CHAPTER 6:

INDUCTIVE LOGIC

A. Inductive Inferences

1. Inductive Generalizations

When we use the information provided by a few instances of a certain kind to draw conclusions about all instances of that kind, we are making a generalization. When we use statistical information provided by a sample to draw statistical conclusions about the population as a whole, we are making a statistical generalization. Thus, if I think that most people won’t like x because most of the people in my family don’t like x, I am making a claim about most people, based on the sample of people in my family: “I know most people don’t like hot spicy food because most of the people in my family don’t like hot spicy food.” This example illustrates two of the major sources of invalidity for inductive generalizations: (a) generalizing from samples that are too small; and (b) generalizing from samples that are biased.

(a) Suppose there are twenty marbles in a bag. And, after shaking the bag and drawing from it without looking, the first marble withdrawn is red. If I conclude that the rest of the marbles in the bag are red, then I am making a hasty generalization, based on a sample that is too small.

Suppose I continue to draw marbles without looking, and the second is red, the third is red, and the fourth and fifth are red. The evidence provided by these five draws makes the conclusion that all twenty of the marbles in the bag are red more probable.
Each random draw without looking increases the probability that all the marbles in the bag are red.

Suppose further that five more marbles are drawn, and all are red, but the marbles drawn were picked because they were red. This additional evidence would not increase the probability that all the marbles in the bag are red as much as the first five choices because the additional evidence is chosen to support the claim that all the marbles are red, whether that claim is true or false.

Following are examples of fallacies resulting from samples that are too small:

1. Three of my friends had lunch at the Princess Restaurant and said they liked it. It seems that everybody who goes there seems to like it.

2. Mary met a very charming man who was French. Thereafter, she was convinced that all Frenchmen were charming.

3. I know that all twenty year olds like to dance because I have five twenty year old friends and each one likes to dance.

4. President Richard Nixon and Vice-president Spiro Agnew deceived the American people, and that shows us that all Washington politicians are inherently deceitful.

5. Bill Clinton and Elliot Spitzer were unfaithful while in public office. That shows us what you can expect of Democrats.

6. John Mason is very aggressive. Maybe the rest of his family is like that too.

Often, one particular case is presented as representative of all similar cases. And with some kinds of things, one instance is like every other instance. Thus, the atomic weight of one gram of pure gold is going to be the same for every other gram of pure gold. And we expect one 16 oz. bottle of Coke to be like all other 16 oz. bottles of coke. With such kinds of things, we can generalize from a single instance to all instances of the
same kind. A conclusion about the population as a whole can be drawn on the basis of a small sample when diversity within the population is small.

But, in diverse populations, what is true of one instance need not be true of all instances of like kind. In such cases, when we generalize from a single instance or a small sample, we generalize hastily and should be prepared to revise our conclusions. Thus, some Frenchmen may be charming, but some may also be rude. Some twenty year olds may love to dance, but some may not. When there is a great deal of diversity within a population, a conclusion about the population as a whole cannot be drawn on the basis of a small sample. In statistics, the standard deviation is a measure of how much diversity there is between the members of a population, and is used in determining the size a sample must have in order to make valid inferences about that population.

Inductive generalizations are also fallacious if they are inferred from samples that are biased, whether the bias is intentional or unintentional. Thus, the grocer who arranges bags of fruit with the unblemished fruit on the top and the blemished fruit on the bottom of the bag may be intentionally misleading the unwary customer. On the other hand, prosecutors may sincerely believe the sample of the evidence they have collected leads to a clear conclusion. Consider the following example: (i) Mr. A's boss, Mr. B, has been found murdered at his home, (ii) Mr. A was the last person seen leaving Mr. B's home on the night of the murder, and (iii) Mr. A had been fired the day before and was quite upset over the loss of his job. Does this lead to the conclusion that Mr. A committed the murder? Not necessarily. The information presented makes it probable that Mr. A committed the murder, and that is why investigators are justified in holding Mr. A suspect. But there may be additional information that might decrease the probability that
Mr. A committed the murder. For instance, additional evidence might show that Mr. A was miles from the scene at the time of the murder. The sample of evidence presented by the prosecution need not be all of the relevant evidence. When evidence that supports a claim is counted and evidence that denies it is discounted or ignored, the evidence is treated in a biased manner.

