two entirely different things, like cheesecake and garden hoses. The two circles below express the same idea.

The Universal Negative relationship can be expressed in several ways

- No S are P [standard form]
- Nothing that is an S is a P
- If something is an S, it is not a P
- An S cannot be a P
The Boolean expression for a Type E statement is

$$S \cap P = \emptyset$$

The equation is read "The set of things that are both S and P is an empty set."

**Particular Affirmative (Type I)**

Some Scientists are Philosophers

The large X in the diagram indicates that the area definitely contains something. We have at least one example of an S that is also a P. Thus Particular affirmative statements also come in a variety of forms.

- Some S are P [standard form]
- At least one S is a P
- There exists an S that is a P
- Something is both S and P

The Boolean expression is

$$S \cap P \neq \emptyset$$

One of the most important things to understand about a particular statement is that it is essentially a claim of observation. That is, it says you have an example (or examples) of something, but it makes no implications beyond that. If you observe a person drop three quarters into a cup, you can safely claim "Some coins in the cup are quarters." However, you cannot assume that some coins in the cup are not quarters (or, in fact, that there are any other coins in the cup at all). The particular statement, if true, shows clearly that the cup is not empty, but it says little else.

The principle at work here is the idea that examples can disprove claims with certainty, but they cannot prove with certainty. If you ask a room full of people to raise their hands if they voted for a democrat in the last election, you cannot assume anything for sure about those who did not raise their hands. They may have voted for a republican; they may not have voted at all; they may have even voted for a democrat but declined to raise their hands; they may not have heard
your request. They only thing you can be sure of is that you have demonstrated that the claim "Everyone here voted for a republican in the last election" would be false.

**Particular Negative (Type O)**

Some Scientists are not Philosophers

A type O statement says that I have at least one case of S that is not P. The large X indicates that the area has something in it. It is not an empty set. Again, the relationship may be expressed in a variety of ways:

- Some S are Not P [standard form]
- At least one S is not a P
- Not every S is a P
- Not all S are P
- Something exists which is an S but not a P

The Boolean expression is

\[ S \bar{P} \neq \emptyset \]

the set of things that are S but not P is not empty

As in the case of the type I statement, the particular claim can disprove a universal claim, but cannot establish one with certain. If someone drops a quarter into a cup, I know that the claim "All the coins in the cup are pennies" is false. I cannot prove what else is or isn't in the cup.

In ordinary conversation and in most persuasive arguments, statements are not presented in the Standard propositional forms, partly because extensive use of "to be" verb forms renders the style flat and unexpressive. However, it is a relatively easy task to convert a claim such as "fluorocarbons destroy the atmosphere" to a proposition such as "all fluorocarbons are atmosphere harming substances." While transitive verbs are rhetorically more effective, linking verbs are easier to work with logically.

Two things must be understood about individual propositions before we can begin combining them into arguments. First, there are specific relationships between them, meaning that a knowledge of the truth or falseness of a specific proposition very often leads to knowledge
about the others. These are called **Immediate Inferences**, that is, inferences which may be drawn with no other fact or knowledge than the truth or falseness of a single claim. Some of these relationships can be expressed in what has been traditionally called the "square of oppositions." Second, these propositions have a set of "equivalent statements" that may be substituted in their place-or more usefully, may be used to reduce convoluted double talk to simple statements. For example, the somewhat mind-twisting statement "some non-detectives are not non-policemen" reduces to "some policemen are not detectives." Both the square of oppositions and the equivalent statements give us immediate inferences, that is conclusions that can be drawn immediately from a single proposition, without further knowledge. Such immediate inferences can be very useful in forming your own arguments and in understanding the arguments of others.

**The Traditional Square of Oppositions**
The diagram illustrates a number of relationships that become obvious with a little thought.

