PHIL 110 Logic and Critical Thinking
Textbook

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Chapter 1

Chapter 1

Chapter 2

Chapter 2

2.1 The Basics of Logical Analysis

2.1.1 What Is Logic?

In Logic, the object of study is reasoning. This is an activity that humans engage in–when we make claims and back them up with reasons, or when we make inferences about what follows from a set of statements.

Like many human activities, reasoning can be done well, or it can be done badly. The goal of logic is to distinguish good reasoning from bad. Good reasoning is not necessarily effective reasoning; in fact, as we shall see, bad reasoning is pervasive and often extremely effective–in the sense that people are often persuaded by it. In Logic, the standard of goodness is not effectiveness in the sense of persuasiveness, but rather correctness according to logical rules.

In logic, we study the rules and techniques that allow us to distinguish good, correct reasoning from bad, incorrect reasoning.

Since there is a variety of different types of reasoning, since it's possible to develop various methods for evaluating each of those types, and since there are different views on what constitutes correct reasoning, there are many approaches to the logical enterprise. We talk of logic, but also of logics. A logic is just a set of rules and techniques for distinguishing good reasoning from bad.

So, the object of study in logic is human reasoning, with the goal of distinguishing the good from the bad. It is important to note that this approach sets logic apart from an alternative way of studying human reasoning, one more proper to a different discipline: psychology. It is possible to study human reasoning in a merely descriptive mode: to identify common patterns of reasoning and explore their psychological causes, for example. This is not logic. Logic takes up reasoning in a prescriptive mode: it tells how we ought to reason, not merely how we in fact typically do.[1]

2.1.2 Basic Notions: Propositions and Arguments

Reasoning involves claims or statements–making them and backing them up with reasons, drawing out their consequences. Propositions are the things we claim, state, assert.

[1]Psychologists have determined, for example, that most people are subject to what is called "confirmation bias"–a tendency to seek out information to confirm one's pre-existing beliefs, and ignore contradictory evidence. There are lots of studies on this effect, including even brain-scans of people engaged in evaluating evidence. All of this is very interesting, but it's psychology, not logic; it's a mere descriptive study of reasoning. From a logical, prescriptive point of view, we simply say that people should try to avoid confirmation bias, because it can lead to bad reasoning.

Propositions are the kinds of things that can be true or false. They are expressed by declarative sentences.[2] 'This book is boring' is a declarative sentence; it expresses the proposition that this book is boring, which is (arguably) true (at least so far–but it's only the first page; wait until later, when things get exciting!

Other kinds of sentences do not express propositions. Imperative sentences issue commands: 'Sit down and shut up' is an imperative sentence; it doesn't make a claim, express something that might be true or false; either it's obeyed or it isn't. Interrogative sentences ask questions: 'Who will win the World Cup this year?' is an interrogative sentence; it does not assert anything that might be true or false either.

Only declarative sentences express propositions, and so they are the only kinds of sentences we will deal with at this stage of the study of logic. (More advanced logics have been developed to deal with imperatives and questions, but we won't look at those in an introductory textbook.)

EXERCISES

Which of the following sentences are statements and which are not?

1. No one understands me but you.
2. Alligators are on average larger than crocodiles.
3. Is an alligator a reptile or a mammal?
4. An alligator is either a reptile or a mammal.
5. Don't let any reptiles into the house.
6. You may kill any reptile you see in the house.
7. East Africans are not the best distance runners.
8. Obama is not a Democrat.
9. Some humans have wings.
10. Some things with wings cannot fly.
11. Was Obama born in Kenya or Hawaii?
12. Oh no! A grizzly bear!
13. Meet me in St Louis.
14. We met in St Louis yesterday.
15. I do not want to meet a grizzly bear in the wild.

[2] We distinguish propositions from the sentences that express them because a single proposition can be expressed by different sentences. 'It's raining' and 'Es regnet' both express the proposition that it's raining; one sentence does it in English, the other in German. Also, 'John loves Mary' and 'Mary is loved by John' both express the same proposition.

The fundamental unit of reasoning is the argument. In logic, by 'argument' we don't mean a disagreement, a shouting match; rather, we define the term precisely:

> Argument = a set of propositions, one of which, the conclusion, is (supposed to be) supported by the others, the premises.

If we're reasoning by making claims and backing them up with reasons, then the claim that's being backed up is the conclusion of an argument; the reasons given to support it are the argument's premises. If we're reasoning by drawing an inference from a set of statements, then the inference we draw is the conclusion of an argument, and the statements from which its drawn are the premises.

We include the parenthetical hedge–"supposed to be"–in the definition to make room for bad arguments. Remember, in Logic, we're evaluating reasoning. Arguments can be good or bad, logically correct or incorrect. A bad argument, very roughly speaking, is one where the premises fail to support the conclusion; a good argument's premises actually do support the conclusion.

To support the conclusion means, again very roughly, to give one good reasons for believing it. This highlights the rhetorical purpose of arguments: we use arguments when we're disputing controversial issues; they aim to persuade people, to convince them to believe their conclusion.[3] As we said, in logic, we don't judge arguments based on whether or not they succeed in this goal– there are logically bad arguments that are nevertheless quite persuasive. Rather, the logical enterprise is to identify the kinds of reasons that ought to be persuasive (even if they sometimes aren't).

2.1.3 Recognizing and Explicating Arguments

Before we get down to the business of evaluating arguments–deciding whether they're good or bad–we need to develop some preliminary analytical skills. The first of these is, simply, the ability to recognize arguments when we see them, and to figure out what the conclusion is (and what the premises are).

What we want to learn first is how to explicate arguments. This involves writing down a bunch of declarative sentences that express the propositions in the argument, and clearly marking which of these sentences expresses the conclusion.

Let's start with a simple example. Here's an argument:

[3] Reasoning in the sense of drawing inferences from a set of statements is a special case of this persuasive activity. When we draw out reasonable conclusions from given information, we're convincing ourselves that we have good reasons to believe them.

> You really shouldn't eat at McDonald's. Why? First of all, they pay their workers very low wages. Second, the animals that go into their products are raised in deplorable, inhumane conditions. Third, the food is really bad for you. Finally, the burgers have poop in them.[4]

The passage is clearly argumentative: its purpose is to convince you of something, namely, that you shouldn't eat at McDonald's. That's the conclusion of the argument. The other claims are all reasons for believing the conclusion–reasons for not eating at McDonald's. Those are the premises.

To explicate the argument is simply to clearly identify the premises and the conclusion, by writing down declarative sentences that express them. We would explicate the McDonald's argument like this:

> McDonald's pays its workers very low wages.
> The animals that go into their products are raised in deplorable, inhumane conditions.
> McDonald's food is really bad for you.
> Their burgers have poop in them.
> ---
> You shouldn't eat at McDonald's.

We separate the conclusion from the premises with a horizontal line, and we put a special symbol in front of the conclusion, which can be read as "therefore."

Speaking of 'therefore', it's one of the words to look out for when identifying and explicating arguments. Along with words like 'consequently' and 'thus', and phrases like 'it follows that' and 'which implies that', it indicates the presence of the conclusion of an argument. Similarly, words like 'because', 'since', and 'for' indicate the presence of premises.

[4] I know, I know. But it's almost certainly true. Consumer Reports conducted a study in 2015, in which they tested 458 pounds of ground beef, purchased from 103 different stores in 26 different cities; all of the 458 pounds were contaminated with fecal matter. This is because most commercial ground beef is produced at facilities that process thousands of animals, and do it very quickly. The quickness ensures that sometimes–rarely, but sometimes–a knifecut goes astray and the gastrointestinal tract is nicked, releasing poop. It gets cleaned up, but again, things are moving fast, so they don't quite get all the poop. Now you've got one carcass–again, out of hundreds or thousands– contaminated with feces. But they make ground beef in a huge vat, with meat from all those carcasses mixed together. So even one accident like this contaminates the whole batch. So yeah, those burgers–basically all burgers, unless you're grinding your own meat or sourcing your beef from a local farm–have poop in them. Not much, but it's there. Of course, it won't make you sick as long as you cook it right: 160 F is enough to kill the poop-bacteria (E-coli, etc.), so, you know, no big deal. Except for the knowledge that you're eating poop. Sorry.

Premise Indicators	**Conclusion indicators**
since	therefore
because	so
for	hence
as	thus
given that	implies that
seeing that	consequently
for the reason that	it follows that
is shown by the fact that	we may conclude that

We should also note that it is possible for a single sentence to express more than one proposition. If we added this sentence to our argument–'McDonald's advertising targets children to try to create lifetime addicts to their high-calorie foods, and their expansion into global markets has disrupted native food distribution systems, harming family farmers'–we would write down two separate declarative sentences in our explication, expressing the two propositions asserted in the sentence–about children and international farmers, respectively. Indeed, it's possible for a single sentence to express an entire argument. 'You shouldn't eat at McDonald's because they're a bad corporate actor' gives you a conclusion and a premise at once. An explication would merely separate them.

Paraphrasing

The argument about McDonald's was an easy case. It didn't have a word like 'therefore' to tip us off to the presence of the conclusion, but it was pretty clear what the conclusion was anyway. All we had to do was ask ourselves, "What is this person trying to convince me to believe?" The answer to that question is the conclusion of the argument.

Another way the McDonald's argument was easy: all of the sentences were declarative sentences, so when we explicated the argument, all we had to do was write them down. But sometimes argumentative passages aren't so cooperative. Sometimes they contain non-declarative sentences. Recall, arguments are sets of propositions, and only declarative sentences express propositions; so if an argumentative passage contains non-declarative sentences (questions, commands, etc.), we need to change their wording when we explicate the argument, turning them into declarative sentences that express a proposition. This is called paraphrasing.

Suppose, for example, that the McDonald's argument were exactly as originally presented, except the first sentence were imperative, not declarative:

> Don't eat at McDonald's. Why? First of all, they pay their workers very low wages. Second, the animals that go into their products are raised in deplorable, inhumane conditions. Third, the food is really bad for you. Finally, the burgers have poop in them.

We just switched from 'You shouldn't eat at McDonald's' to 'Don't eat at McDonald's.' But it makes a difference. The first sentence is declarative; it makes a claim about how things are (morally, with respect to your obligations in some sense): you shouldn't do such-and-such. It's possible to disagree with the claim: Sure I should, and so should everybody else; their fries are delicious! 'Don't eat at McDonald's', on the other hand, is not like that. It's a command. It's possible to disobey it, but not to disagree with it; imperative sentences don't make claims about how things are, don't express propositions.

Still, the passage is clearly argumentative: the purpose remains to persuade the listener not to eat at McDonald's. We just have to be careful, when we explicate the argument, to paraphrase the first sentence–to change its wording so that it becomes a declarative, proposition-expressing sentence. 'You shouldn't eat at McDonald's' works just fine.

Let's consider a different example:

> I can't believe anyone would support a $15 per hour minimum wage. Don't they realize that it would lead to massive job losses? And the strain such a policy would put on small businesses could lead to an economic recession.

The passage is clearly argumentative: this person is engaged in a dispute about a controversial issue–the minimum wage–and is staking out a position and backing it up. What is that position? Apparently, this person opposes the idea of raising the minimum wage to $15.

There are two problems we face in explicating this argument. First, one of the sentences in the passage–the second one–is non-declarative: it's an interrogative sentence, a question. Nevertheless, it's being used in this passage to express one of the person's reasons for opposing the minimum wage increase–that it would lead to job losses. So we need to paraphrase, transforming the interrogative into a declarative–something like 'A $15 minimum wage would lead to massive job losses'.