In our personal lives, we are prone to use samples that are familiar and accessible in order to infer conclusions about the population the sample is taken to represent. (examples needed) Given the ever-present possibility of biased sampling (intentional and unintentional), procedures have been developed to insure that bias in the selection of the sample is minimized. This typically involves using a randomizing procedure for choosing the sample that eliminates many common sources of bias (e.g., stirring the soup thoroughly before tasting it, calling a coin before flipping it; rolling the dice rather than sliding them; shuffling the deck before dealing a card, etc.).

In order to validly infer that what is true of the sample is true of the population as a whole, the sample must be representative of the population as a whole, rather than representative of one person’s predilections and preferences. Since our choices can be influenced in subtle ways, we must be vigilant to ensure that the generalizations we accept are not based on evidence that is hasty, biased or both.
5.B.1. **Exercises (more needed) on inductive generalizations:**

1. Ten dead bats were submitted to Wildlife Services. Five were rabid. Can we therefore expect that 50% of all bats are rabid.

2. Women talk more than men. I know this because my mother talks more than my father.

3. My neighbor solved my plumbing problem. He is probably good at solving math problems as well.

4. We prayed before the game, and we won. That proves that if a team wants to win then that team has got to pray for it.

5. The last two Sundays have been beautiful. We should expect every Sunday to be a beautiful day.

6. In a random sample of homeowners, 50% were against higher real estate taxes. Therefore, we can expect 50% of voters will oppose legislation for higher real estate taxes.

7. This sample of gold has a boiling point of 267°C. Therefore all gold has a boiling point of 267°C.

II. **Inductive Instantiation**

In inductive instantiations, general information about a group is used to draw conclusions about an individual member of the group.

Examples:

1. Most boys like to play soccer. Jose is a boy. Therefore Jose probably likes to play soccer.

2. Most boys don’t like to play with dolls. Jose is a boy. Therefore, Jose probably does not like to play with dolls.

3. Most girls like to play with dolls. Maria is a girl. Therefore Maria probably likes to play with dolls.

4. Most girls don’t like to play violent video games. Maria is a girl. Therefore Maria probably does not like to play violent video games.
These examples use widely held preconception about boys and girls in order to infer information about Jose and Maria. We tend to categorize individuals in terms of the preconceptions we have accepted without critical appraisal. Those preconceptions reflect the kinds of things we believe exist and implies we can expect of such things. Typically the preconceptions we use are not explicitly stated, and often a conclusion may be drawn about a current situation on the basis of faulty generalizations.

Because the generalizations that are incorporated into our preconceptions are typically not stated explicitly, the arguments they are used in take the form of enthymemes. Recall that an enthymeme is an incomplete argument where either a premise or the conclusion is unstated. Thus, the above examples might be phrased as enthymemes as follows:

1. Jose is a boy. Therefore Jose probably likes to play soccer.
2. Jose is a boy, so Jose probably doesn’t like to play with dolls.
3. Maria is a girl and we know what girls like to play with dolls, don’t we.
4. Maria is a girl, so she probably doesn’t like to play violent video games.

When an argument is given with a missing premise, the speaker is able to avoid openly stating and asserting the missing generalization. Instead, the speaker leaves it up to the listener to supply the missing premise and its assumption of truth. When an argument is given with a missing conclusion, the speaker can avoid explicitly endorsing the conclusion. Instead, it is left to the listener to infer the conclusion, which may be implied but unstated.

Sometimes, it may be necessary to act on unexamined preconceptions. If Mary is walking through the grass and sees a long slender figure lying ahead, she may become
frightened and wary of proceeding further. If the long slender figure remains straight and unchanging, she might re-evaluate her reaction that it might be a reptile. But if the figure appears to move, she would be confirmed in her belief that it might be a reptile. Mary’s initial preconception that the figure is a reptile would should be critically appraised on the basis of relevant information.