1. **Contradiction.** If the A-Statement that all scientists are philosophers is true, then the corresponding O-Statement that some scientists are not philosopher cannot be true. (A single contradictory example disproves the universal.) If the A-Statement that all scientists are philosophers is false, then the corresponding O-Statement that some scientists are not philosopher must be true. That is, an A-Statement and its corresponding O-Statement are contradictory; one must be true and the other false. All the contradictory relationships may be expressed as follows:

   **Contradiction = One true, One false**

   - If A is true, O must be false
   - If O is true, A must be false
   - If E is true, I must be false
   - If I is true, E must be false

   This relationship simply says that a thing either exists or does not exist. There is no middle ground. This "law of non-contradiction" is an important tool of persuasive discourse.

2. **Contrary** statements cannot both be true at the same time. If all S are P, then it cannot be true that no S are P.

   However, do not mistake a contrary relationship for a contradictory one. While A and E cannot both be true at the same time, it is perfectly possible for them both to be false (if we're dealing with a mixed group, with some scientists being philosophers and some not). (Confusion of contrary relationships with contradictory ones creates a false dilemma—a common logical fallacy.) The contrary relationships may be expressed as follows:

   **Contrary = Not both True**

   - If A is true, E is false
   - If A is false, nothing can be determined about E
   - If E is true, A is false
   - If E is false, nothing can be determined about A

3. **Subcontrary** statements cannot both be false at the same time, but they may both be true (if we’re dealing with a mixed group, with some scientists being philosophers and some not).

   **Subcontrary = Not both False**

   - If I is false, O is true
   - If I is true, nothing can be determined about O
   - If O is false, I is true
   - If O is true, nothing can be determined about I

4. **Subalternation.** Combining these three relationships produces a fourth relationship. Looking at the square, consider the following: Assume the A-Statement is true; then E must be false (contrary). Next, since E is shown to be false, I must be true
(contradiction). Thus a true A-statement assures us that its corresponding I statement must also be true. All the subalternate relationships may be expressed as follows.

<table>
<thead>
<tr>
<th>A is true</th>
<th>I is true</th>
<th>A is false</th>
<th>I is false</th>
</tr>
</thead>
<tbody>
<tr>
<td>I is true</td>
<td>A is false</td>
<td>E is true</td>
<td>O is true</td>
</tr>
<tr>
<td>E is false</td>
<td>O is false</td>
<td>E is true</td>
<td>O is true</td>
</tr>
<tr>
<td>A is false</td>
<td>I is not determinable</td>
<td>E is false</td>
<td>O is not determinable</td>
</tr>
<tr>
<td>I is true</td>
<td>A is not determinable</td>
<td>E is false</td>
<td>O is not determinable</td>
</tr>
</tbody>
</table>

A word of warning: these relationships hold true only if we are dealing with things that actually exist. The use of this square of oppositions in conjunction with things that do not actually exist produces a formal fallacy known as the existential fallacy. The only relationship that will still hold true is contradiction.

This is called the modern square of oppositions. It shows the only provable relationships when the existence of things has not been established. It is important to understand, for example what it means when we say "The Type I statement that 'Some unicorns are blue' is false." With the Traditional square we would conclude (by the subcontrary rule) that the Type O statement "Some unicorns are not blue" would be true. But if unicorns do not exist, then that statement would also be false, not because they are some color other than blue, but because there are no unicorns.

These relationships are frequently (and properly) listed among the “Common Topics” used by rhetoricians to “discover” arguments. They are also used, perhaps even more often, to refute arguments.
Other Immediate Inferences
There are some other immediate inferences that can be derived by transposing and negating elements in propositions. These inferences are called equivalent statements. They are Conversion (reversing the subject and predicate terms), Obversion (giving opposite truth values to the subject and predicate terms), and Contraposition (doing both). You can see these equivalent statements, along with a summation of other points in the chart below. One of the greatest uses of these equivalent statements is in unraveling convoluted sentences.