The other problem is that the first sentence, while a perfectly respectable declarative sentence, can't be used as-is in our explication. For while it's clearly being used by to express this person's main point, the conclusion of his argument against the minimum wage increase, it does so indirectly. What the sentence literally and directly expresses is not a claim about the wisdom of the minimum wage increase, but rather a claim about the speaker's personal beliefs: 'I can't believe anyone would support a $ 15 per hour minimum wage'. But that claim isn't the conclusion of the argument. The speaker isn't trying to convince people that he believes (or can't believe) a certain thing; he's trying to convince them to believe the same thing he believes, namely, that raising the minimum wage to $ 15 is a bad idea. So, despite the first sentence being a declarative, we still have to paraphrase it. It expresses a proposition, but not the conclusion of the argument.

Our explication of the argument would look like this:

Increasing the minimum wage to $ 15 per hour would lead to massive job losses.
The policy would put a strain on small businesses that might lead to a recession.
/ Increasing the minimum wage to $ 15 per hour is a bad idea.

EXERCISES

Which of the following are arguments? If it is an argument, identify the conclusion of the argument.

1. The woman in the hat is not a witch since witches have long noses and she doesn't have a long nose.

2. I have been wrangling cattle since before you were old enough to tie your own shoes.

3. Albert is angry with me so he probably won't be willing to help me wash the dishes.

4. First I washed the dishes and then I dried them.

5. If the road wasn't icy, the car wouldn't have slid off the turn.

6. Albert isn't a fireman and he isn't a fisherman either.

7. Are you seeing that rhinoceros over there? It is huge!

8. The fact that obesity has become a problem in the U.S. is shown by the fact that obesity rates have risen significantly over the past four decades.

9. Bob showed me a graph with the rising obesity rates and I was very surprised to see how much they've risen.

10. Albert isn't a fireman because Albert is a Greyhound, which is a kind of dog, and dogs can't be firemen.

11. Charlie and Violet are dogs and since dogs dont sweat, it is obvious that Charlie and Violet don't sweat.

12. The reason I forgot to lock the door is that I was distracted by the clown riding a unicycle down our street while singing Lynyrd Skynyrd's "Simple Man."

13. What Bob told you is not the real reason that he missed his plane to Denver.

14. Samsung stole some of Apple's patents for their smartphones, so Apple stole some of Samsung's patents back in retaliation.

15. No one who has ever gotten frostbite while climbing K2 has survived to tell about it, therefore no one ever will.

Enthymemes: Tacit Propositions

So sometimes, when we explicate an argument, we have to take what's present in the argumentative passage and change it slightly, so that all of the sentences we write down express the propositions that are in the argument. This is paraphrasing. Other times, we have to do even more: occasionally, we have to fill in missing propositions; argumentative passages might not state all of the propositions in an argument explicitly, and in the course of explicating their arguments, we have to make these implicit, tacit propositions explicit by writing down the appropriate declarative sentences.

There's a fancy Greek word for argumentative passages that leave certain propositions unstated: enthymemes. Here's an example:

> Hillary Clinton has more experience in public office than Donald Trump; she has a much deeper knowledge of the issues; she's the only one with the proper temperament to lead our country. I rest my case.

Again, the argumentative intentions here are plain: this person is staking out a position on a controversial topic–a presidential election. But notice, that position–that one should prefer Clinton to Trump–is never stated explicitly. We get reasons for having that preference–the premises of the argument are explicit–but we never get a statement of the conclusion. But since this is clearly the upshot of the passage, we need to include a sentence expressing it in our explication:

> Clinton has more experience than Trump.
> Clinton has deeper knowledge of issues than Trump.
> Clinton has the proper temperament to lead the country, while Trump does not.

/ One should prefer Clinton to Trump in the presidential election.

In that example, the conclusion of the argument was tacit. Sometimes, premises are unstated and we should make them explicit in our explication of the argument. Now consider this passage:

> The sad fact is that wages for middle-class workers have stagnated over the past several decades. We need a resurgence of the union movement in this country.

This person is arguing in favor of labor unions; the second sentence is the conclusion of the argument. The first sentence gives the only explicit premise: the stagnation of middle-class wages. But notice what the passage doesn't say: what connection there might be between the two things. What do unions have to do with middle-class wages?

There's an implicit premise lurking in the background here–something that hasn't been said, but which needs to be true for the argument to go through. We need a claim that connects the premise to the conclusion–that bridges the gap between them. Something like this: A resurgence of unions would lead to wage growth for middle-class workers. The first sentence identifies a problem; the second sentence purports to give a solution to the problem. But it's only a solution if the tacit premise we've uncovered is true. If unions don't help raise middle-class wages, then the argument falls apart.

This is the mark of the kinds of tacit premises we want to uncover: if they're false, they undermine the argument. Often, premises like this are unstated for a reason: they're controversial claims on their own, requiring a lot of evidence to support them; so the arguer leaves them out, preferring not to get bogged down. When we draw them out, however, we can force a more robust dialectical exchange, focusing the argument on the heart of the matter. In this case, a discussion about the connection between unions and middle-class wages would be in order. There's a lot to be said on that topic.

Arguments v Explanations

One final item on the topic of "Recognizing and Explicating Arguments." We've been focusing on explication; this is a remark about the recognition side. Some passages may superficially resemble arguments–they may, for example, contain words like 'therefore' and 'because', which normally indicate conclusions and premises in argumentative passages–but which are nevertheless not argumentative. Instead, they are explanations.

Consider this passage:

> Because female authors of her time were often stereotyped as writing light-hearted romances, and because her real name was well-known for other (sometimes scandalous) reasons, Mary Ann Evans was reluctant to use her own name for her novels. She wanted her work to be taken seriously and judged on its own merits. Therefore, she adopted the pen name 'George Eliot'.

This passage has the words 'because' (twice), and 'therefore', which typically indicate the presence of premises and a conclusion, respectively. But it is not an argument. It's not an argument because it does not have the rhetorical purpose of an argument: the aim of the passage is not to convince you of something. If it were an argument, the conclusion would be the claim following 'therefore', namely, the proposition that Mary Ann Evans adopted the pen name 'George Eliot'. But this claim is not the conclusion of an argument; the passage is not trying to persuade us to believe that Evans adopted a pen name. That she did so is not a controversial claim. Rather, that's a fact that's assumed to be known already. The aim of the passage is to explain to us why Evans made that choice. The rhetorical purpose is not to convince; it is to inform, to edify. The passage is an explanation, not an argument.

So, to determine whether a given passage is an argument or an explanation, we need to figure out its rhetorical purpose. Why is the author saying these things to me? Is she trying to convince me of something, or is she merely trying to inform me–to give me an explanation for something I already knew? Sometimes this is easy, as with the George Eliot passage; it's hard to imagine someone saying those things with persuasive intent. Other times, however, it's not so easy. Consider the following:

Many of the celebratory rituals (of Christmas), as well as the timing of the holiday, have their origins outside of, and may predate, the Christian commemoration of the birth of Jesus. Those traditions, at their best, have much to do with celebrating human relationships and the enjoyment that this life has to offer. As an atheist, I have no hesitation in embracing the holiday and joining with believers and nonbelievers alike to celebrate what we have in common.[5]

Unless we understand a little bit more about the context of this passage, it's difficult to determine the speaker's intentions. It may appear to be an argument. That atheists should embrace a religious holiday like Christmas is, among many, a controversial claim. Controversial claims are the kinds of claims that we often try to convince skeptical people to believe. If the speaker's audience for this passage is a bunch of hard-line atheists, who

[5] John Teehan, 12/24/2006, "A Holiday Season for Atheists, Too," The New York Times. Excerpted in Copi and Cohen, 2009, Introduction to Logic 13e, p. 25.

vehemently reject anything with a whiff of religiosity, who consider Christmas a humbug, then it's pretty clear that the speaker is trying to offer reasons for them to reconsider their stance; he's trying to convince them to embrace Christmas; he's making an argument. If we explicated the argument, we would paraphrase the last sentence to represent the controversial conclusion: 'Atheists should have no hesitation embracing and celebrating Christmas'.

But in a different context, with a different audience, this may not be an argument. If we leave the claim in the final sentence as-is–'As an atheist, I have no hesitation in embracing the holiday and joining with believers and nonbelievers alike to celebrate what we have in common'–we have a claim about the speaker's personal beliefs and inclinations. Typically, as we saw above, such claims are not suitable as the conclusions of arguments; we don't usually spend time trying to convince people that we believe such-and-such. But what is more typical is providing people with explanations for why we believe things. If the author of our passage is an atheist, and he's saying these things to friends of his, say, who know he's an atheist, we might have just such an explanation. His friends know he's not religious, but they know he loves Christmas. That's kind of weird. Don't atheists hate religious holidays? Not so, says our speaker. Let me explain to you why I have no problems with Christmas, despite my atheism. Again, the difference between arguments and explanations comes down to rhetorical purpose: arguments try to convince people; explanations try to inform them. Determining whether a given passage is one or the other involves figuring out the author's intentions. To do this, we must carefully consider the context of the passage.

EXERCISES

1. Identify the conclusions in the following arguments.

(a) Every citizen has a right–nay, a duty–to defend himself and his family. This is all the more important in these increasingly dangerous times. The framers of the Constitution, in their wisdom, enshrined the right to bear arms in that very document. We should all oppose efforts to restrict access to guns.

(b) Totino's pizza rolls are the perfect food. They have all the great flavor of pizza, with the added benefit of portability!

(c) Because they go overboard making things user-friendly, Apple phones are inferior to those with Android operating systems. If you want to change the default settings on an Apple phone to customize it to your personal preferences, it's practically impossible to figure out how. The interface is so dumbed down to appeal to the "average consumer" that it's super hard to find where the controls for advanced settings even are. On Android phones, though, everything's right there in the open.

(d) The U.S. incarcerates more people per capita than any other country on Earth, many for non-violent drug offenses. Militarized policing of our inner cities has led to scores of unnecessary deaths and a breakdown of trust between law enforcement and the communities they are supposed to serve and protect. We need to end the "War on Drugs" now. Our criminal justice system is broken. The War on Drugs broke it.

(e) The point of a watch is to tell you what time it is. Period. Rolexes are a complete waste of money. They don't do any better at telling the time, and they cost a ton!

2. Explicate the following arguments, paraphrasing as necessary.

(a) You think that if the victims of the mass shooting had been armed that would've made things better? Are you nuts? The shooting took place in a bar; not even the NRA thinks it's a good idea to allow people to carry guns in a drinking establishment. And don't be fooled by the fantasy that "good guys with guns" would prevent mass murder. More likely, the situation would've been even bloodier, with panicked people shooting randomly all over the place.

(b) The heat will escape the house through the open door, which means the heater will keep running, which will make our power bill go through the roof. Then we'll be broke. So stop leaving the door open when you come into the house.

(c) Do you like delicious food? How about fun games? And I know you like cool prizes. Well then, Chuck E. Cheese's is the place for you.

3. Write down the tacit premises that the following arguments depend on for their success.

(a) Cockfighting is an exciting pastime enjoyed by many people. It should therefore be legal.

(b) The president doesn't understand the threat we face. He won't even use the phrase "Radical Islamic Terror."