Likewise, if Mary has had no personal encounter with pit-bulls and only knows of them through reputation, then she might hesitate to continue forward if she sees one approaching her. But suppose Mary is assured by all concerned that the pit-bull is old, arthritic, and a pet for children in a nursery school. If she continues to act as if this pit-bull is likely to violently assault her, then she has a preconception of a pit-bull that is resistant to further information.

A stereotype is a preconception that is resistant to modification on the basis of relevant information. If Mary is afraid of pit bulls, her preconception that pit bulls are violent may benefit her by making her cautious around them. But if she ignores additional information showing that a particular pit-bull is highly unlikely to be violent, then her concept of a pit-bull is fixed and rigid. If all one knows is that Jose is a boy, it might be reasonable to assume that he probably likes to play soccer, because many boys do like to play soccer. But if we learn subsequently that Jose has been paraplegic from birth, it may be unreasonable to claim that Jose would still probably like to play soccer.

Many stereotypes have evolved as historical tools of oppression, when individuals were forced to conform to society’s prior preconceptions about them. Women and people of color were considered to be naturally subservient, and this subservience was coerced under threat of violence. Though a person may have little choice about which
preconceptions they have inherited from the past, they do have a moral obligation to examine those preconceptions in the face of contrary evidence. Many preconceptions escape attention because they remain unstated. Articulating and critically examining preconceptions is the best antidote to stereotyped behavior. Being rational requires being open to new information that may lead us to alter our preconceptions, no matter how we may have acquired them.

5.B.3. Exercises (editing needed) on inductive syllogisms:

For each of the following, complete the enthymeme by identifying the generalization that is unstated. Provide (a) additional information that increases and (b) additional information that decreases the probability that the generalization is applicable:

1. John is Jewish. So John probably likes money.

2. Ben Carson is a successful African-American neuro-surgeon. He is also probably a good athlete.

3. Alice Walker is a successful African-American writer. But we can be certain that Alice probably still loves fried chicken.

4. Hector is an 88 yr. old Afro-Cuban male. But Hector probably still loves to dance.

5. Jamaal is African-American and Phillip is European-American. So Phillip probably has a higher IQ than Jamaal.

6. Mr. and Mrs. Gonzalez own a highly successful business. But I’ll bet that Mr. and Mrs. Gonzalez still have a large family.

7. Jim is Native American. So he probably receives income from casino gambling.

8. Mary Wong is Japanese. So she is probably docile and submissive to her husband.

9. Cornel West is a contemporary African American philosopher. So it is likely that he has a criminal past.

10. Mary has been unmarried all her life. That is probably why Mary is unhappy.
11. Phyllis is majoring in physics. But it is likely that Phyllis will give up when the math becomes really difficult.

12. I have encouraged my daughter to follow her natural inclinations and be a wonderful mother for children she can be proud of.

13. Mary is probably weaker than Mike because that’s how women and men usually are.

14. My wife is more emotional than me because that’s how men and women usually are.

15. Toni is HIV positive. (S)He is probably homosexual.

16. Toni is homosexual, so (s)he is probably HIV positive.

17. Jim is Irish, so he probably loves to drink and fight.

18. K is driving a Mercedes so K must be wealthy.

19. B graduated from Smith College, so B is probably a feminist.

20. D is a computer scientist, so D is probably horrible at sports.

21. Z is a doctor, so Z must know CPR.

22. I saw K buying a cake. So K must love sweets.

23. My German Shepard was very easy to train, so I’m sure your German Shepard will be housebroken in no time.
III. Analogical Inference

Some inductive arguments involve reasoning by analogy, where the properties of one instance are used to infer what properties a similar instance will have. Reasoning by analogy proceeds from one instance, X, to another instance, Y (without necessarily generalizing) and has the following form:

Primary analogue: X has properties a, b, c, d, e;
Secondary analogue: Y has properties a, b, c, d;
Therefore, probably Y has property e.

Examples:

1. At time t₁ I ate mushrooms and I got sick. Therefore, if I eat mushrooms at time t₂, then I will probably get sick.

2. When X pet dog₁, it bit X. Therefore, if Y pets dog₁, the dog will probably bite Y.

3. X purchased a Yotota and was very pleased with its performance. Therefore if Y purchases a Yotota, then Y will probably be pleased with its performance.