<table>
<thead>
<tr>
<th>Type A</th>
<th>Type E</th>
<th>Type I</th>
<th>Type O</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Universal Affirmative</td>
<td>Universal Negative</td>
<td>Particular Affirmative</td>
</tr>
<tr>
<td>sample</td>
<td>All S are P</td>
<td>No S are P</td>
<td>Some S are P</td>
</tr>
<tr>
<td>An older propositional form</td>
<td>All S &lt; P</td>
<td>No S &lt; P</td>
<td>Some S &lt; P</td>
</tr>
<tr>
<td>Boolean form</td>
<td>S ∨ P = ø</td>
<td>S P = ø</td>
<td>S P ≠ ø</td>
</tr>
<tr>
<td>Venn diagram</td>
<td><img src="image" alt="Venn Diagram for Type A" /></td>
<td><img src="image" alt="Venn Diagram for Type E" /></td>
<td><img src="image" alt="Venn Diagram for Type I" /></td>
</tr>
</tbody>
</table>

Equivalent statements may be substituted for the statements above

- **Conversion** (reverse S and P)
  - Not equivalent
  - No P are S (equivalent)
  - Some P are S (equivalent)
  - Not equivalent
- **Obversion** (opposite values of S and P)
  - No S are not P (equivalent)
  - All S are non-P (equivalent)
  - Some S are not non-P (equivalent)
  - Some S are non-P (equivalent)
- **Contraposition** (reverse and opposite values of S and P)
  - All non P are non-S (equivalent)
  - Not equivalent
  - Not equivalent
  - Some non-P are not non-S (equivalent)

**Distribution of terms**

<table>
<thead>
<tr>
<th>Subject term distributed</th>
<th>Both terms distributed</th>
<th>Neither term distributed</th>
<th>Predicate term distributed</th>
</tr>
</thead>
</table>

The concept of distribution of terms becomes important when combining propositions into syllogisms.

Distribution indicates the full extension of a term. A distributed term covers all members in the class denoted. Obviously in a type A statement (all dogs are mammals) the subject term is distributed simply because of the term “all.” In an E statement, both the predicate and subject terms are distributed because all members of both the subject class and the predicate are mutually exclusive. In an I statement, no terms are distributed. The O statement is sometimes
more difficult to comprehend. It does indicate something about every member of the predicate class; namely, they are not the particular subject.

This concept of distribution is not easily grasped, especially as it involves predicate terms. Here are some principles of distribution that may help:

1. The subject terms of universals (A and E) are distributed (because they are, by definition, universal)
2. The predicate terms of Affirmatives (A and I) are not distributed
3. The predicate terms of Negatives (E and O) are distributed.

**Categorical Syllogisms**

It is when the propositions are combined into syllogisms that the usefulness of deductive logic to argument becomes more apparent. The syllogism is made up of three propositions: a major premise, a minor premise, and a conclusion. These three propositions will contain three terms: a major term, a minor term, and a middle term. Consider the following syllogism

\[
\begin{align*}
\text{All Scientists} & \text{ are Philosophers} \quad \text{Major premise} \\
\text{All Thinkers} & \text{ are Scientists} \quad \text{Minor Premise} \\
\text{All Thinkers} & \text{ are Philosophers} \quad \text{Conclusion}
\end{align*}
\]

The **Major term (Philosophers)** is the largest class of things and the predicate term of the conclusion.

The **Minor term (Thinkers)** is the smallest class and the subject term of the conclusion.

The **Middle term (scientists)** does not appear in the conclusion.

Since all of the propositions in this particular syllogism are universals, it is fairly easy to follow the reasoning. It could be represented by the concentric circles below.

![Diagram of syllogism]

**Philsophers**

**Scientists**

**Thinkers**
Of course syllogisms may include E, I, and O propositions as well. Additionally, “equivalent statements” may appear. Here are some rules for a valid syllogism:

1. There must be 3 (only) terms (Major, Minor, Middle).
2. The Middle Term must be distributed at least once.
3. No term may be distributed in the conclusion unless it was distributed in the premise.
4. If one premise is particular, the conclusion must be particular; no conclusion may be drawn from two particular premises.
5. If one premise is negative, the conclusion must be negative; no conclusion may be drawn from two negative premises.
6. Two universal premises can produce a valid particular conclusion only if is can be assumed that the terms refer to actual things (existential fallacy).