4. Write down the tacit conclusion that follows most immediately from the following.

(a) If there really were an all-loving God looking down on us, then there wouldn't be so much death and destruction visited upon innocent people.

(b) The death penalty is immoral. Numerous studies have shown that there is racial bias in its application. The rise of DNA testing has exonerated scores of inmates on death row; who knows how many innocent people have been killed in the past? The death penalty is also impractical. Revenge is counterproductive: "An eye for an eye leaves the whole world blind," as Gandhi said. Moreover, the costs of litigating death penalty cases, with their endless appeals, are enormous. The correct decision for policymakers is clear.

5. Decide whether the following are arguments or explanations, given their context. If the passage is an argument, write down its conclusion; if it is an explanation, write down the fact that is being explained.

(a) Michael Jordan is the best of all time. I don't care if Kareem scored more points; I don't care if Russell won more championships. The simple fact is that no other player in history displayed the stunning combination of athleticism, competitive drive, work ethic, and sheer jaw-dropping artistry of Michael Jordan. (Context: Sports talk radio host going on a "rant")

(b) Because different wavelengths of light travel at different velocities when they pass through water droplets, they are refracted at different angles. Because these different wavelengths correspond to different colors, we see the colors separated. Therefore, if the conditions are right, rainbows appear when the sun shines through the rain. (Context: grade school science textbook)

(c) The primary motivation for the Confederate States in the Civil War was not so much the preservation of the institution of slavery, but the preservation of the sovereignty of individual states guaranteed by the 10th Amendment to the U.S. Constitution. Southerners of the time were not the simple-minded racists they were often depicted to be. Leaders in the southern states were disturbed by the over-reach of the Federal government into issues of policy more properly decided by the states. That slavery was one of those issues is incidental. (Context: excerpt from Rebels with a Cause: An Alternative History of the Civil War)

(d) This is how natural selection works: those species with traits that promote reproduction tend to have an advantage over competitors and survive; those without such traits tend to die off. The way that humans reproduce is by having sex. Since the human species has survived, it must have traits that encourage reproduction–that encourage having sex. This is why sex feels good. Sex feels good because if it didn't, the species would not have survived. (Context: excerpt from *Evolutionary Biology for Dummies*)

2.1.4 Deductive and Inductive Arguments

As we noted earlier, there are different logics–different approaches to distinguishing good arguments from bad ones. One of the reasons we need different logics is that there are different kinds of arguments. In this section, we distinguish two types: deductive and inductive arguments.

Sally Johansson does all her grocery shopping at an organic food co-op. She's a huge fan of tofu. She's really into those week-long juice cleanse thingies. And she's an active member of PETA. I conclude that she's a vegetarian.

(a) Make up a new piece of information about Sally that weakens the argument.

(b) Make up a new piece of information about Sally that strengthens the argument.

2.1.5 Diagramming Arguments

Before we get down to the business of evaluating arguments–of judging them valid or invalid, strong or weak–we still need to do some preliminary work. We need to develop our analytical skills to gain a deeper understanding of how arguments are constructed, how they hang together. So far, we've said that the premises are there to support the conclusion. But we've done very little in the way of analyzing the structure of arguments: we've just separated the premises from the conclusion. We know that the premises are supposed to support the conclusion. What we haven't explored is the question of just how the premises in a given argument do that job–how they work together to support the conclusion, what kinds of relationships they have with one another. This is a deeper level of analysis than merely distinguishing the premises from the conclusion; it will require a mode of presentation more elaborate than a list of propositions with the bottom one separated from the others by a horizontal line. To display our understanding of the relationships among premises supporting the conclusion, we are going to depict them: we are going to draw diagrams of arguments.

Here's how the diagrams will work. They will consist of three elements: (1) circles with numbers inside them–each of the propositions in the argument we're diagramming will be assigned a number, so these circled numbers in the diagram will represent the propositions; (2) arrows pointed at circled numbers–these will represent relationships of support, where one or more propositions provide a reason for believing the one pointed to; and (3) horizontal brackets–propositions connected by these will be interdependent (in a sense to be specified below).

Our diagrams will always feature the circled number corresponding to the conclusion at the bottom. The premises will be above, with brackets and arrows indicating how they collectively support the conclusion and how they're related to one another. There are a number of different relationships that premises can have to one another. We will learn how to draw diagrams of arguments by considering them in turn.

Independent Premises

Often, different premises will support a conclusion–or another premise–individually, without help from any others. When this is the case, we draw an arrow from the circled number representing that premise to the circled number representing the proposition it supports.

Consider this simple argument:

> (1) Marijuana is less addictive than alcohol. In addition, (2) it can be used as a medicine to treat a variety of conditions. Therefore, (3) marijuana should be legal.

The last proposition is clearly the conclusion (the word ‘therefore’ is a big clue), and the first two propositions are the premises supporting it. They support the conclusion independently. The mark of independence is this: each of the premises would still provide support for the conclusion even if the other weren’t true; each, on its own, gives you a reason for believing the conclusion. In this case, then, we diagram the argument as follows:

Intermediate Premises

Some premises support their conclusions more directly than others. Premises provide more indirect support for a conclusion by providing a reason to believe another premise that supports the conclusion more directly. That is, some premises are intermediate between the conclusion and other premises.

Consider this simple argument:

(1) Automatic weapons should be illegal. (2) They can be used to kill large numbers of people in a short amount of time. This is because (3) all you have to do is hold down the trigger and bullets come flying out in rapid succession.

The conclusion of this argument is the first proposition, so the premises are propositions 2 and 3. Notice, though, that there’s a relationship between those two claims. The third sentence starts with the phrase ‘This is because’, indicating that it provides a reason for another claim. The other claim is proposition 2; ‘This’ refers to the claim that automatic weapons can kill large numbers of people quickly. Why should I believe that they can do that? Because all one has to do is hold down the trigger to release lots of bullets really fast. Proposition 2 provides immediate support for the conclusion (automatic weapons can kill lots of people really quickly, so we should make them illegal); proposition 3 supports the conclusion more indirectly, by giving support to proposition 2. Here is how we diagram in this case:

Joint Premises

Sometimes premises need each other: the job of supporting another proposition can't be done by each on its own; they can only provide support together, jointly. Far from being independent, such premises are interdependent. In this situation, on our diagrams, we join together the interdependent premises with a bracket underneath their circled numbers.

There are a number of different ways in which premises can provide joint support. Sometimes, premises just fit together like a hand in a glove; or, switching metaphors, one premise is like the key that fits into the other to unlock the proposition they jointly support. An example can make this clear:

> (1) The chef has decided that either salmon or chicken will be tonight's special. (2) Salmon won't be the special. Therefore, (3) the special will be chicken.

Neither premise 1 nor premise 2 can support the conclusion on its own. A useful rule of thumb for checking whether one proposition can support another is this: read the first proposition, then say the word 'therefore', then read the second proposition; if it doesn't make any sense, then you can't draw an arrow from the one to the other. Let's try it here: "The chef has decided that either salmon or chicken will be tonight's special; therefore, the special will be chicken." That doesn't make any sense. What happened to salmon? Proposition 1 can't support the conclusion on its own. Neither can the second: "Salmon won't be the special; therefore, the special will be chicken." Again, that makes no sense. Why chicken? What about steak, or lobster? The second proposition can't support the conclusion on its own, either; it needs help from the first proposition, which tells us that if it's not salmon, it's chicken. Propositions 1 and 2 need each other; they support the conclusion jointly. This is how we diagram the argument:

The same diagram would depict the following argument:

> (1) John Le Carre gives us realistic, three-dimensional characters and complex, interesting plots. (2) Ian Fleming, on the other hand, presents an unrealistically glamorous picture of international espionage, and his plotting isn't what you'd call immersive. (3) Le Carre is a better author of spy novels than Fleming.

In this example, the premises work jointly in a different way than in the previous example. Rather than fitting together hand-in-glove, these premises each give us half of what we need to arrive at the conclusion. The conclusion is a comparison between two authors. Each of the premises makes claims about one of the two authors. Neither one, on its own, can support the comparison, because the comparison is a claim about both of them. The premises can only support the conclusion together. We would diagram this argument the same way as the last one.

Another common pattern for joint premises is when general propositions need help to provide support for particular propositions. Consider the following argument:

(1) People shouldn't vote for racist, incompetent candidates for president. (2) Donald Trump seems to make a new racist remark at least twice a week. And (3) he lacks the competence to run even his own (failed) businesses, let alone the whole country. (4) You shouldn't vote for Trump to be the president.

The conclusion of the argument, the thing it's trying to convince us of, is the last proposition– you shouldn't vote for Trump. This is a particular claim: it's a claim about an individual person, Trump. The first proposition in the argument, on the other hand, is a general claim: it asserts that, generally speaking, people shouldn't vote for incompetent racists; it makes no mention of an individual candidate. It cannot, therefore, support the particular conclusion–about Trump–on its own. It needs help from other particular claims–propositions 2 and 3–that tell us that the individual in the conclusion, Trump, meets the conditions laid out in the general proposition 1: racism and incompetence. This is how we diagram the argument:

Occasionally, an argumentative passage will only explicitly state one of a set of joint premises because the others "go without saying"–they are part of the body of background information about which both speaker and audience agree. In the last example, that Trump was an incompetent racist was not uncontroversial background information. But consider this argument:

> (1) It would be good for the country to have a woman with lots of experience in public office as president. (2) People should vote for Hillary Clinton.

Diagramming this argument seems straightforward: an arrow pointing from (1) to (2) But we've got the same relationship between the premise and conclusion as in the last example: the premise is a general claim, mentioning no individual at all, while the conclusion is a particular claim about Hillary Clinton. Doesn't the general premise "need help" from particular claims to the effect that the individual in question, Hillary Clinton, meets the conditions set forth in the premise–i.e., that she's a woman and that she has lots of experience in public office? No, not really. Everybody knows those things about her already; they go without saying, and can therefore be left unstated (implicit, tacit).

But suppose we had included those obvious truths about Clinton in our presentation of the argument; suppose we had made the tacit premises explicit:

> (1) It would be good for the country to have a woman with lots of experience in public office as president. (2) Hillary Clinton is a woman. And (3) she has deep experience with public offices–as a First Lady, U.S. Senator, and Secretary of State. (4) People should vote for Hillary Clinton.

How do we diagram this? Earlier, we talked about a rule of thumb for determining whether or not it's a good idea to draw an arrow from one number to another in a diagram: read the sentence corresponding to the first number, say the word 'therefore', then read the sentence corresponding to the second number; if it doesn't make sense, then the arrow is a bad idea. But if it does make sense, does that mean you should draw the arrow? Not necessarily. Consider the first and last sentences in this passage. Read the first, then 'therefore', then the last. Makes pretty good sense! That's just the original formulation of the argument with the tacit propositions remaining implicit. And in that case we said it would be OK to draw an arrow from the general premise's number straight to the conclusion's. But when we add the tacit premises–the second and third sentences in this passage–we can't draw an arrow directly from (1) to (4) To do so would obscure the relationship among the first three propositions and misrepresent how the argument works. If we drew an arrow from (1) to (4) what would we do with (2) to (3) in our diagram? Do they get their own arrows, too? No, that won't do. Such a diagram would be telling us that the first three propositions each independently provide a reason for the conclusion. But they're clearly not independent; there's a relationship among them that our diagram must capture, and it's the same relationship we saw in the parallel argument about Trump, with the particular claims in the second and third propositions working together with the general claim in the first:

EXERCISES

Diagram the following arguments.