4. When water was poured on a campfire, the fire went out. Therefore, if we pour water on this grease fire, the fire will go out.

5. X appears, and has on white shoes, a white suit, and a white tie. Y appears, and has on white shoes and a white suit. His back is to us, however, and we can’t see the color of his tie. But it will probably be white.

Things, persons, and groups are often described in analogical terms as a way of undermining or inflating their value. Thus, if B is described as strong as an ox, we might easily conclude that B is also probably as dumb as an ox. But if B is described as strong as a lion, we are more likely to conclude that B is probably as brave as a lion, as well. When the aim is to oppress a group, that group is often characterized as analogous to
non-human animals we detest. But when the aim is to valorize a group, they are described as analogues of animals we admire.

1. The T are like the cockroaches in our homes. We would kill the cockroaches. We should kill the T.

2. The Js in our country are like rats in our neighborhoods. We exterminate rats. We should exterminate the Js.

3. B people are like dangerous animals. We need to keep them locked up for our protection.

In reasoning by analogy, we infer that Y has property e because Y shares properties a, b, c, and d with X, and X has property e. An analogy is strong if the presence of a, b, c, and d makes the presence of e more probable. But an analogy is weak if the presence of a, b, c, and d does not make the presence of e more probable. Thus, knowing the manufacturer of a car is relevant to inferences about whether the car will perform well. But knowing the color of a car neither increases nor decreases the probability that the car will perform well. We base our expectations on a weak analogy if we expect the color and trim of Y’s car to be relevant to the performance of Y’s car. And though the logo of a car may have no causal relationship to the mechanical functions of the car, companies go to great lengths to insure that their logo is a reliable indicator of the mechanical quality of the car.

X is in a red and white bottle and X tastes great. Y is in a similar red and white bottle. Therefore, Y will taste great as well.

On the other hand, relevant dissimilarities between X and Y decrease the probability that what is true of X will also be true of Y. In such cases, though there are similarities between X and Y, there are also relevant dis-similarities between X and Y that make the analogical inference faulty.
1. If J was tired at time $t_1$ when she ate mushrooms and got sick and J is not tired at time $t_2$ when she eats mushrooms, then the probability that she will get sick at time $t_2$ may be less than it was at time $t_1$.

2. If dog$_1$ was eating when X pet it at time $t_1$, and dog$_1$ is not eating when X pets it at time $t_2$, then the probability that the dog will bite X at time $t_2$ may be less than it was at time $t_1$.

3. If X purchased a Yotota sedan and Y purchases a Yotota truck, what holds true for the sedans may not hold true for the trucks.

4. Mary is a human and Mary can become pregnant. Tom is a human. Therefore Tom can become pregnant.

In law, the primary analogue X is called the precedent. In legal litigation, one party attempts to show that a current case, Y, is similar in all relevant respects to a precedent, X, and should be decided as the precedent was decided. The other party attempts to show that Y is not similar in all relevant respects to X, and should be decided in a manner contrary to the decision in X. Similar cases should receive similar treatment under the law, but dissimilar cases may require different treatments. Many legal controversies hinge on how the primary analogue is framed.

**Examples:**

1. A fetus is similar in all important respects to a child. Therefore, abortion is like killing an innocent child and is a form of murder.

2. A fetus is growing tissue that is not yet a child. Therefore abortion is not like murder.

3. A mother who takes drugs while pregnant is guilty of child-abuse.

4. A mother who takes drugs while pregnant is guilty of self-abuse.

There are correct and incorrect uses of the argument from analogy.
Strong Analogies:

1. Housecats are felines and have whiskers. Lions are felines. Therefore, lions probably have whiskers.

2. A home is like a castle. A castle is a place where you should feel secure. So, a home is a place where you should feel secure.

Weak Analogies:

1. Housecats are felines and need protection from large vicious dogs. Lions are felines. Therefore, lions need protection from large vicious dogs.

2. A home is like your castle. A castle has guards and a moat. Therefore, I should build a moat around my house and hire guards for protection.

3. Water is a liquid and pouring water on the fire extinguished it. Oil is a liquid. So, pouring oil on the fire will probably extinguish it.