You can also check the validity of a categorical syllogism by using a Venn diagram:

![Venn diagram for a categorical syllogism](image)

All members the “T” term are contained within the "P" circle; that is, there are no thinkers who are not philosophers (the equivalent obversion of the A-statement "All thinkers are philosophers")

To create a Venn diagram for each premise, construct the three-circle pattern
Label the circles. Then diagram each of the premises, ignoring the other premise as you do. Then examine the diagram to see if it expresses the conclusion. The diagram will work no matter how it is rotated. In general, diagram a Particular premise (I or O), after a universal and be very careful about the placement of the X, not assuming it is a particular area if there is no claim that it must be in that area.

![Diagram](image)

If you know a X goes in the S circle, place it in an area that is not blacked out. If no area is blacked-out, place the X so that it reveals the ambiguity.

Let’s try a syllogism that involves a particular term

**All fire fighters are public employees**
**Some students are fire fighters**
**Some students are public employees**

The major premise is a Universal Affirmative.

![Diagram](image)

The minor premise is a Particular Affirmative.
Now examine the complete diagram. The faint gray arrow shows how the axis of the minor premise is rotated. We could just as easily have rotated the axis of the major premise. As you see, the conclusion, some students are public employees, is valid.

Some people find the Venn diagram to be more useful in analyzing syllogisms than using the rules listed earlier. As pointed out earlier, in practice rhetoricians rarely employ full syllogisms. Instead, the argument is more likely to sound like this: Of course all tigers are mammals; after all, they are cats. Frequently people give their claim (conclusion) first and reasons (premises) second. Notice also that something is missing: the major premise “All cats are mammals.” Whenever the syllogism is missing a premise, it is referred to as an **enthymeme**. Enthymemes can be handled (with some difficulty) by laying out the parts in syllogistic form and supplying the missing items. Since deductive arguments are usually expressed in persuasive arguments through enthymemes rather than syllogisms, an understanding of their use is important. However, there may be an easier way for rhetoricians to understand and to use both enthymemes and syllogisms: the **Toulmin method**. More on this later.

**Hypothetical Syllogisms**

One of the “Common Topics” long used by rhetoricians is that of “Antecedent and Consequent.” Here too the rhetorician is employing “logos.” First of all, we will make a small distinction here between “antecedent and consequence: and “cause and effect” as common topics. “Antecedent and Consequence” is going to be used primarily in deductive logic, drawing specific conclusions from propositions (called “hypothetical propositions,” while causal analysis (determination of
cause) can be a very complex problem requiring use of an “inductive method” or both induction and deduction in a series of tests or experiments involving the scientific method.

Arguments involving the topic of antecedent and consequence frequently take the form of a hypothetical syllogism (also called “conditional” syllogism). Such a syllogism begins with a “conditional” or “hypothesis” proposition, such as the following:

**If it rains, then all your chalk drawings will be ruined.**

The proposition has two parts, the antecedent (the “if” part) and the consequent (the “then” part). A relationship between the antecedent and the consequent is being claimed. However, the nature of that relationship is very important to understand. The proposition is claiming that the truth of the antecedent implies the truth of the consequent, but not vice versa. If we **affirm the antecedent**, we also affirm the consequent:

\[
\text{If it rains, then all your chalk drawings will be ruined.} \quad \text{if } P, \text{ then } Q \\
\text{It has rained.} \quad P \\
\text{Therefore, all your chalk drawings are ruined. (VALID)} \quad Q
\]

Affirming the consequent, however, does not affirm the antecedent.

\[
\text{If it rains, then all your chalk drawings will be ruined.} \quad \text{if } P, \text{ then } Q \\
\text{All your chalk drawings are ruined} \quad Q \\
\text{Therefore it has rained. (INVALID)} \quad P (\text{not valid})
\]

Clearly, any number of things could have ruined the chalk drawings other than rain: water sprinklers, malicious children, etc. Thus **affirming the consequent** is a logical fallacy.