1. (1) Hillary Clinton would make a better president than Donald Trump. (2) Clinton is a toughminded pragmatist who gets things done. (3) Trump is a thin-skinned maniac who will be totally ineffective in dealing with Congress.

2. (1) Donald Trump is a jerk who's always offending people. Furthermore, (2) he has no experience whatsoever in government. (3) Nobody should vote for him to be president.

3. (1) Human beings evolved to eat meat, so (2) eating meat is not immoral. (3) It's never immoral for a creature to act according to its evolutionary instincts.

4. (1) We need new campaign finance laws in this country. (2) The influence of Wall Street money on elections is causing a breakdown in our democracy with bad consequences for social justice. (3) Politicians who have taken those donations are effectively bought and paid for, consistently favoring policies that benefit the rich at the expense of the vast majority of citizens.

5. (1) Voters shouldn't trust any politician who took money from Wall Street bankers. (2) Hillary Clinton accepted hundreds of thousands of dollars in speaking fee from Goldman Sachs, a big Wall Street firm. (3) You shouldn't trust her.

6. (1) There are only three possible explanations for the presence of the gun at the crime scene: either the defendant just happened to hide from the police right next to where the gun was found, or the police planted the gun there after the fact, or it was really the defendant's gun like the prosecution says. (2) The first option is too crazy a coincidence to be at all believable, and (3) we've been given no evidence at all that the officers on the scene had any means or motivation to plant the weapon. Therefore, (4) it has to be the defendant's gun.

7. (1) Golden State has to be considered the clear favorite to win the NBA Championship. (2) No team has ever lost in the Finals after taking a 3-games-to-1 lead, and (3) Golden State now leads Cleveland 3-to-1. In addition, (4) Golden State has the MVP of the league, Stephen Curry.

8. (1) We should increase funding to public colleges and universities. First of all, (2) as funding has decreased, students have had to shoulder a larger share of the financial burden of attending college, amassing huge amounts of debt. (3) A recent report shows that the average college student graduates with almost $ 30,000 in debt. Second, (4) funding public universities is a good investment. (5) Every economist agrees that spending on public colleges is a good investment for states, where the economic benefits far outweigh the amount spent.

9. (1) LED lightbulbs last for a really long time and (2) they cost very little to keep lit. (3) They are, therefore, a great way to save money. (4) Old-fashioned incandescent bulbs, on the other hand, are wasteful. (5) You should buy LEDs instead of incandescent bulbs.

10. (1) There's a hole in my left shoe, which means (2) my feet will get wet when I wear them in the rain, and so (3) I'll probably catch a cold or something if I don't get a new pair of shoes. Furthermore, (4) having new shoes would make me look cool. (5) I should buy new shoes.

11. Look, it's just simple economics: (1) if people stop buying a product, then companies will stop producing it. And (2) people just aren't buying tablets as much anymore. (3) The CEO of Best Buy recently said that sales of tablets are "crashing" at his stores. (4) Samsung's sales of tablets were down 14% this year alone. (5) Apple's not going to continue to make your beloved iPad for much longer.

12. (1) We should increase infrastructure spending as soon as possible. Why? First, (2) the longer we delay needed repairs to things like roads and bridges, the more they will cost in the future. Second, (3) it would cause a drop in unemployment, as workers would be hired to do the work. Third, (4) with interest rates at all-time lows, financing the spending would cost relatively little. A fourth reason? (5) Economic growth. (6) Most economists agree that government spending in the current climate would boost GDP.

13. (1) Smoking causes cancer and (2) cigarettes are really expensive. (3) You should quit smoking. (4) If you don't, you'll never get a girlfriend. (5) Smoking makes you less attractive to girls: (6) it stains your teeth and (7) it gives you bad breath.

Chapter 3

Chapter 3

3.1 Deductive and Inductive Arguments

As we noted earlier, there are different logics–different approaches to distinguishing good arguments from bad ones. One of the reasons we need different logics is that there are different kinds of arguments. In this section, we distinguish two types: deductive and inductive arguments.

3.1.1 Deductive Arguments

First, deductive arguments. These are distinguished by their aim: a deductive argument attempts to provide premises that guarantee, necessitate its conclusion. Success for a deductive argument, then, does not come in degrees: either the premises do in fact guarantee the conclusion, in which case the argument is a good, successful one, or they don't, in which case it fails. Evaluation of deductive arguments is a black-and-white, yes-or-no affair; there is no middle ground. We have a special term for a successful deductive argument: we call it valid. Validity is a central concept in the study of logic. It's so important, we're going to define it three times. Each of these three definitions is equivalent to the others; they are just three different ways of saying the same thing:

An argument is valid just in case ...
(i) its premises guarantee its conclusion; i.e.,
(ii) if its premises are true, then its conclusion must also be true; i.e.,
(iii) it is impossible for its premises to be true and its conclusion false.

Here's an example of a valid deductive argument:

All humans are mortal.
Socrates is a human.
Socrates is mortal.

This argument is valid because the premises do in fact guarantee the conclusion: if they're true (as a matter of fact, they are), then the conclusion must be true; it's impossible for the premises to be true and the conclusion false.

Here's a surprising fact about validity: what makes a deductive argument valid has nothing to do with its content; rather, validity is determined by the argument's form. That is to say, what makes our Socrates argument valid is not that it says a bunch of accurate things about Socrates, humanity, and mortality. The content doesn't make a difference. Instead, it's the form that matters–the pattern that the argument exhibits.

Later, when undertake a more detailed study of deductive logic, we will give a precise definition of logical form.[1] For now, we'll use this rough gloss: the form of an argument is what's left over when you strip away all the non-logical terms and replace them with blanks.[2]

Here's what that looks like for our Socrates argument:

All A are B.
x is A.
x is B.

The letter are the blanks: they're placeholders, variables. As a matter of convention, we're using capital letters to stand for groups of things (humans, mortals) and lower case letters to stand for individual things (Socrates).

The Socrates argument is a good, valid argument because it exhibits this good, valid form. Our third way of wording the definition of validity helps us see why this is a valid form: it's impossible for the premises to be true and the conclusion false, in that it's impossible to plug in terms for A, B, and x in such a way that the premises come out true and the conclusion comes out false. A consequence of the fact that validity is determined entirely by an argument's form is that, given a valid form, every single argument that has that form will be valid. So any argument that has the same form as our Socrates argument will be valid; that is, we can pick things at random to stick in for A, B, and x, and we're guaranteed to get a valid argument. Here's a silly example:

All apples are bananas.
Donald Trump is an apple.
Donald Trump is a banana.

This argument has the same form as the Socrates argument: we simply replaced A with 'apples', B with 'bananas', and x with 'Donald Trump'. That means it's a valid argument.

[1] Definitions, actually. We'll study two different deductive logics, each with its own definition of form.

[2] What counts as a "logical term," you're wondering? Unhelpful answer: it depends on the logic; different logics count different terms as logical. Again, this is just a rough gloss. We don't need precision just yet, but we'll get it eventually.

That's a strange thing to say, since the argument is just silly–but it's the form that matters, not the content. Our second way of wording the definition of validity can help us here. The standard for validity is this: IF the premises are true, then the conclusion must be. That's a big 'IF'. In this case, as a matter of fact, the premises are not true (they're silly, plainly false). However, IF they were true–if in fact apples were a type of banana and Donald Trump were an apple–then the conclusion would be unavoidable: Trump would have to be a banana. The premises aren't true, but if they were, the conclusion would have to be–that's validity.

So it turns out that the actual truth or falsehood of the propositions in a valid argument are completely irrelevant to its validity. The Socrates argument has all true propositions and it's valid; the Donald Trump argument has all false propositions, but it's valid, too. They're both valid because they have a valid form; the truth/falsity of their propositions don't make any difference. This means that a valid argument can have propositions with almost any combination of truthvalues: some true premises, some false ones, a true or false conclusion. One can fiddle around with the Socrates' argument's form, plugging different things in for A, B, and x, and see that this is so. For example, plug in 'ants' for A, 'bugs' for B, and Beyonc for x: you get one true premise (All ants are bugs), one false one (Beyoncé is an ant), and a false conclusion (Beyoncé is a bug). Plug in other things and you can get any other combination of truth-values.

Any combination, that is, but one: you'll never get true premises and a false conclusion. That's because the Socrates' argument's form is a valid one; by definition, it's impossible to generate true premises and a false conclusion in that case.

This irrelevance of truth-value to judgments about validity means that those judgments are immune to revision. That is, once we decide whether an argument is valid or not, that decision cannot be changed by the discovery of new information. New information might change our judgment about whether a particular proposition in our argument is true or false, but that can't change our judgment about validity. Validity is determined by the argument's form, and new information can't change the form of an argument. The Socrates argument is valid because it has a valid form. Suppose we discovered, say, that as a matter of fact Socrates wasn't a human being at all, but rather an alien from outer space who got a kick out of harassing random people on the streets of ancient Athens. That information would change the argument's second premise–Socrates is human–from a truth to a falsehood. But it wouldn't make the argument invalid. The form is still the same, and it's a valid one.

It's time to face up to an awkward consequence of our definition of validity. Remember, logic is about evaluating arguments–saying whether they're good or bad. We've said that for deductive arguments, the standard for goodness is validity: the good deductive arguments are the valid ones. Here's where the awkwardness comes in: because validity is determined by form, it's possible to generate valid arguments that are nevertheless completely ridiculous-sounding on their face. Remember, the Donald Trump argument–where we concluded that he's a banana–is valid. In other words, we're saying that the Trump argument is good; it's valid, so it gets the logical thumbsup. But that's nuts! The Trump argument is obviously bad, in some sense of 'bad', right? It's a collection of silly, nonsensical claims.

We need a new concept to specify what's wrong with the Trump argument. That concept is soundness. This is a higher standard of argument-goodness than validity; in order to meet it, an argument must satisfy two conditions.

> An argument is sound just in case (i) it's valid, AND (ii) its premises are in fact true.[3]

The Trump argument, while valid, is not sound, because it fails to satisfy the second condition: its premises are both false. The Socrates argument, however, which is valid and contains nothing but truths (Socrates was not in fact an alien), is sound.

The question now naturally arises: if soundness is a higher standard of argument-goodness than validity, why didn't we say that in the first place? Why so much emphasis on validity? The answer is this: we're doing logic here, and as logicians, we have no special insight into the soundness of arguments. Or rather, we should say that as logicians, we have only partial expertise on the question of soundness. Logic can tell us whether or not an argument is valid, but it cannot tell us whether or not it is sound. Logic has no special insight into the second condition for soundness, the actual truth-values of premises. To take an example from the silly Trump argument, suppose you weren't sure about the truth of the first premise, which claims that all apples are bananas (you have very little experience with fruit, apparently). How would you go about determining whether that claim was true or false? Whom would you ask? Well, this is a pretty easy one, so you could ask pretty much anybody, but the point is this: if you weren't sure about the relationship between apples and bananas, you wouldn't think to yourself, "I better go find a logician to help me figure this out." Propositions make claims about how things are in the world. To figure out whether they're true or false, you need to consult experts in the relevant subject-matter. Most claims aren't about logic, so logic is very little help in determining truth-values. Since logic can only provide insight into

[3]What about the conclusion? Does it have to be true? Yes: remember, for valid arguments, if the premises are true, the conclusion has to be. Sound arguments are valid, so it goes without saying that the conclusion is true, provided that the premises are.

the validity half of the soundness question, we focus on validity and leave soundness to one side.