4. Men in power have often coerced sexual favors from women subordinates. Women will probably do the same thing to men subordinates when they gain power.

5.C.1. Exercises (more needed):

A. For each of the following, determine if the analogy is weak or strong:

1. Human beings and watches are similar in that they are all finely structured. Watches do not evolve from random combinations of glass and steel, and by analogy, human beings do not evolve from the random combination of cells and tissues.

2. Electrons revolve around the nucleus just like planets revolve around the sun. By analogy, electrons must be attracted to the nucleus because of gravity.

3. Mars and Earth both orbit around the sun, and they both have satellites. Since life exists on earth, it is reasonable to predict that life exists on Mars as well.
B. In the following Arguments from Analogy, introduce factors that increase and factors that decrease the probability that the conclusion is true:

1. Tar smeared on the exposed skin of mice caused an 80% increase in the incidence of skin cancer in the group. Therefore, tar smeared on the lining of the lungs of human beings will cause an increase in the incidence of lung cancer.

2. My last pair of Hike running shoes made my feet feel extra good. That’s how I know that my new pair will give me great satisfaction.

3. You let my older sister stay out till midnight when she became 16. Now I am 16, so you should let me stay out till midnight.

4. Fathers should set the rules for their family in the same way that God set the rules for the universe. Wives should obey their husbands as nature obeys God’s laws.

5. Chimps have learned to use sign language. Therefore, birds will probably be able to learn sign language.

6. If a person spends more than they make, they will face financial ruin. And if our country spends more than it receives in taxes, then it will face financial ruin.

C. In each of the following, identify the primary and secondary analogue, and discuss their similarities and dissimilarities.

1. Most men are like spoiled children. They must have cars and tools the way a child has toys and games.

2. The earth is like a lifeboat afloat on the sea. That is why we must conserve our resources.

3. I felt horrible when I had the flu so I know how you must feel.

D. For each of the following, underline the term that best completes the analogy:

1. Woman/man = day/? (week, hour, year, night, darkness)

2. Bachelor/unmarried man = father/? (mother, child, male parent, uncle)
C. Causal Inference

Necessary and Sufficient Conditions

Some inductive arguments involve inferring that two events, C and E, have a cause-effect relationship. What we identify as the cause, C, of E must precede E and is influenced by the kinds of interests we have in E events. If we are interested in producing E events, then we look for sufficient conditions, CS, such that CS ⇒ E. If we are interested in preventing E events, then we look for necessary conditions, CN, such that ~CN ⇒ ~E.

Suppose we are interested in sufficient conditions for accidental housefires. There are many ways that housefires can be produced: cigarettes, cooking, heating, electric short-circuits, gas leaks, lightning, etc. In each case, a particular cause may probably be sufficient to produce a housefire. Thus, a lit cigarette that falls onto dry paper will probably produce a flame, but not necessarily. And the flame it produces may cause the house to catch fire, but not necessarily.

When we say that CS is sufficient to cause E, we really mean that CS makes E highly probable given the circumstances. Thus, if an electrical short-circuit burns the insulation from around the wires, it becomes more probable (but not necessary) that a fire will result. Likewise, if a house is struck by lightning or develops a gas leak, the probability of a housefire increases significantly. Each of these might probably be sufficient to produce a housefire under ordinary circumstances.
If we are interested in preventing E events, then we look for **necessary conditions**, CN, for E such that ~CN ⊃ ~E. Thus, lack of intention to start a fire is a necessary condition for an accidental fire. Likewise oxygen is a necessary condition for fires, because if there is no oxygen present then there will be no fires. But we cannot remove all oxygen from the atmosphere to prevent housefires. And even if we could we should not, since oxygen is necessary for our metabolic processes as well.

While we cannot eliminate the conditions necessary for all fires, we can reduce the probability that a housefire will occur by eliminating the conditions necessary for the major types of housefire. Thus, by eliminating the smoking of cigarettes in a house (No smoking allowed!), eliminating electrical short-circuits and gas leaks from the house (through regular inspection and maintenance), by eliminating the presence of combustionable materials in the house (No storage of gasoline allowed!), we reduce the probability of housefires. But we do not eliminate all possibility of housefires.