It is also possible to construct an argument involving the hypothetical syllogism using denial rather than affirmation. **Denying the consequent** produces a valid denial of the antecedent:

\[
\text{If it rains, then all your chalk drawings will be ruined.} \quad \text{if } P, \text{ then } Q \\
\text{Your chalk drawings have not been ruined.} \quad \text{not } Q \\
\text{Therefore it has not rained. (VALID)} \quad \text{not } P
\]

**Denying the antecedent**, however, leads nowhere.

\[
\text{If it rains, then all your chalk drawings will be ruined.} \quad \text{if } P, \text{ then } Q \\
\text{It has not rained.} \quad \text{not } P \\
\text{Therefore your chalk drawings have not been ruined. (INVALID)} \quad \text{not } Q (\text{not valid})
\]

Clearly again the drawings could have ruined by other events. Thus in summary:

- Affirming the antecedent affirms the consequent.
- Affirming the consequent produces no valid conclusion.

Denying the consequent denies the antecedent.
Denying the antecedent produces no valid conclusion.

Take note of the number of times you will hear the two invalid forms used in advertising rhetoric.

There is another form of the hypothetical proposition that establishes exclusiveness:

If (and only if) $P$, then $Q$

This would be a claim that the only way your chalk drawings could be ruined would be by rain. We call such a statement, “Material equivalence.” The truth of either one automatically implies the truth of the other.

Beyond the hypothetical syllogism is a whole range of formal deductive logic used to combine and compare statements and to draw conclusions from complicated data. This “propositional logic” (or propositional calculus) is a bit beyond our immediate purpose, although it is quite useful to the rhetorician involved in complex “logos” arguments.

A Look at Inductive Methods

With very little exaggeration it could be said that the development of systematic inductive reasoning has created the modern, scientific world we live in. Many have attempted to trace the origin of this phenomenon, and the subject is an important part of the history of ideas. Some say it all begins with the renaissance; others say the rediscovery of Aristotle in the thirteenth planted the seed. Copernicus, Galileo, Bacon, Kepler, Newton—a great many people are involved. But in effect, a complete intellectual revolution took place between 1500 and 1700, and to a large degree it involved an acceptance (and often a rather grudging acceptance) that the world around us is “real,” that it obeys some simple scientific “laws,” and that these laws can be determined by observation and reason.1 The purpose of modern science is primarily to discover the causes of the phenomena observed in nature (whereas prior to this, natural phenomena were studied primarily to determine their purposes. You can see the difference by looking back to the section discussing the two systems used to discuss “cause.”

There are some important principles involved in the use of induction for causal analysis that may be of use to the rhetorician. The first of these is observation. Almost any writing course in college begins with “description,” treating it as equal to (or even one of) the common topics. Description involves the use of sensory data in writing. Usually, description is taught as a method of creating an emotional reaction in the reader—that is, as a tool of “pathos.” But in a very real sense, all modern science begins with observation.

Consider the following personal narrative:

Take this Fish and Look at It
Samuel Scudder

It was more than fifteen years ago that I entered the laboratory of Professor Agassiz, and told him I had enrolled my name in the Scientific School as a student of natural history. He asked me a few
questions about my object in coming, my antecedents generally, the mode in which I afterwards proposed to use the knowledge I might acquire, and, finally, whether I wished to study any special branch. To the latter I replied that, while I wished to be well grounded in all departments of zoology, I purposed to devote myself specially to insects.

"When do you wish to begin?" he asked.
"Now," I replied.

This seemed to please him, and with an energetic "Very well." he reached from a shelf a huge jar of specimens in yellow alcohol. "Take this fish," he said, "and look at it; we call it a haemulon; by and by I will ask what you have seen."

With that he left me, but in a moment returned with explicit instructions as to the care of the object entrusted to me.

