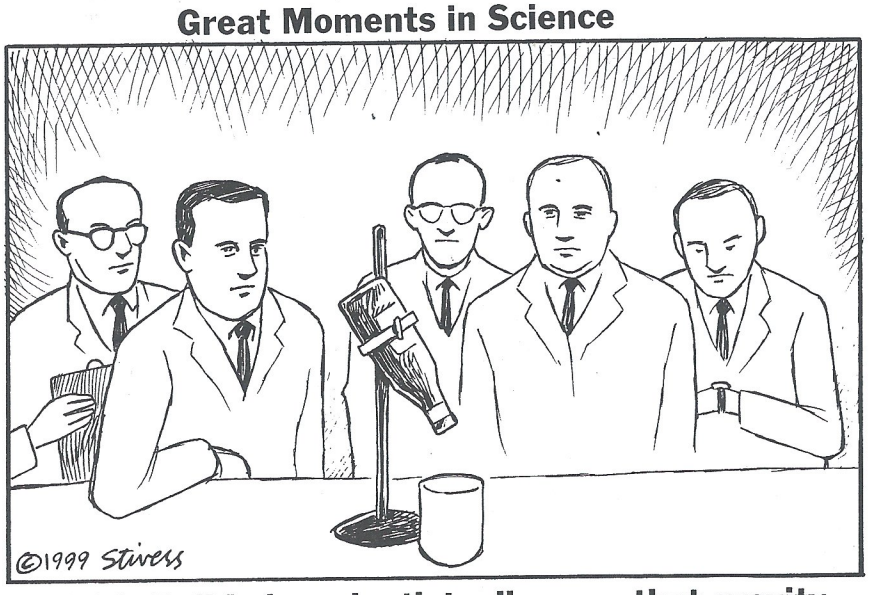
Chapter 10

Inductive Reasoning:
How Do I Reason from Evidence?



1962: Bell Labs scientists discover that gravity does not function inside a ketchup bottle.

Inductive reasoning is a method used to discover new information or to supply missing information. When we use inductive reasoning, we observe, test, and check things out in some systematic fashion. Although it is an open-ended method of learning and discovering, it is not hit or miss, or trial and error, but has its own rules for arriving at the most reliable answers. This chapter serves as a basic introduction to the forms, methods, and rules of inductive reasoning.

DISCOVERY EXERCISES

Defining Key Terms

Using at least two dictionaries, write down definitions of the following terms:

1. Induction
2. Reasoning
3. Empirical
4. Scientific method
5. Inductive reasoning

Answering a Survey on Test Performance

Write your answers to the following questions in preparation for discussion. Use a mindmap or cluster if you wish. Pay attention to the way in which you must reason in order to reply.

1. Think of a time when you made a high score on a challenging test. What steps did you take to prepare yourself mentally, physically, and in actual study?
2. Think of a time when you did poorly on a challenging test. How did you prepare? What did you fail to do?
3. What conclusions can you draw on the basis of this comparison?

Now discuss the following questions in class:

1. Explain how you were reasoning in order to answer these questions. Was this inductive reasoning?
2. How was this reasoning similar to, or different from, the way you worked mentally as you worked in the first exercises describing a fruit, vegetable, or tool?

Looking at Inductive Reasoning

Induction comes from the Latin *inducere*, to lead in. In logic, induction is to reason to a conclusion about all members of a class on the basis of an examination of a few members of a class. Induction reasons chiefly, but not entirely, from the particular to the general.

This chapter's opening discovery exercise as well those in the first chapter of this text required you to use inductive reasoning. Now is the time to step back and consider its forms and rules.

When you reasoned inductively, you observed, gathered data, then drew inferences about patterns, configurations, and meanings. You recorded your findings and reported them. This method of researching from personal observation is basic to the **empirical** or **scientific method.** It was the approach, you will remember, used by Samuel Scudder. The rules and standards used to guide scientific research were developed over many centuries.

Critical Thinking Hero: Anna Politkovskaya

"I know the sacred rule of war reporters that no shot or story is worth your life. That is true. But I think the second Chechnya war is such a cruel and unjust war that in reporting this material, you have no right to think of yourself. You just don't have this right. You are the transmitter of truth. That is worth a life." (Quoted in 2007. *Frontline documentary, Requiem: Reporting in a dangerous world.*")

When Anna Politkovskaya (1958–2006) spoke these words before a camera, she was a Russian journalist well known for her exposure of human rights abuses by the Russian military in Chechnya and for her fearless criticisms of Vladimir Putin. During her career she was jailed, tortured, and poisoned. In 2006 she was shot and killed in the elevator of her apartment building. As of 2011, the case remained unsolved.