Returning to validity, then, we're now in a position to do some actual logic. Given what we know, we can demonstrate invalidity; that is, we can prove that an invalid argument is invalid, and therefore bad (it can't be sound, either; the first condition for soundness is validity, so if the argument's invalid, the question of actual truth-values doesn't even come up). Here's how:

To demonstrate the invalidity of an argument, one must write a down a new argument with the same form as the original, whose premises are in fact true and whose conclusion is in fact false. This new argument is called a counterexample.

Let's look at an example. The following argument is invalid:

> Some mammals are swimmers.
> All whales are swimmers.
> All whales are mammals.

Now, it's not really obvious that the argument is invalid. It does have one thing going for it: all the claims it makes are true. But we know that doesn't make any difference, since validity is determined by the argument's form, not its content. If this argument is invalid, it's invalid because it has a bad, invalid form. This is the form:

> Some A are B.
> All C are B.
> All C are A.

To prove that the original whale argument is invalid, we have to show that this form is invalid. For a valid form, we learned, it's impossible to plug things into the blanks and get true premises and a false conclusion; so for an invalid form, it's possible to plug things into the blanks and get that result. That's how we generate our counterexample: we plug things in for A, B, and C so that the premises turn out true and the conclusion turns out false. There's no real method here; you just use your imagination to come up with an A, B, and C that give the desired result.[4]

[4]Possibly helpful hint: universal generalizations (All ... are ...) are rarely true, so if you have to make one true, as in this example, it might be good to start there; likewise, particular claims (Some ... are ...) are rarely false, so if you have to make one false–you don't in this particular example, but if you had one as a conclusion, you would– that would be a good place to start.

Here's a counterexample:

Some lawyers are American citizens.
All members of Congress are American citizens.
———
All members of Congress are lawyers.

For A, we inserted 'lawyers', for B we chose 'American citizens', and for C, 'members of Congress'. The first premise is clearly true. The second premise is true: non-citizens aren't eligible to be in Congress. And the conclusion is false: there are lots of people in Congress who are nonlawyers–doctors, businesspeople, etc. That's all we need to do to prove that the original whale-argument is invalid: come up with one counterexample, one way of filling in the blanks in its form to get true premises and a false conclusion. We only have to prove that it's possible to get true premises and a false conclusion, and for that, you only need one example.

What's far more difficult is to prove that a particular argument is valid. To do that, we'd have to show that its form is such that it's impossible to generate a counterexample, to fill in the blanks to get true premises and a false conclusion. Proving that it's possible is easy; you only need one counterexample. Proving that it's impossible is hard; in fact, at first glance, it looks impossibly hard! What do you do? Check all the possible ways of plugging things into the blanks, and make sure that none of them turn out to have true premises and a false conclusion? That's nuts! There are, literally, infinitely many ways to fill in the blanks in an argument's form. Nobody has the time to check infinitely many potential counterexamples.

Well, take heart; it's still early. For now, we're able to do a little bit of deductive logic: given an invalid argument, we can demonstrate that it is in fact invalid. We're not yet in the position we'd like to be in, namely of being able to determine, for any argument whatsoever, whether it's valid or not. Proving validity looks too hard based on what we know so far. But we'll know more later: in chapters 3 and 4 we will study two deductive logics, and each one will give us a method of deciding whether or not any given argument is valid. But that'll have to wait. Baby steps.

Inductive Arguments

That's all we'll say for now about deductive arguments. On to the other type of argument we're introducing in this section: inductive arguments. These are distinguished from their deductive cousins by their relative lack of ambition. Whereas deductive arguments aim to give premises that guarantee/necessitate the conclusion, inductive arguments are more modest: they aim merely to provide premises that make the conclusion more probable than it otherwise would be; they aim to support the conclusion, but without making it unavoidable. Here is an example of an inductive argument:

> I'm telling you, you're not going die taking a plane to visit us. Airplane crashes happen far less frequently than car crashes, for example; so you're taking a bigger risk if you drive. In fact, plane crashes are so rare, you're far more likely to die from slipping in the bathtub. You're not going to stop taking showers, are you?

The speaker is trying to convince her visitor that he won't die in a plane crash on the way to visit her. That's the conclusion: you won't die. This claim is supported by the others–which emphasize how rare plane crashes are–but it is not guaranteed by them. After all, plane crashes sometimes do happen. Instead, the premises give reasons to believe that the conclusion–you won't die–is very probable.

Since inductive arguments have a different, more modest goal than their deductive cousins, it would be unreasonable for us to apply the same evaluative standards to both kinds of argument. That is, we can't use the terms 'valid' and 'invalid' to apply to inductive arguments. Remember, for an argument to be valid, its premises must guarantee its conclusion. But inductive arguments don't even try to provide a guarantee of the conclusion; technically, then, they're all invalid. But that won't do. We need a different evaluative vocabulary to apply to inductive arguments. We will say of inductive arguments that they are (relatively) strong or weak, depending on how probable their conclusions are in light of their premises. One inductive argument is stronger than another when its conclusion is more probable than the other, given their respective premises.

One consequence of this difference in evaluative standards for inductive and deductive arguments is that for the former, unlike the latter, our evaluations are subject to revision in light of new evidence. Recall that since the validity or invalidity of a deductive argument is determined entirely by its form, as opposed to its content, the discovery of new information could not affect our evaluation of those arguments. The Socrates argument remained valid, even if we discovered that Socrates was in fact an alien. Our evaluations of inductive arguments, though, are not immune to revision in this way. New information might make the conclusion of an inductive argument more or less probable, and so we would have to revise our judgment accordingly, saying that the argument is stronger or weaker. Returning to the example above about plane crashes, suppose we were to discover that the FBI in the visitor's hometown had recently being hearing lots of “chatter” from terrorist groups active in the area, with strong indications that they were planning to blow up a passenger plane. Yikes! This would affect our estimation of the probability of the conclusion of the argument–that the visitor wasn’t going to die in a crash. The probability of not dying goes down (as the probability of dying goes up). This new information would trigger a re-evaluation of the argument, and we would say it’s now weaker. If, on the other hand, we were to learn that the airline that flies between the visitor’s and the speaker’s towns had recently upgraded its entire fleet, getting rid of all of its older planes, replacing them with newer, more reliable model, while in addition instituting a new, more thorough and rigorous program of pre- and post-flight safety and maintenance inspections–well, then we might revise our judgment in the other direction.

Given this information, we might judge that things are even safer for the visitor as it regards plane travel; that is, the proposition that the visitor won’t die is now even more probable than it was before. This new information would strengthen the argument to that conclusion.

Reasonable follow-up question: how much is the argument strengthened or weakened by the new information imagined in these scenarios? Answer: how should I know? Sorry, that’s not very helpful. But here’s the point: we’re talking about probabilities here; sometimes it’s hard to know what the probability of something happening really is. Sometimes it’s not: if I flip a coin, I know that the probability of it coming up tails is 0.5. But how probable is it that a particular plane from Airline X will crash with our hypothetical visitor on board? I don’t know. And how much more probable is a disaster on the assumption of increased terrorist chatter? Again, I have no idea. All I know is that the probability of dying on the plane goes up in that case. And in the scenario in which Airline X has lots of new planes and security measures, the probability of a crash goes down.

Sometimes, with inductive arguments, all we can do is make relative judgments about strength and weakness: in light of these new facts, the conclusion is more or less probable than it was before we learned of the new facts. Sometimes, however, we can be precise about probabilities and make absolute judgments about strength and weakness: we can say precisely how probable a conclusion is in light of the premises supporting it. But this is a more advanced topic. We will discuss inductive logic in chapters 5 and 6, and will go into more depth then. Until then, patience. Baby steps.

EXERCISES

1. Determine whether the following statements are true or false.

1. Not all valid arguments are sound.
2. An argument with a false conclusion cannot be sound.
3. An argument with true premises and a true conclusion is valid.
4. An argument with a false conclusion cannot be valid.

2. Demonstrate that the following argument is invalid.

Some politicians are Democrats.
Hillary Clinton is a politician.
———
Hillary Clinton is a Democrat.

The argument's form is:

Some A are B.
x is A.
———
x is B.

(where 'A' and 'B' stand for groups of things and 'x' stands for an individual)

3. Consider the following inductive argument (about a made-up person):
Sally Johansson does all her grocery shopping at an organic food co-op. She's a huge fan of tofu. She's really into those week-long juice cleanse thingies. And she's an active member of PETA. I conclude that she's a vegetarian.

1. Make up a new piece of information about Sally that weakens the argument.
2. Make up a new piece of information about Sally that strengthens the argument.

3.1.2 Arguments with missing premises

Quite often, an argument will not explicitly state a premise that we can see is needed in order for the argument to be valid. In such a case, we can supply the premise(s) needed in order so make the argument valid. Making missing premises explicit is a central part of reconstructing arguments in standard form. We have already dealt in part with this in the section on paraphrasing, but now that we have introduced the concept of validity, we have a useful tool for knowing when to supply missing premises in our reconstruction of an argument. In some cases, the missing premise will be fairly obvious, as in the following:

> Gary is a convicted sex-offender, so Gary is not allowed to work with children.

The premise and conclusion of this argument are straightforward:

Gary is a convicted sex-offender
___
Therefore, Gary is not allowed to work with children (from premise 1)

However, as stated, the argument is invalid. (Before reading on, see if you can provide a counterexample for this argument. That is, come up with an imaginary scenario in which the premise is true and yet the conclusion is false.) Here is just one counterexample (there could be many): Gary is a convicted sex-offender but the country in which he lives does not restrict convicted sex-offenders from working with children. I don't know whether there are any such countries, although I suspect there are (and it doesn't matter for the purpose of validity whether there are or aren't). In any case, it seems clear that this argument is relying upon a premise that isn't explicitly stated. We can and should state that premise explicitly in our reconstruction of the standard form argument. But what is the argument's missing premise? The obvious one is that no sexoffenders are allowed to work with children, but we could also use a more carefully statement like this one:

> Where Gary lives, no convicted sex-offenders are allowed to work with children.

It should be obvious why this is a more "careful" statement. It is more careful because it is not so universal in scope, which means that it is easier for the statement to be made true. By relativizing the statement that sex-offenders are not allowed to work with children to the place where Gary lives, we leave open the possibility that other places in the world don't have this same restriction. So even if there are other places in the world where convicted sex-offenders are allowed to work with children, our statements could still be true since in this place (the place where Gary lives) they aren't. (For more on strong and weak statements, see section 1.10). So here is the argument in standard form:

> Gary is a convicted sex-offender.
> Where Gary lives, no convicted sex-offenders are allowed to work with children.
> Therefore, Gary is not allowed to work with children. (from premises 1-2)

This argument is now valid: there is no way for the conclusion to be false, assuming the truth of the premises. This was a fairly simple example where the missing premise needed to make the argument valid was relatively easy to see. As we can see from this example, a missing premise is a premise that the argument needs in order to be as strong as possible. Typically, this means supplying the statement(s) that are needed to make the argument valid. But in addition to making the argument valid, we want to make the argument plausible. This is called "the principle of charity." The principle of charity states that when reconstructing an argument, you should try to make that argument (whether inductive or deductive) as strong as possible. When it comes to supplying missing premises, this means supplying the most plausible premises needed in order to make the argument either valid (for deductive arguments) or inductively strong (for inductive arguments).