**Mill’s Methods**

Mill’s Methods of Agreement and Difference have been widely used in identifying necessary and sufficient conditions. In the **Method of Agreement**, we look at all cases in which an event of type E occurs, and we identify those conditions that are present with each of the occurrences of E. These conditions are possible sufficient causes of E: whenever events of type E have occurred, conditions of type CS have been present.

Sometimes a factor, B, is co-present with CS when E is produced, but B is nonetheless not causally related to E. In such cases, we would have a correlation between B and E, but B would not be a cause of E. To illustrate, increased ice cream sales accompany

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increased deaths from swimming, but increased ice cream sales do not cause increases in swimming deaths.

Mill’s **Method of Difference** is used to identify those conditions, CN, such that, when they are not present, an event of type E does not occur. The Method of Difference will identify all conditions that could be necessary for E. CN is a necessary condition for E means \( \sim CN \supset \sim E \). When events of type CN are prevented, events of type E are prevented. Thus, the presence of oxygen is a necessary condition for fires because eliminating the presence of oxygen eliminates the possibility of fires. And eliminating rags and paint thinner reduces the probability of fire from spontaneous combustion.

Many detective stories analyze and solve crimes using the methods of agreement and difference. Suppose Jones has been somewhere nearby each time cars have been sprayed with yellow paint on Elm Street. And suppose further that such incidents have not taken place where Jones was not present. Then we have good reason to consider Jones to be necessary and sufficient for the spray painting crimes in question.

Finally, Mill’s method of **Concomitant Variation** involves varying a condition C to see if it brings about variations in the occurrences of E. This notion of causation has been widely used in dealing with events where neither necessary nor sufficient conditions can be readily identified. Thus, smoking is considered a major cause of lung cancer, though smoking is neither a necessary nor a sufficient condition for lung cancer. Some people who smoke do not get lung cancer. And some who get lung cancer have never smoked. But populations with lower rates of smoking have lower rates of cancer, and populations with higher rates of smoking have higher rates of cancer. It is because variations in rates of smoking bring about concomitant variations in rates of lung cancer.
that we are justified in saying that smoking causes cancer. The causal relation between smoking and lung cancer allows us to predict that lung cancer rates will rise if smoking rates increase, and lung cancer rates will decrease if there is a decrease in the incidence of smoking. And we can know this even though we may not know exactly how smoking is causally connected to lung cancer in individual cases.

5.D.1. Exercises on Necessary and Sufficient conditions:

For each of the following, determine whether a necessary or a sufficient cause is implied:

1. x failed the test because he was too tired to concentrate.

2. y will graduate with honors because he had straight A’s in every class.

3. x loves too dance because she’s a teenager.

4. y will not go to college because he did not apply.

5. The fire was arson because it was intentionally started.

6. The fire was accidental because it originated from spontaneous combustion of oily rags.

7. x confessed because he was tortured.

8. y caught the flu because his roommate infected him.

Likewise smoking is considered a major cause of housefires, even though smoking is neither necessary nor sufficient for the occurrence of housefires. Some people smoke in their homes but never have housefires. And some people have housefires who do not smoke. Nonetheless, the frequency of housefires is less among those who do not smoke and greater among those who do smoke. See Hill.
9. The flowers did not grow because they were not watered (did not get enough sunshine).

10. The snow is melting because it is getting warmer outside.

11. Saccharine causes tumors in lab rats.

12. The A rats have tumors and the B rats do not because A rats were fed saccharine and the B rats were not.

13. The assassination of MLK caused the black community to erupt in violence.

14. Slavery and Jim Crow are the major causes of black poverty.

15. Lack of competition is the major cause of higher prices.

16. Global warming is being caused by industrial development.

17. Sea levels are rising because of global warming.

18. Smoking causes cancer.

19. x has cancer because x was a heavy smoker all her life.

20. The water will not boil because it has antifreeze in it.

21. x is no longer lonely because she now has a close friend.

22. The window broke because it was hit by a stone.

23. X’s tires went flat because y slashed them
24. The gun fired because x removed the safety lock and pulled the trigger.