Although we now have more freedom of the press than ever before, many countries still do not guarantee freedom of speech and press; moreover, more journalists are now being killed in the line of duty than ever before. According to the Committee to Protect Journalists (CPJ), since 1992, 899 journalists have died in crossfires, dangerous situations and murders. Of this number, 562 were murdered with impunity, i.e., there have been no prosecutions.

Writing and Discussion

1. Watch the Frontline video *Requiem: Reporting in a Dangerous World* to learn more about other journalist heroes such as Sheila Coronel of the Philippines, Hrant Dink of Turkey, and Jiang Weiping of China.
2. How is reporting an inductive process?

In the inductive process, sensory observation is used to note details and forms, to compare similarities and differences, and thus to recognize designs. This was the case in the discovery of Velcro, when a microscope revealed the pattern between seed bur hooks and fabric loops. Gradually such a discernment of pattern leads to inferences about their correspondences, trends, and tendencies as well as to explanations or conclusions about their nature and meaning. All the accumulated evidence might be called the *parts* and the generalizations the *whole*. In medicine, the name given to an interpretation of the whole pattern is called the *diagnosis*.

> A child is brought to the doctor with the following symptoms: fever, cough, and eye inflammation. The doctor examines the patient and finds small red spots with white centers on the insides of her cheeks. The doctor begins to recognize a pattern of symptoms that could lead to a diagnosis of common measles. He knows that if a rash appears first on her neck and then on the rest of her body within three to five days, and if there is a diminution of the fever, then he can be sure of this diagnosis. However, the onset of other symptoms or the worsening of the patient's condition could suggest other possibilities.

Thus, the process of examining a patient and arriving at a correct diagnosis (and with that a correct treatment) requires not only considerable knowledge but also skills in discerning patterns and forming dependable hypotheses about them.

Writing and Class Discussion

1. Bring to class a piece of art or design (such as an Escher drawing) that contains patterns that can only be discerned through close viewing. As you study the work, write down whatever conclusions come to you about the patterns and their significance.
2. Close your eyes while a friend gives you something to eat. Note how your taste and smell sensations lead you to identify the food or a dish's ingredients.

Reasoning to Determine Cause

We use inductive reasoning to determine the probable causes of events. We also need standards to guide us in doing so.

Cause comes from the Latin *causa*, meaning reason or purpose. Cause means that which produces an effect, or result, or a consequence; something that is responsible for an event; or a source of influence.

Causal reasoning uses an inductive method to explain why certain things occur, persist, or vanish. Sometimes we want these things to happen, and sometimes we don't, especially when such causes might hurt or kill us. Skillful causal reasoning enables us to exercise control over our environments, to predict and relate to changes, to survive individually and collectively. What we do to keep ourselves healthy, how we interpret the expressions and behaviors of others, how we make decisions about what to eat, what to wear, where to go: all these involve causal reasoning. Moreover, much of our interest in the news has to do with unexpected effects, surprising effects, predicted events, speculations, investigations and findings about cause. Yet, although causal reasoning is an on-going constant in our lives, we may not be fully aware of it as a mental process nor may we be as skillful in this form of reasoning as we might. This chapter section is designed to help you heighten your awareness of causal reasoning and show you some standards for improving or evaluating its process.

Writing/Discussion

1. List some things that you learned as a child about cause and effect.
2. Describe something that you learned recently about cause and effect.
3. Name some recent event in the news that concerned a question about cause.

Examples, Problems and Standards of Causal Reasoning

Study the following examples that use causal reasoning and discover how well you can explain why each one is well or poorly reasoned.

1. The leaves on our maple tree turn red in October.

   Some years it is cold in October, and some years it is warm through October. No matter what the temperature, our tree always turns in October.

   Therefore, October makes the leaves of maple trees turn red.

2. I always get a cold after I go swimming.

   I only get colds after swimming.

   Swimming causes my colds.

3. The last ten times I flipped this coin, it came up tails.

   The next time I flip it, it is certain to be tails.

4. I get nervous when I drink coffee.

   I get nervous when I drink tea.

   I get nervous when I drink cola.

   All drinks make me nervous.

5. When I stopped smoking, I gained 10 pounds.

   Smoking keeps my weight down.

6. My wife and I know how beneficial fresh garlic can be to health, but we worried about the smell. Then we found a solution. We chop up pieces of garlic and put them inside a banana to share just before going to bed. Afterwards I never noticed any garlic on my breath or hers. Even the next morning, there is no garlic smell.