"No man is fit to be a naturalist," said he, "who does not know how to take care of specimens." I was to keep the fish before me in a tin tray, and occasionally moisten the surface with alcohol from the jar, always taking care to replace the stopper tightly. Those were not the days of ground-glass stoppers and elegantly shaped exhibition jars; all the old students will recall the huge neckless glass bottles with their leaky, wax-besmeared corks, half eaten by insects, and begrimed with cellar dust. Entomology was a cleaner science than ichthyology, but the example of the Professor, who had unhesitatingly plunged to the bottom of the jar to produce the fish, was infectious; and though this alcohol had a "very ancient and fishlike smell," I really dared not show any aversion within these scared precincts, and treated the alcohol as though it were pure water. Still, I was conscious of a passing feeling of disappointment, for gazing at a fish did not commend itself to an ardent entomologist. My friends at home, too, were annoyed when they discovered that no amount of eau-de-cologne would drown the perfume which haunted me like a shadow.

In ten minutes I had seen all that could be seen in that fish, and started in search of the Professor—who had, however, left the Museum; and when I returned, after lingering over some of the odd animals stored in the upper apartment, my specimen was dry all over. I dashed the fluid over the fish as if to resuscitate the beast from a fainting fit, and looked with anxiety for a return of the normal sloppy appearance. This little excitement over, nothing was to be done but to return to a steadfast gaze at my mute companion. Half an hour passed—an hour—another hour; the fish began to look loathsome. I turned it over and around; looked it in the face—ghastly; from behind, beneath, above, sideways, at a three-quarters' view—just as ghastly. I was in despair; at an early hour I concluded that lunch was necessary; so, with infinite relief, the fish was carefully replaced in the jar, and for an hour I was free.

On my return, I learned that Professor Agassiz had been at the Museum, but had gone, and would not return for several hours. My fellow-students were too busy to be disturbed by continued conversation. Slowly I drew forth that hideous fish, and with a feeling of desperation again looked at it. I might not use a magnifying glass; instruments of all kinds were interdicted. My two hands, my two eyes, and the fish; it seemed a most limited field. I pushed my finger down its throat to feel how sharp the teeth were. I began to count the scales in the different rows, until I was convinced that was nonsense. At last a happy thought struck me—I would draw the fish; and now with surprise I began to discover new features in the creature. Just then the Professor returned.

"That is right," said he; "a pencil is one of the best of eyes. I am glad to notice, too, that you keep your specimen wet and your bottle corked."

With these encouraging words, he added:
"Well, what is it like?"

He listened attentively to my brief rehearsal of the structure of parts whose names were still unknown to me: the fringed gill-arches and movable operculum; the pores of the head, fleshy lips and lidless eyes; the lateral line, the spiny fins and forked tail; the compressed and arched body. When I finished, he waited as if expecting more, and then, with an air of disappointment:

"You have not looked very carefully: why," he continued more earnestly, "you haven't even seen one of the most conspicuous features of the animal which is plainly before your eyes as the fish itself; look again, look again!" and he left me to my misery.

I was piqued; I was mortified. Still more of that wretched fish! But now I set myself to my task with a will, and discovered one new thing after another, until I saw how just the Professor's criticism had been. The afternoon passed quickly; and when, towards its close, the Professor inquired:
"Do you see it yet?"
"No," I replied, "I am certain that I do not, but I see how little I saw before."
"That is next best," said he, earnestly, "but I won't hear you now; put away your fish and go home; perhaps you will be ready with a better answer in the morning. I will examine you before you look at the fish."

This was disconcerting. Not only must I think of my fish all night, studying, without the object before me, what the unknown but most visible feature might be; but also, without reviewing my discoveries, I must give and exact account of them the next day. I had a bad memory; so I walked home by Charles River in a distracted state, with my two perplexities.

The cordial greeting from the Professor the next morning was reassuring; here was a man who seemed to be quite as anxious as I that I should see for myself what he saw.

"Do you perhaps mean," I asked, "that the fish has symmetrical sides with paired organs?"

His thoroughly pleased "of course! of course!" repaid the wakeful hours of the previous night. After he had discoursed most happily and enthusiastically—as he always did—upon the importance, I ventured to ask what I should do next.

"Oh, look at your fish!" he said, and left me again to my own devices. In a little more than an hour he returned, and heard my new catalogue.

"That is good, that is good!" he repeated; "but that is not all; go on"; and so for three long days he placed that fish before my eyes, forbidding me to look at anything else, or to use any artificial aid. "Look, look, look," was his repeated injunction.