25. Y was shot because x aimed the gun at Y and pulled the trigger.

26. The fire was extinguished because we poured water on it.

27. The fire was started because the children were playing with matches.

28. Eating undercooked chicken ill cause you to be sick.

29. The lights came on because I flipped the switch.

30. Poor kids show poor academic aptitudes because life is not academic for them (they must devote their time to surviving rather than to reading).

31. The sea level is rising because the icebergs are melting.

32. Crime increases when unemployment increases.

33. Homosexuality will increase because same-sex marriage has become acceptable.

34. Cloning is possible because of in vitro fertilization.

35. Allergies are increasing because of increases in the use of antibiotics.

36. Stainless steel is resistant to rust because the iron it is made from has been treated with alloys.
Causal Inference in Science and Medicine

A central feature of modern science is use of the Experimental Method to identify the cause C of an effect E. While our discussion has proceeded as if a causal relation is a two place predicate connecting two variables, C and E, experiments make it clear that causal relations are three-place predicates: “C is the cause of E” is short for “C is the cause of E in conditions Z”. In a controlled experiment, the control situation Z₁ and the experimental situation Z₂ are analogues, and CS is introduced into Z₂ but not into Z₁. If E occurs in Z₂ but does not occur in Z₁, then we have good reason to believe that, in situations like Z₁ and Z₂, CS is sufficient to produce E. On the other hand, if CN is followed by E in Z₂ but E ceases to occur when CN is removed, then CN is necessary for E in Z situations.

Modern medicine begins with the Germ Theory of Disease, when microbes were first identified as necessary and sufficient causes of disease. It is based on the work of Robert Koch, who first identified the microbial agent that causes cholera. Koch’s method of identifying a cause is referred to as Koch’s Postulates: In order for an agent, C, to be identified as the cause of malady E, C had to be: a. extracted from a host Z₁ who is suffering from E; b. cultivated in vitro; c. then re-introduced into a healthy host Z₂. d. If the malady subsequently manifests in the new host Z₂, this demonstrates that C is sufficient to cause E in hosts like Z. On the other hand, if a host Z is suffering from E, and removing C removes E, this shows that C is necessary for E in hosts like Z.³

Sometimes it is not possible to carry out an experiment where an element, C, is deliberately introduced or withdrawn from a situation Z in order to see how E is affected. But if it is possible to identify naturally occurring situations which are similar except for the presence or absence of the suspected cause C, we can then observe how this affects the presence or absence of E. Such non-experimental observations are the basis of research in epidemiology.

Something like this occurred prior to Koch’s discovery of the cholera bacillus. John Snow noted that cholera occurred at a much higher rate in an area that received sewage contaminated drinking water than in an area that received uncontaminated water. He conjectured that reducing the level of human sewage in drinking water would reduce the rate of cholera. And where human sewage was reduced, cholera rates diminished. But this was before Koch identified the cholera virus. Snow showed how sources and remedies for a malady may be identified even when the specific cause of the malady is unknown.

In scientific studies, patients often show improvement simply because they believe they have been treated with something that will help them. But in many cases it is their belief that they will get better from the treatment, rather than the specific treatment itself, that causes them to feel better. Likewise, people often feel worse if they believe someone else has done something to make them feel worse. It is the belief in the potency of a curse, rather than the potency of the curse itself, that makes them feel worse. This is called the Placebo effect.

A similar situation is produced when experimenters (often unintentionally) interact with their experimental subjects differently from how they interact with their
control subjects. And it is the difference in interactions rather than the difference in treatments that causes differences in outcomes between the experimental and the control group. This is called the Experimenter Effect. Double blind experiments are used to eliminate sources of bias generated by the expectations of both the experimental subject and the experimenter. In a double-blind experiment, neither the experimenter nor the experimental subject knows whether the subject is receiving a genuine treatment or a fake treatment.

Common Causal Fallacies

Post hoc, ergo propter hoc: If B follows A, then B was caused by A.

One of the basic rules of causation is that a cause must precede its effect. Thus, when two things occur together in sequence, we tend to believe that the earlier event is the cause of the subsequent event. This is why, when the magician taps his magic cane and a rabbit appears, we are inclined to believe that tapping the cane caused the rabbit to appear. However, the fact that two events occur in sequence does not mean that the earlier event is the cause of the later event. This expectation is the source of many fallacies in causal attribution.