   We discovered a cure for garlic breath.

7. My baby was two weeks late in coming. I made myself a salad with red balsamic vinegar. Three hours later I was on my way to the delivery room.

   The vinegar caused me to go into labor.

8. Studies show that people who follow up months of strenuous work with a vacation often have heart attacks on the first days of their vacation.

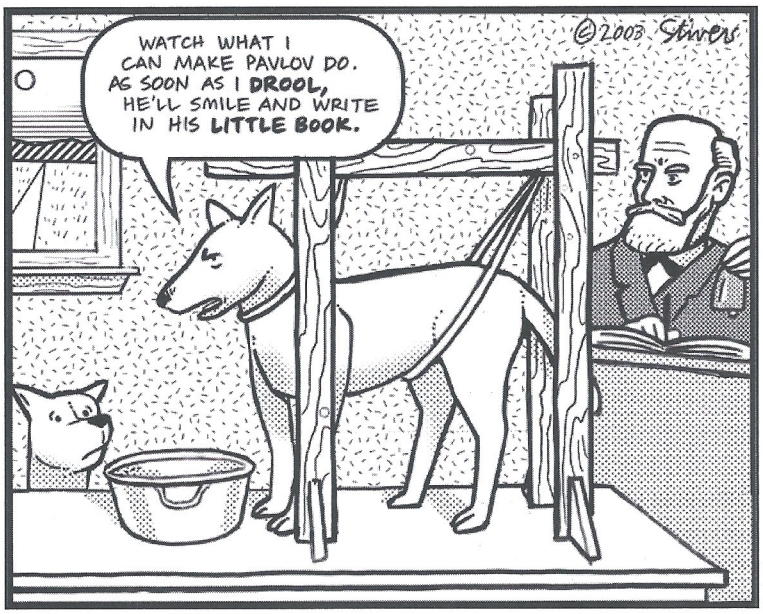
   Heart attacks are caused by vacations.

Writing/Discussion Questions

1. Do any of these items seem well reasoned to you? Explain why.
2. Which of these assume only one variable as cause when there could be other variables or a combination of them?
3. Would any of these conclusions seem more acceptable if some of the words were changed to indicate probability or possibility rather than certainty? Give an example.
4. Do any of the conclusions claim more or something different from what than its evidence can support?
5. Do any draw a conclusion about cause on the basis of a study of two few cases?
6. Do any of these examples assume that because some effect followed an event, the event was its cause? In other words, if a cat ate a mouse and then had kittens the next day, would the mouse have caused the cat to have kittens?
7. Given your answers to these questions, what might be some guidelines for good causal reasoning?

When you have finished answering the above question, check to see if your list of rules includes these guidelines:

1. Any hypothesis or generalization drawn from inductive reasoning is a probability not a certainty.



- When investigating to determine a cause, first look for a common variable in the symptoms, or actions, or environment of those affected by it.
- Look also to see if this variable was missing among those who were not affected by this cause.
- Check to determine if there was a ratio between the degree of effect and the amount of consumption or exposure to the variable under consideration.

Reasoning with Hypotheses

Science formulates and tests hypotheses in order to explain and predict phenomena.

Hypothesis comes from the Greek word *hupothesis,* meaning a supposition. A hypothesis is the name given to a trial idea, tentative explanation, or working assumption that can be used to further investigation.

The **conclusion of an inductive study** generalizes to produce a universal claim based on empirical findings. This conclusion may or may not confirm the hypotheses tested. Yet such a conclusion remains probable rather than totally certain because further evidence could challenge its findings.

Now let's review what we have been learning about the hypothesis. In the examples given on pages 288–289, all the "conclusions" were prematurely drawn; their sampling was insufficient to warrant their conclusions. Moreover, they need extensive testing. Yet even if a hypothesis becomes repeatedly confirmed through testing, it may never be considered certain. The discovery of even one exception, or counterexample, challenges the reliability of a hypothesis. Because inductive generalizations have these limitations, special precautions have to be taken in order to reach the most reliable hypothesis. Thus, we learn the rules for gathering and examining evidence, for controlling variables, and for creating experiments that can be duplicated and thus tested by others. Moreover we have to be continually willing to modify and refine our hypotheses depending on the feedback we receive.

It takes time and testing to establish the truth of a hypothesis. Obviously Sir Isaac Newton's hypothesis that gravity explains an apple's perpendicular fall to the ground has not been improved upon. The discovery that a vaccination could prevent smallpox also proved to be true, although it took the interweaving of many hypotheses and many tests to establish its reliability. By 1979, vaccination had eradicated the disease worldwide.