Although in the last example figuring out the missing premise was relatively easy to do, it is not always so easy. Here is an argument whose missing premises are not as easy to determine:

> Since children who are raised by gay couples often have psychological and emotional problems, the state should discourage gay couples from raising children.

The conclusion of this argument, that the state should not allow gay marriage, is apparently supported by a single premise, which should be recognizable from the occurrence of the premise indicator, "since." Thus, our initial reconstruction of the standard form argument looks like this:

> Children who are raised by gay couples often have psychological and emotional problems.
> Therefore, the state should discourage gay couples from raising children.

However, as it stands, this argument is invalid because it depends on certain missing premises. The conclusion of this argument is a normative statement a statement about whether something ought to be true, relative to some standard of evaluation.

Normative statements can be contrasted with descriptive statements, which are simply factual claims about what is true. For example, "Russia does not allow gay couples to raise children" is a descriptive statement. That is, it is simply a claim about what is in fact the case in Russia today. In contrast, "Russia should not allow gay couples to raise children" is a normative statement since it is not a claim about what is true, but what ought to be true, relative to some standard of evaluation (for example, a moral or legal standard). An important idea within philosophy, which is often traced back to the Scottish philosopher David Hume (1711-1776), is that statements about what ought to be the case (i.e., normative statements) can never be derived from statements about what is the case (i.e., descriptive statements). This is known within philosophy as the is-ought gap. The problem with the above argument is that it attempts to infer a normative statement from a purely descriptive statement, violating the is-ought gap. We can see the problem by constructing a counterexample. Suppose that in society x it is true that children raised by gay couples have psychological problems. However, suppose that in that society people do not accept that the state should do what it can to decrease harm to children. In this case, the conclusion, that the state should discourage gay couples from raising children, does not follow. Thus, we can see that the argument depends on a missing or assumed premise that is not explicitly stated. That missing premise must be a normative statement, in order that we can infer the conclusion, which is also a normative statement. There is an important general lesson here: Many times an argument with a normative conclusion will depend on a normative premise which is not explicitly stated. The missing normative premise of this particular argument seems to be something like this:

> The state should always do what it can to decrease harm to children.

Notice that this is a normative statement, which is indicated by the use of the word "should." There are many other words that can be used to capture normative statements such as: good, bad, and ought. Thus, we can reconstruct the argument, filling in the missing normative premise like this:

> Children who are raised by gay couples often have psychological and emotional problems.
> The state should always do what it can to decrease harm to children.
> ---
> Therefore, the state should discourage gay couples from raising children. (from premises 1-2)

However, although the argument is now in better shape, it is still invalid because it is still possible for the premises to be true and yet the conclusion false. In order to show this, we just have to imagine a scenario in which both the premises are true and yet the conclusion is false. Here is one counterexample to the argument (there are many). Suppose that while it is true that children of gay couples often have psychological and emotional problems, the rate of psychological problems in children raised by gay couples is actually lower than in children raised by heterosexual couples. In this case, even if it were true that the state should always do what it can to decrease harm to children, it does not follow that the state should discourage gay couples from raising children. In fact, in the scenario I've described, just the opposite would seem to follow: the state should discourage heterosexual couples from raising children.

But even if we suppose that the rate of psychological problems in children of gay couples is higher than in children of heterosexual couples, the conclusion still doesn't seem to follow. For example, it could be that the reason that children of gay couples have higher rates of psychological problems is that in a society that is not yet accepting of gay couples, children of gay couples will face more teasing, bullying and general lack of acceptance than children of heterosexual couples. If this were true, then the harm to these children isn't so much due to the fact that their parents are gay as it is to the fact that their community does not accept them. In that case, the state should not necessarily discourage gay couples from raising children. Here is an analogy: At one point in our country's history (if not still today) it is plausible that the children of black Americans suffered more psychologically and emotionally than the children of white Americans. But for the government to discourage black Americans from raising children would have been unjust, since it is likely that if there was a higher incidence of psychological and emotional problems in black Americans, then it was due to unjust and unequal conditions, not to the black parents, per se. So, to return to our example, the state should only discourage gay couples from raising children if they know that the higher incidence of psychological problems in children of gay couples isn't the result of any kind of injustice, but is due to the simple fact that the parents are gay.

Thus, one way of making the argument (at least closer to) valid would be to add the following two missing premises:

A. The rate of psychological problems in children of gay couples is higher than in children of heterosexual couples.
B. The higher incidence of psychological problems in children of gay couples is not due to any kind of injustice in society, but to the fact that the parents are

gay.

So the reconstructed standard form argument would look like this:

Children who are raised by gay couples often have psychological and emotional problems.
The rate of psychological problems in children of gay couples is higher than in children of heterosexual couples.
The higher incidence of psychological problems in children of gay couples is not due to any kind of injustice in society, but to the fact that the parents are gay.
The state should always do what it can to decrease harm to children.
Therefore, the state should discourage gay couples from raising children. (from premises 1-4)

In this argument, premises 2-4 are the missing or assumed premises. Their addition makes the argument much stronger, but making them explicit enables us to clearly see what assumptions the argument relies on in order for the argument to be valid. This is useful since we can now clearly see which premises of the argument we may challenge as false. Arguably, premise 4 is false, since the state shouldn't always do what it can to decrease harm to children. Rather, it should only do so as long as such an action didn't violate other rights that the state has to protect or create larger harms elsewhere.

The important lesson from this example is that supplying the missing premises of an argument is not always a simple matter. In the example above, I have used the principle of charity to supply missing premises. Mastering this skill is truly an art (rather than a science) since there is never just one correct way of doing it (cf. section 1.5) and because it requires a lot of skilled practice.

EXERCISES:

Supply the missing premise or premises needed in order to make the following arguments valid. Try to make the premises as plausible as possible while making the argument valid (which is to apply the principle of charity).

1. Ed rides horses. Therefore, Ed is a cowboy.
2. Tom was driving over the speed limit. Therefore, Tom was doing something wrong.
3. If it is raining then the ground is wet. Therefore, the ground must be wet.
4. All elves drink Guinness, which is why Olaf drinks Guinness.

5. Mark didn't invite me to homecoming. Instead, he invited his friend Alexia. So he must like Alexia more than me.

6. The watch must be broken because every time I have looked at it, the hands have been in the same place.

7. Olaf drank too much Guinness and fell out of his second story apartment window. Therefore, drinking too much Guinness caused Olaf to injure himself.

8. Mark jumped into the air. Therefore, Mark landed back on the ground.

9. In 2009 in the United States, the net worth of the median white household was $113,149 a year, whereas the net worth of the median black household was $5,677. Therefore, as of 2009, the United States was still a racist nation.

10. The temperature of the water is 212 degrees Fahrenheit. Therefore, the water is boiling.

11. Capital punishment sometimes takes innocent lives, such as the lives of individuals who were later found to be not guilty. Therefore, we should not allow capital punishment.

12. Allowing immigrants to migrate to the U.S. will take working class jobs away from working class folks. Therefore, we should not allow immigrants to migrate to the U.S.

13. Prostitution is a fair economic exchange between two consenting adults. Therefore, prostitution should be allowed.

14. Colleges are more interested in making money off of their football athletes than in educating them. Therefore, college football ought to be banned.

15. Edward received an F in college Algebra. Therefore, Edward should have studied more.

Chapter 4

Chapter 4

4.1 Induction

4.1.1 Inductive argumentation

Inductive argumentation is a less certain, more realistic, more familiar way of reasoning that we all do, all the time. Inductive argumentation recognizes, for instance, that a premise like “All horses have four legs” comes from our previous experience of horses. If one day we were to encounter a three-legged horse, deductive logic would tell us that “All horses have four legs” is false, at which point the premise becomes rather useless for a deducer. In fact, deductive logic tells us that if the premise “All horses have four legs” is false, even if we know there are many, many four-legged horses in the world, when we go to the track and see hordes of four-legged horses, all we can really be certain of is that “There is at least one four-legged horse.”

Inductive logic allows for the more realistic premise, “The vast majority of horses have four legs”. And inductive logic can use this premise to infer other useful information, like “If I’m going to get Chestnut booties for Christmas, I should probably get four of them.” The trick is to recognize a certain amount of uncertainty in the truth of the conclusion, something for which deductive logic does not allow. In real life, however, inductive logic is used much more frequently and (hopefully) with some success.

Predicting the Future

We constantly use inductive reasoning to predict the future. We do this by compiling evidence based on past observations, and by assuming that the future will resemble the past. For instance, I make the observation that every other time I have gone to sleep at night, I have woken up in the morning. There is actually no certainty that this will happen, but I make the inference because of the fact that this is what has happened every other time. In fact, it is not the case that “All people who go to sleep at night wake up in the morning”. But I’m not going to lose any sleep over that. And we do the same thing when our experience has been less consistent. For instance, I might make the assumption that, if there’s someone at the door, the dog will bark. But it’s not outside the realm of possibility that the dog is asleep, has gone out for a walk, or has been persuaded not to bark by a clever intruder with sedative-laced bacon. I make the assumption that if there’s someone at the door, the dog will bark, because that is what usually happens.

Explaining Common Occurrences

We also use inductive reasoning to explain things that commonly happen. For instance, if I'm about to start an exam and notice that Bill is not here, I might explain this to myself with the reason that Bill is stuck in traffic. I might base this on the reasoning that being stuck in traffic is a common excuse for being late, or because I know that Bill never accounts for traffic when he's estimating how long it will take him to get somewhere. Again, that Bill is actually stuck in traffic is not certain, but I have some good reasons to think it's probable. We use this kind of reasoning to explain past events as well. For instance, if I read somewhere that 1986 was a particularly good year for tomatoes, I assume that 1986 also had some ideal combination of rainfall, sun, and consistently warm temperatures. Although it's possible that a scientific madman circled the globe planting tomatoes wherever he could in 1986, inductive reasoning would tell me that the former, environmental explanation is more likely. (But I could be wrong.)

Generalizing

Often we would like to make general claims, but in fact it would be very difficult to prove any general claim with any certainty. The only way to do so would be to observe every single case of something about which we wanted to make an observation. This would be, in fact, the only way to prove such assertions as, "All swans are white". Without being able to observe every single swan in the universe, I can never make that claim with certainty. Inductive logic, on the other hand, allows us to make the claim, with a certain amount of modesty.

4.1.2 Inductive Generalization

Inductive generalization allows us to make general claims, despite being unable to actually observe every single member of a class in order to make a certainly true general statement. We see this in scientific studies, population surveys, and in our own everyday reasoning. Take for example a drug study. Some doctor or other wants to know how many people will go blind if they take a certain amount of some drug for so many years. If they determine that 5% of people in the study go blind, they then assume that 5% of all people who take the drug for that many years will go blind. Likewise, if I survey a random group of people and ask them what their favourite color is, and 75% of them say "purple", then I assume that purple is the favourite colour of 75% of people. But we have to be careful when we make an inductive generalization. When you tell me that 75% of people really like purple, I'm going to want to know whether you took that survey outside a Justin Bieber concert.

Let's take an example. Let's say I asked a class of 400 students whether or not they think logic is a valuable course, and 90% of them said yes. I can make an inductive argument like this:

<u>90% of 400 students believe that logic is a valuable course</u>.
Therefore 90% of all students believe that logic is a valuable course.