This was the best entomological lesson I ever had—a lesson whose influence has extended to the details of every subsequent study; a legacy the Professor left to me, as he left it to so many others, of inestimable value, with which we cannot part.

A year afterward some us were amusing ourselves with chalking outlandish beasts on the Museum blackboard. We drew prancing starfishes; frogs in mortal combat; hydra-headed worms, stately crawfish, standing on their tails, bearing aloft umbrellas; and grotesque fishes with gaping mouths and staring eyes. The Professor came in shortly after, and was as amused as any at our experiments. He looked at the fishes.

"Haemulons, every one of them," he said; Mr.______ drew them."

True; and to this day if I attempt a fish, I can draw nothing by haemulons.

The fourth day, a second fish of the same group was placed beside the first, and I was bidden to point out the resemblances and differences between the two; another and another followed, until the entire family lay before me, and a whole legion of jars covered the table and surrounding shelves; the odor had become a pleasant perfume; and even now, the sight of an old, six-inch, worm-eaten cork brings fragrant memories.

The whole group of haemulons was thus brought in review; and, whether engaged upon the dissection of the internal organs, the preparation and examination of the bony framework, or the description of the various parts, Agassiz's training in the method of observing facts and their orderly arrangement was ever accompanied by the urgent exhortation not to be content with them.

"Facts are stupid things," he would say, "until brought into connection with some general law."

At the end of eight months, it was almost with reluctance that I left these friends and turned to insects; but what I had gained by this outside experience has been of greater value than years of later investigation in my favorite groups.

All that observation to gather facts, and then the professor says, “Facts are stupid things until brought into connection with some general law.”

**Inductive Reasoning plays a major role in bringing those facts into connection.**

We discussed the role of induction in the scientific method earlier. Here I would like to mention some inductive methods suggested by John Stuart Mill (1806-1873).

**METHOD OF AGREEMENT:** “If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon.” A common way of explaining this is by suggesting a situation in which a group of people who all ate at the same restaurant
experienced food poisoning. A health department official will make a list of what everyone ate. Suppose he found that every sick person ate fish. By the method of agreement he would conclude that the fish was the cause.

**METHOD OF DIFFERENCE:** “If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former: the circumstances in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.” Suppose that the health department worker found that every sick person ate not only the fish but also green beans. Which is the cause? He might review his list of people and find a person who ate at the restaurant but did not get sick. If that person ate the green beans but not the fish, the green beans could be ruled out as a cause.

These two methods, of course, work in conjunction

**METHOD OF RESIDUES:** “Subduct from any phenomenon such part as is known by previous induction to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents.” In a sense, the planet Neptune was discovered by this method. Using Newton’s laws scientists had attempted calculate the orbital motion of Uranus, but found that its position was variously ahead or behind the schedule predicted by the Newton formulæ. Instead of throwing out Newton, they deducted (subtracted) the amount of the motion that could be explained by those formulæ. Then they looked at the residue, the small amounts the planet was “ahead” or “behind.” It was that part which needed explaining. They applied the Newton formulæ to just that residue and, by working backwards, developed a probable cause for the variation: another planet’s gravity. They calculated the position of this previously unknown planet, pointed their telescopes, and “discovered” what they knew must be there already.

**METHOD OF CONCOMITANT VARIATIONS:** “Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or and effect of that phenomenon, or is connected with it through some face of causation.” Stuart’s careful language here is used to avoid the *Post hoc, ergo propter hoc* fallacy, the assumption that just because Q follows P, P must be the cause of Q. There is a good deal to this method that involves careful observation of related phenomena, but one thing it makes possible is experiment. In the example of the food poisoning above, we could somewhat callously feed some of the suspect fish to the cat. If it dies, our hypothesis is confirmed.

Much of this extends beyond the normal needs of the rhetorician, but we often find ourselves in complex situations in which we must make arguments and must evaluate the arguments of others. So, in addition to all the other things a rhetorician must know, add a bit of scientific reasoning.