The first hypothesis is usually not always the last; indeed, one hypothesis can lead to another and another, or can serve as an imaginative guide for further research. Here are two examples of the way in which hypotheses can function as working assumptions:

- A patient developed a high fever and complained of pains in the kidney area; the doctor first diagnosed a kidney infection (first hypothesis). However, on a second visit, an examination of the patient's mouth and throat revealed enlarged and swollen tonsils (new evidence), and it seemed more likely at this point that the fever and kidney pains were due to the infected tonsils (new hypothesis).
- In the eighteenth century, Europeans began to experiment with the nature of electricity. The similarity between lightning and electric sparks was observed, and it was conjectured that lightning was simply a big electric spark. Ben Franklin decided to test this hypothesis. Using analogous reasoning, he noticed that lightning and electric sparks were similar in color and in shape, that they traveled at about the same speed, and that both killed animals. Franklin published a proposal suggesting that a "sentry box" be built on a high tower with a man inside on an insulated platform who would draw sparks from passing clouds with a long pointed iron rod (test for a hypothesis). Before Franklin got around to trying out this experiment himself, it was conducted in France, and it was proved that clouds are electrified (confirmation of the hypothesis). Franklin then found a way to verify

his hypothesis again, using his well-known kite experiment. He fixed a sharp-pointed wire to the top of a kite, then knotted a large iron key between the kite string and a length of ribbon used for insulation. When a storm cloud passed by, Franklin saw the fibers of the kite string stand on end and drew a spark from the key with his knuckle (second confirmation of the hypothesis in an experiment conducted under different conditions).

Writing and Discussion

Following are four examples of inductive reasoning that include hypotheses. Read and underline the hypothetical statements, and discuss whether you find adequate support for these hypotheses. What other hypotheses might better explain some of these situations? Note also whether each example uses analogies, extrapolates and predicts from patterns, speculates about cause and effect, or gathers data and statistics.

1. I started drinking iced coffee when I was 14. I didn't think I'd ever become addicted. Then, six months later, I found that when I tried to go without coffee, I'd get a headache, and I would be drowsy and irritable. I knew then I was addicted and had to get off the stuff.
2. It all began with a question: What if good citizenship was made fun? It was decided to test this idea to see if fun could persuade people to use a stairway rather than an escalator. A stairway was found in a Stockholm subway station that ran adjacent to an escalator. The stairway was redesigned to resemble piano keys with black and white steps that would play one note of piano music for each step trodden upon. Now a YouTube video shows people heading for the escalator, then turning back to try out the stairs. Some even begin to dance on them. The video announces that 66% more people now use the stairs. (www.youtube.com/watch?v=2lXh2n0aPyw)
3. I have been wearing a wool knitted cap for the past ten years. People think it is strange, but it has kept me from having sore throats. Before I started wearing the cap, I had sore throats all the time. But since I started wearing it, I have not had any.
4. Japanese government officials and auto industry spokesmen said American drivers might be having trouble with their Japanese-made seat belts because their cars are too dirty. They reported finding animal hair in American cars, pieces of food, and soft drink drippings. In Japan, people do not drink or eat in their cars or even wear shoes. This explanation for the faulty seat belts (whose release button gradually became brittle and would not lock securely) came in response to reports that federal safety officials in the United States were planning to recall and

repair defective seat belts in 9 million cars. The Japanese manufacturers said that they had received no complaints in Japan about the 4.79 million vehicles on the road with the same seat belts. (Summarized from an article in the *San Francisco Chronicle,* May 23, 1995.)

Reasoning Through Statistics and Probability

Induction uses the sciences of statistics and probability to gather, organize, and interpret data and make predictions with these data.

Statistics: The mathematics of the collection, organization, and interpretation of numerical data.

Probability: In statistics probability is the ratio of the number of actual occurrences of a specific event to the total number of possible occurrences.

Inductive reasoning can work with statistical samplings (a form of enumeration) and make predictions on the basis of an estimate of probabilities. For example, the payoffs for betting on the winners of horse races are determined by inductive reasoning. Suppose you read in the papers that today at Green Meadows racetrack the following horses will run with the odds as listed: Post Flag, 9.90 to 1; Bru Ha Ha, 3.40 to 1; Plane Fast, 6.80 to 1; En-Durance, 5.20 to 1. These odds are based on the Racing Association's estimates of each horse's chance of winning. Bettors who pick winners will be paid an amount equal to the first number in each of these odds for each dollar bet.