There are certain things I need to take into account in judging the quality of this argument. For instance, did I ask this in a logic course? Did the respondents have to raise their hands so that the professor could see them, or was the survey taken anonymously? Are there enough students in the course to justify using them as a representative group for students in general?

If I did, in fact, make a class of 400 logic students raise their hands in response to the question of whether logic is valuable course, then we can identify a couple of problems with this argument. The first is bias. We can assume that anyone enrolled in a logic course is more likely to see it as valuable than any random student. I have therefore skewed the argument in favour of logic courses. I can also question whether the students were answering the question honestly. Perhaps if they are trying to save the professor's feelings, they are more likely to raise their hands and assure her that the logic course is a valuable one.

Now let's say I've avoided those problems. I have assured that the 400 students I have asked are randomly selected, say, by soliciting email responses from randomly selected students from the university's entire student population. Then the argument looks stronger.

Another problem we might have with the argument is whether I have asked enough students so that the whole population is well-represented. If the student body as a whole consists of 400 students, my argument is very strong. If the student body numbers in the tens of thousands, I might want to ask a few more before assuming that the opinions of a few mirror those of the many. This would be a problem with my sample size.

Let's take another example. Now I'm going to run a scientific study, in which I will pay someone $50 to take a drug with unknown effects and see if it makes them blind. In order to control for other variables, I open the study only to white males between the ages of 18 and 25.

A bad inductive argument would say:

40% of 1000 people who took the drug went blind.
40% of people who take the drug will go blind.

A better inductive argument would make a more modest claim:

40% of the 1000 people who took the drug went blind.
40% of white males between the ages of 18 and 25 who take the drug will go blind.

The point behind this example is to show how inductive reasoning imposes an important limitation on the possible conclusions a study or a survey can make. In order to make good generalizations, we need to ensure that our sample is representative, non-biased, and sufficiently sized.

4.1.3 Statistical Syllogism

Where in an inductive generalization we saw statement expressing a statistic applied to a more general group, we can also use statistics to go from the general to the particular. For instance, if I know that most computer science majors are male, and that some random individual with the androgynous name "Cameron" is an computer science major, then we can be reasonably certain that Cameron is a male. We tend to represent the uncertainty by qualifying the conclusion with the word "probably". If, on the other hand, we wanted to say that something is unlikely, like that Cameron were a female, we could use "probably not". It is also possible to temper our conclusion with other similar qualifying words.

Let's take an example.

Of the 133 people found guilty of homicide last year in Canada, 79% were jailed.
Socrates was found guilty of homicide last year in Canada.
Therefore, Socrates was probably jailed.

In this case we can be reasonably sure that Socrates is currently rotting in prison. Now the certainty of our conclusion seems to be dependent on the statistics we're dealing with. There are definitely more certain and more uncertain cases.

In the last election, 50% of voting Americans voted for Obama, while 48% voted for Romney.

Jim is a voting American.
Jim probably voted for Obama.

Clearly, this argument is not as strong as the first. It is only slightly more likely than not that Jim voted for Obama. In this case we might want to revise our conclusion to say:

(C) It is slightly more likely than not that Jim voted for Obama.

In other cases, the likelihood that something is or is not the case approaches certainty. For example:

There is a 0.00000059% chance you will die on any single flight, assuming you use one of the most poorly rated airlines.
I'm flying to Paris next week.
There's more than a million to one chance that I will die on my flight.

Note that in all of these examples, nothing is ever stated with absolute certainty. It is possible to improve the chances that our conclusions will be accurate by being more specific, or finding out more information. We would know more about Jim's voting strategy, for instance, if we knew where he lived, his previous voting habits, or if we simply asked him for whom he voted (in which case, we might also want to know how often Jim lies).

Induction is the process of justifying quantified, categorical generalizations such as "All dogs like hot dogs." and "92% of Canadian adults are owners of a mobile phone." based on data about particular cases which we have experienced.

Claims like this are made all the time by people in everyday life. For example, a lot of common knowledge about things are their properties is encoded in generalizations, such as "Birds have wings." and "Bananas grow on trees.".

Stereotypes about different nations or ethnicities, such as "All Irish people love a drink.", are generalizations. So are superstitions such as "I always play well when I wear my lucky socks.".

As the examples of stereotypes and superstitions show, induction in everyday life is often done hastily. Doing it properly requires collecting a large, unbiased sample, so that the percentage discovered in the sample is likely to be close to that in the population. When a categorical proposition has a quantity that is universal or near-universal it can be used in inferences which classify new objects or events. For example, if you know "Almost all dogs have tails.", you can infer that Jack's new dog, Jim, has a tail.

4.1.4 Inductive Generalization (IG)

Induction is the process of justifying quantified, categorical propositions such as "All dogs like hot dogs." and "92% of Canadian adults are owners of a mobile phone." based on information about particular cases which we have experienced.

People make claims like this all the time. For example, a lot of common knowledge about things and their properties is encoded in such propositions, such as "Birds have wings." and "Bananas grow on trees.". Stereotypes about different nations or ethnicities, such as "All Irish people love a drink.", are also quantified categorical propositions.

These propositions are categorical in that they are about categories or classes or types of thing, rather than a particular case or instance of that type. For example, "Jim loves chasing squirrels." is about a specific dog, Jim, while "Most dogs are things that love chasing squirrels." (or more naturally "Most dogs love chasing squirrels.") is about dogs in general.

These proposition are quantified in that they specify what proportion or percentage of members of the initial class belong to the class mentioned in the predicate. "Nine out of ten dentists brush with Oral-B toothbrushes." tells us that the percentage of dentists who use an Oral-B toothbrush is 90%. If the quantity is "All" or 100%, or "None" or 0%, the proposition is universal. Universality is rarely the case; what we more often get is a proposition describing a probabilistic relation–e.g. if F is present, G is present in 90% of cases. We are happy if the frequency of joint appearance or non-appearance is very high or near-universal.

We turn now to the process of generalization from a sample to a wider population. Consider the following scenario:

Jack shakes a large opaque basket filled with 4,000 black and red cubes, reaches in without looking, and grabs 500. He counts the reds, sees that he has 450, and then on this basis infers that roughly 90% of the cubes in the basket are red.

Jack's inference is an instance of inductive generalization (IG) (or sometimes simply induction), and in standard form (i.e. with the premises above the line and the conclusion below) it looks like this:

> Cube1 through Cube500 are all cubes in the basket.
> <u>90% of the 500 cubes examined are red</u>.
> Roughly 90% of the 4,000 cubes in the basket are red.

(Important Note: This analysis of the inference does not use the literal propositions in the passage. Rather, the relevant information is extracted from the passage. Which information is important is about to be explained.)

This inference concerns a sample of cubes (500 of them) from a wider population (of 4,000). The population is all the cubes in the basket, and this is mentioned in the conclusion. The sample is the cubes Jack looked at, and this is mentioned in premise (1).

Since we are interested in the percentage of the cubes that are red, the cubes can divided into two types: those that are red, and those that are not red. The color of the cubes is a variable, which means that it can take multiple values, in this case two: red and black. Writing out all of the information in propositions would be a lot of work; there would be 500 premises stating that each cube is a cube in the basket (i.e. (1) Cube 1 is a cube in the basket. (2) Cube 2 is a cube in the basket. . . .) and 500 more stating the color of each cube (i.e. (1) Cube 1 is red. (2) Cube 2 is red. (3) Cube 3 is black. . . .). What we do instead is summarize all of this information in two premises. Premise (1) states that the 500 cases are cubes in the basket, while premise (2) states the proportion that are red. (The remainder are then assumed to be black.)

From the fact that 90% of the cubes in the sample are red, Jack infers that roughly 90% of the population of cubes are red. That is, he generalizes. The conclusion moves beyond the specific cubes which were examined to cubes in the basket generally.

Here is the general form of IG:

Case1 through caseN are all F.
The % of case1 through caseN are also G.
The sample is large.
The sampling method yields an unbiased sample.
Roughly % of cases of F are G.

"F" and "G" stand for any two types of thing; they can refer to either the presence or the absence of any type of thing. The first two premises refer to a limited number of cases of F, while the conclusion refers to all Fs. The sample is numbered from 1 to n. The percentage-sign (%) stands for a proportion, expressed as a percentage (or sometimes a fraction, and in ordinary speech by a quantifying word or phrase such as "All", "Most", "A majority of", "Some", and so on). The word "roughly" (or some equivalent word) appears in the conclusion because it is improbable that the percentage of Gs in the population is exactly the same as the percentage of Gs in the sample.

IG can be used whether F and G are described positively or negatively. For example, we might be interested in the percentage of cases in which something is absent that are also cases where a second thing is absent (e.g. In 100% of places where water is absent, life is impossible), or one thing is absent and another present (e.g. 72% of buildings without sprinkler systems suffer serious damage in fires) or the first thing is present and the second absent (e.g. 97% of children who have been vaccination do not contract a certain illness).

4.2 Potential Problems with Inductive arguments and statistical generalizations

As we've seen, an inductive argument is an argument whose conclusion is supposed to follow from its premises with a high level of probability, rather than with certainty. This means that although it is possible that the conclusion doesn't follow from its premises, it is unlikely that this is the case. We said that inductive arguments are "defeasible," meaning that we could turn a strong inductive argument into a weak inductive argument simply by adding further premises to the argument. In contrast, deductive arguments that are valid can never be made invalid by adding further premises. Consider our "Tweets" argument:

> Tweets is a healthy, normally functioning bird
> Most healthy, normally functioning birds fly
> ---
> Therefore, Tweets probably flies

Without knowing anything else about Tweets, it is a good bet that Tweets flies. However, if we were to add that Tweets is 6 ft. tall and can run 30 mph, then it is no longer a good bet that Tweets can fly (since in this case Tweets is likely an ostrich and therefore can't fly). The second premise, "most healthy, normally functioning birds fly," is a statistical generalization. Statistical generalizations are generalizations arrived at by empirical observations of certain regularities. Statistical generalizations can be either universal or partial. Universal generalizations assert that all members (i.e., 100%) of a certain class have a certain feature, whereas partial generalizations assert that most or some percentage of members of a class have a certain feature. For example, the claim that "67.5% of all prisoners released from prison are rearrested within three years" is a partial generalization that is much more precise than simply saying that "most prisoners released from prison are rearrested within three years." In contrast, the claim that "all prisoners released from prison are rearrested within three years" is a universal generalization. As we can see from these examples, deductive arguments typically use universal statistical generalizations whereas inductive arguments typically use partial statistical generalizations. Since statistical generalizations are often crucial premises in both deductive and inductive arguments, being able to evaluate when a statistical generalization is good or bad is crucial for being able to evaluate arguments. What we are doing in evaluating statistical generalizations is determining whether the premise in our argument is true (or at least wellsupported by the evidence). For example, consider the following inductive argument, whose premise is a (partial) statistical generalization:

70% of voters say they will vote for candidate X
Therefore, candidate X will probably win the election

This is an inductive argument because even if the premise is true, the conclusion could still be false (for example, an opponent of candidate X could systematically kill or intimidate those voters who intend to vote for candidate X so that very few of them will actually vote). Furthermore, it is clear that the argument is intended to be inductive because the conclusion contains the word "probably," which clearly indicates that an inductive, rather than deductive, inference is intended. Remember that in evaluating arguments we want to know about the strength of the inference from the premises to the conclusion, but we also want to know whether the premise is true! We can assess whether or not a statistical generalization is true by considering whether the statistical generalization meets certain conditions. There are two conditions that any statistical generalization must meet in order for the generalization to be deemed "good."