Examples:

1. Every time we have won we have prayed before the game. That is how we know that prayer is the primary cause of our success.

2. A black cat crossed my path. That is probably why I had an accident later on.

3. I took xyz cold medicine and two days later my cold was gone. Therefore xyz cold medicine caused my recovery from the cold.
Correlation is not causation:

Just because two events vary together doesn’t mean that one is the cause of the other.

Often, the variation in both the two events may be the effect of another factor altogether.

Examples:

1. As ice cream sales increase, drowning deaths increase. And as ice cream sales decrease, drowning deaths decrease. Therefore more ice cream eating is causing more drowning deaths.

2. Night is always followed by day. Therefore the passing of the night brings about the coming of a new day.

Confusing cause with effect

1. The crowing of the rooster causes the sun to rise. (Or does the rising of the sun cause the rooster to crow?)

2. Low IQ causes impoverishment. (Or does impoverishment cause low IQ?)

3. The child’s misbehavior causes the parents to be short-tempered. (Or does the parents’ short temper cause the child to misbehave?)

Fallacies of Variation

1. Rain is necessary for corn to grow. Therefore, the more it rains, the more the corn will grow.

2. A good education is necessary for a good job. Therefore, the more education you get, the better job you will get.

Confirmation Bias

If C1, C2, and C3 are possible sufficient causes of E, focusing initial attention on C1 increases the likelihood that C1 will be accepted as the cause of E, even if additional evidence makes C2 or C3 the more likely cause. Confirmation bias makes it likely that people will look for evidence that confirms their assumptions rather than for evidence
that challenges those assumptions. But preconceptions that are maintained in the face of contrary evidence are fixed and likely to mislead.

**Causation in the Social Sciences**

Currently, a famous set of experiments in the social sciences has been used to demonstrate the existence what is called “stereotype threat”. Prof. Claude Steele has provided evidence to show that fear of confirming a demeaning stereotype negatively affects performance. There is much anecdotal evidence (from coaches, parents, counselors) that what a person believes about their capabilities affects their performance. Steele provides experimental evidence, generated under controlled conditions, showing how preexisting beliefs can produce performances that reinforce those beliefs. Steele’s innovation is in creating experimental, and not just anecdotal, evidence for the existence of effects produced by preexisting stereotypes. This evidence is meant to be replicable by others under similar conditions.

Steele proceeds in classic scientific manner. A group of subjects, Z, is chosen and (randomly) divided into two groups, Z1 and Z2. C is introduced into Z2, the experimental group and C is not introduced into Z1, the control group. If E is produced in Z2 but not in Z1, then we are justified in considering C to be the cause of E in groups like Z1 and Z2. Using this model, Steele was able to demonstrate the effect of stereotype threat on many different groups.

Thus, suppose two groups of black students, B1 and B2, are chosen who are alike in all relevant features, and B1’s are told they will take an IQ test while B2s are told that it is a vocabulary test under development. Steele showed that B2’s consistently performed worse than B1s, and he attributed this to B2’s apprehension that they would
confirm the stereotype of black people having low IQs. Likewise, two groups of female students, F1 and F2, were chosen who were alike in all relevant features, and F2s were told they would take a test of their potential for athletics and F1s were told that it was a test of their vocabularies. Again F2s consistently performed worse than F1s, because of the threat of confirming the stereotype that women have low athletic ability.

In another recent study (4/24/2104) student athletes were divided into two groups, A1s and A2s. Before the test, students in A2 were asked about their sports activities on campus while students in group A1 were asked about the dining services. Students in group A2 who were reminded of their status as athletes consistently performed worse on the test (confirming the “dumb-jock” stereotype) than similar students who were not reminded of their status as athletes.

The effect of stereotype threat on performance has become a model of how unexamined preconceptions can contribute to behavior that supports those very preconceptions. Being rational requires resisting the tendency to (i) favor evidence that confirms a preexisting assumption and (ii) ignore evidence that tends to disconfirm that assumption.

5.D.2. Exercises needed on (a) experiments in the natural and social sciences; (b) common causal fallacies.