The field of mathematics known as statistics is a science that seeks to make accurate predictions about a whole from a sampling of its parts. Probability and statistics have yielded some basic rules for evaluating the reliability of conclusions drawn by inductive reasoning from statistical samplings. For the purposes of our introduction to the subject, there are five basic rules:

1. The *greater the size of the sample* (or number of study subjects), the greater is the probability that that sample is representative of the whole population or group it is supposed to represent.

The results of a survey of the coffee-drinking habits of students in one high school based on questioning only ten students would obviously not be as reliable as the results of a survey of the whole student body. However, samplings are made for the sake of convenience or necessity, and the same information can be extrapolated for a full population when some rules for

size, margin of error, and random selection are followed. These rules are taught in the study of statistics. Yet, without knowing all these rules, you can still estimate that a survey of ten students could not speak for a whole high school, or one high school for all U.S. high schools.

2. The *more representative* the sample is of a population, the more likely it is that accurate conclusions will be drawn about the full population from the sample.

In a poll seeking a representative sampling of menopausal women in Illinois, the most representative respondents would probably be Illinois women between the ages of forty and sixty. Less likely to be representative would be women under the age of thirty. Moreover, a survey limited to women in their forties would also not be representative, nor would a survey of women in the city of Chicago only.

3. One *counterexample* can refute a generalization arrived at through inductive reasoning.

If you complain that your friend *always* comes late and is *never* reliable, and then one day your friend arrives early, you have a counterexample that refutes your generalization.

4. If statistical evidence is offered, it should be offered in *sufficient detail* to permit verification. Sources or background material about the researchers should also be cited so others can determine their reputation and independence from vested interests in the study's outcome.

In the following example, consider the vague references to "independent laboratory tests" as well as to the research data used to support the claims:

> *Fatoff* has been proven to cause weight loss. After years of research and expensive experimentation, an independent laboratory with expertise in biotechnology has finally uncovered a naturally occurring substance that can be taken orally in tablet form. Now it is being made available to millions of overweight men and women who are losing as much as 10 lbs. a month. It has taken over 15 years of research and over 200 medically documented studies to produce *Fatoff*. But there is only one catch: *Fatoff* is expensive to produce.

5. When polls are taken, it is important to know not only whether a *reputable organization* or agency took the poll such as Gallup, Roper, Harris, or Pew Research Center. Also one should know the *exact formulation* of the question.

   Compare the following questions:

   a. Should fish farming be banned?

   b. In view of the fact that fish farming is a cheap and sustainable way to provide healthy food for people, should it be banned?

The first question might elicit quite a different response than the second.

When you hear or read about polls, be sure to see if the exact wording of the question is given so that you can analyze it for bias. Also, do not accept without question results from polls identified only vaguely as "a recent poll." If the pollster's name is given, consider whether it was an independent source or a source filtering information to represent its own political or commercial interests. You need to be able to determine whether the source was unbiased and whether the results are verifiable.

Class Discussion

The following examples offer statistical evidence. Rate the statistics given in each as *reliable* or *not reliable* and then state what rule or standard you used in making your judgment.

1. According to the Center for Academic Integrity at Duke University, three quarters of college students confess to cheating at least once. And a *U.S. News* poll found 90 percent of college kids believe cheaters never pay the price. [*U.S. News* poll of 1,000 adults (including an over sample of 200 college students) conducted by Celinda Lake of Lake Snell Perry & Associates and Ed Goeas of the Tarrance Group. Oct. 18–23, 1999. Margin of error: plus or minus 3.5 percent.] (*U.S. News & World Report*, November 22, 1999)
2. I would guess that the average office female makes 509 visits to the lavatory to a male's 230, and spends 10.7 minutes there to a male's 2.5. What management is going to put up with this "primp time" featherbedding at equal pay? (Edgar Berman, guest columnist, *USA Today*)
3. Intermarriage continues to rise in the United States. The share of new marriages between spouses of a different race or ethnicity increased to 15.1% in 2010, more than double the share in 1980. (PewResearch.org. Email Newsletter. 16 February 2012)

Composition Writing Application

Working from Facts to Inferences to Hypotheses

Follow these steps in this assignment:

1. Skim through books that list facts, such as *The World Almanac* or go online to *Refdesk.com*.
2. Find a group of related facts on one subject and write them down.
3. Draw all the inferences you can that would explain what these facts mean. Write them down as a list of potential conclusions.