1. Adequate sample size: the sample size must be large enough to support the generalization.
2. Non-biased sample: the sample must not be biased.

A sample is simply a portion of a population. A population is the totality of members of some specified set of objects or events. For example, if I were determining the relative proportion of cars to trucks that drive down my street on a given day, the population would be the total number of cars and trucks that drive down my street on a given day. If I were to sit on my front porch from 12-2 pm and count all the cars and trucks that drove down my street, that would be a sample. A good statistical generalization is one in which the sample is representative of the population. When a sample is representative, the characteristics of the sample match the characteristics of the population at large. For example, my method of sampling cars and trucks that drive down my street would be a good method as long as the proportion of trucks to cars that drove down my street between 12-2 pm matched the proportion of trucks to cars that drove down my street during the whole day. If for some reason the number of trucks that drove down my street from 12-2 pm was much higher than the average for the whole day, my sample would not be representative of the population I was trying to generalize about (i.e., the total number of cars and trucks that drove down my street in a day). The "adequate sample size" condition and the "non-biased sample" condition are ways of making sure that a sample is representative. In the rest of this section, we will explain each of these conditions in turn.

It is perhaps easiest to illustrate these two conditions by considering what is wrong with statistical generalizations that fail to meet one or more of these conditions. First, consider a case in which the sample size is too small (and thus the adequate sample size condition is not met). If I were to sit in front of my house for only fifteen minutes from 12:00-12:15 and saw only one car, then my sample would consist of only 1 automobile, which happened to be a car. If I were to try to generalize from that sample, then I would have to say that only cars (and no trucks) drive down my street. But the evidence for this universal statistical generalization (i.e., "every automobile that drives down my street is a car") is extremely poor since I have sampled only a very small portion of the total population (i.e., the total number of automobiles that drive down my street). Taking this sample to be representative would be like going to Flagstaff, AZ for one day and saying that since it rained there on that day, it must rain every day in Flagstaff. Inferring to such a generalization is an informal fallacy called "hasty generalization." One commits the fallacy of hasty generalization when one infers a statistical generalization (either universal or partial) about a population from too few instances of that population. Hasty generalization fallacies are very common in everyday discourse, as when a person gives just one example of a phenomenon occurring and implicitly treats that one case as sufficient evidence for a generalization. This works especially well when fear or practical interests are involved. For example, Jones and Smith are talking about the relative quality of Fords versus Chevys and Jones tells Smith about his uncle's Ford, which broke down numerous times within the first year of owning it. Jones then says that Fords are just unreliable and that that is why he would never buy one. The generalization, which is here ambiguous between a universal generalization (i.e., all Fords are unreliable) and a partial generalization (i.e., most/many Fords are unreliable), is not supported by just one case, however convinced Smith might be after hearing the anecdote about Jones's uncle's Ford.

The non-biased sample condition may not be met even when the adequate sample size condition is met. For example, suppose that I count all the cars on my street for a three hour period from 11-2 pm during a weekday. Let's assume that counting for three hours straight give us an adequate sample size. However, suppose that during those hours (lunch hours) there is a much higher proportion of trucks to cars, since (let's suppose) many work trucks are coming to and from worksites during those lunch hours. If that were the case, then my sample, although large enough, would not be representative because it would be biased. In particular, the number of trucks to cars in the sample would be higher than in the overall population, which would make the sample unrepresentative of the population (and hence biased).

Another good way of illustrating sampling bias is by considering polls. So consider candidate X who is running for elected office and who strongly supports gun rights and is the candidate of choice of the NRA. Suppose an organization runs a poll to determine how candidate X is faring against candidate Y, who is actively anti gun rights. But suppose that the way the organization administers the poll is by polling subscribers to the magazine, Field and Stream. Suppose the poll returned over 5000 responses, which, let's suppose, is an adequate sample size and out of those responses, 89% favored candidate X. If the organization were to take that sample to support the statistical generalization that "most voters are in favor of candidate X" then they would have made a mistake. If you know anything about the magazine Field and Stream, it should be obvious why. Field and Stream is a magazine whose subscribers who would tend to own guns and support gun rights. Thus we would expect that subscribers to that magazine would have a much higher percentage of gun rights activists than would the general population, to which the poll is attempting to generalize. But in this case, the sample would be unrepresentative and biased and thus the poll would be useless. Although the sample would allow us to generalize to the population, "Field and Stream subscribers," it would not allow us to generalize to the population at large. Let's consider one more example of a sampling bias. Suppose candidate X were running in a district in which there was a high proportion of elderly voters. Suppose that candidate X favored policies that elderly voters were against. For example, suppose candidate X favors slashing Medicare funding to reduce the budget deficit, whereas candidate Y favored maintaining or increasing support to Medicare. Along comes an organization who is interested in polling voters to determine which candidate is favored in the district. Suppose that the organization chooses to administer the poll via text message and that the results of the poll show that 75% of the voters favor candidate X. Can you see what's wrong with the poll–why it is biased? You probably recognize that this polling method will not produce a representative sample because elderly voters are much less likely to use cell phones and text messaging and so the poll will leave out the responses of these elderly voters (who, we've assumed make up a large segment of the population).

Thus, the sample will be biased and unrepresentative of the target population. As a result, any attempt to generalize to the general population would be extremely ill-advised.

EXERCISES

What kinds of problems, if any, do the following statistical generalizations have? If there is a problem with the generalization, specify which of the two conditions (adequate sample size, non-biased sample) are not met. Some generalizations may have multiple problems. If so, specify all of the problems you see with the generalization.

1. Bob, from Silverton, CO drives a 4x4 pickup truck, so most people from Silverton, CO drive 4x4 pickup trucks.

2. Tom counts and categorizes birds that land in the tree in his backyard every morning from 5:00-5:20 am. He counts mostly morning doves and generalizes, "most birds that land in my tree in the morning are morning doves."

3. Tom counts and categorizes birds that land in the tree in his backyard every morning from 5:00-6:00 am. He counts mostly morning doves and generalizes, "most birds that land in my tree during the 24-hour day are morning doves."

4. Tom counts and categorizes birds that land in the tree in his backyard every day from 5:00-6:00 am, from 11:00-12:00 pm, and from 5:006:00 pm. He counts mostly morning doves and generalizes, "most birds that land in my tree during the 24-hour day are morning doves."

5. Tom counts and categorizes birds that land in the tree in his backyard every evening from 10:00-11:00 pm. He counts mostly owls and generalizes, "most birds that land in my tree throughout the 24-hour day are owls."

6. Tom counts and categorizes birds that land in the tree in his backyard every evening from 10:00-11:00 pm and from 2:00-3:00 am. He counts mostly owls and generalizes, "most birds that land in my tree throughout the night are owls."

7. A poll administered to 10,000 registered voters who were homeowners showed that 90% supported a policy to slash Medicaid funding and decrease property taxes. Therefore, 90% of voters support a policy to slash Medicaid funding.

8. A telephone poll administered by a computer randomly generating numbers to call, found that 68% of Americans in the sample of 2000 were in favor of legalizing recreational marijuana use. Thus, almost 70% of Americans favor legalizing recreation marijuana use.

9. A randomized telephone poll in the United States asked respondents whether they supported a) a policy that allows killing innocent children in the womb or b) a policy that saves the lives of innocent children in the womb. The results showed that 69% of respondents choose option "b" over option "a." The generalization was made that "most Americans favor a policy that disallows abortion."

10. Steve's first rock and roll concert was an Ani Difranco concert, in which most of the concert-goers were women with feminist political slogans written on their t-shirts. Steve makes the generalization that "most rock and roll concert-goers are women who are feminists." He then applies this generalization to the next concert he attends (Tom Petty) and is greatly surprised by what he finds.

11. A high school principal conducts a survey of how satisfied students are with his high school by asking students in detention to fill out a satisfaction survey. Generalizing from that sample, he infers that 79% of students are dissatisfied with their high school experience. He is surprised and saddened by the result.

12. After having attended numerous Pistons home games over 20 years, Alice cannot remember a time when she didn't see ticket scalpers selling tickets outside the stadium. She generalizes that there are always scalpers at every Pistons home game.

13. After having attended numerous Pistons home games over 20 years, Alice cannot remember a time when she didn't see ticket scalpers selling tickets outside the stadium. She generalizes that there are ticket scalpers at every NBA game.

14. After having attended numerous Pistons home games over 20 years, Alice cannot remember a time when she didn't see ticket scalpers selling tickets outside the stadium. She generalizes that there are ticket scalpers at every sporting event.

15. Bob once ordered a hamburger from Burger King and got violently ill shortly after he ate it. From now on, he never eats at Burger King because he fears he will get food poisoning.

Chapter 5

Chapter 5

5.1 Causal reasoning

When I strike a match it will produce a flame. It is natural to take the striking of the match as the cause that produces the effect of a flame. But what if the matchbook is wet? Or what if I happen to be in a vacuum in which there is no oxygen (such as in outer space)? If either of those things is the case, then the striking of the match will not produce a flame. So it isn't simply the striking of the match that produces the flame, but a combination of the striking of the match together with a number of other conditions that must be in place in order for the striking of the match to create a flame. Which of those conditions we call the "cause" depends in part on the context. Suppose that I'm in outer space striking a match (suppose I'm wearing a space suit that supplies me with oxygen but that I'm striking the match in space, where there is no oxygen). I continuously strike it but no flame appears (of course). But then someone (also in a space suit) brings out a can of compressed oxygen that they spray on the match while I strike it. All of a sudden a flame is produced. In this context, it looks like it is the spraying of oxygen that causes flame, not the striking of the match. Just as in the case of the striking of the match, any cause is more complex than just a simple event that produces some other event. Rather, there are always multiple conditions that must be in place for any cause to occur. These conditions are called *background conditions*. That said, we often take for granted the background conditions in normal contexts and just refer to one particular event as the cause. Thus, we call the striking of the match the cause of the flame. We don't go on to specify all the other conditions that conspired to create the flame (such as the presence of oxygen and the absence of water). But this is more for convenience than correctness. For just about any cause, there are a number of conditions that must be in place in order for the effect to occur. These are called necessary conditions (recall the discussion of necessary and sufficient conditions from chapter 2, section 2.7). For example, a necessary condition of the match lighting is that there is oxygen present. A necessary condition of a car running is that there is gas in the tank. We can use necessary conditions to diagnose what has gone wrong in cases of malfunction. That is, we can consider each condition in turn in order to determine what caused the malfunction. For example, if the match doesn't light, we can check to see whether the matches are wet. If we find that the matches are wet then we can explain the lack of the flame by saying something like, "dropping the matches in the water caused the matches not to light." In contrast, a sufficient condition is one which if present will always bring about the effect. For example, a person being fed through an operating wood chipper is sufficient for causing that person's death (as was the fate of Steve Buscemi's character in the movie Fargo).

Because the natural world functions in accordance with natural laws (such as the laws of physics), causes can be generalized. For example, any object near the surface of the earth will fall towards the earth at 9.8 m/s2 unless impeded by some contrary force (such as the propulsion of a rocket). This generalization applies to apples, rocks, people, wood chippers and every other object. Such causal generalizations are often parts of explanations. For example, we can explain why the airplane crashed to the ground by citing the causal generalization that all unsupported objects fall to the ground and by noting that the airplane had lost any method of propelling itself because the engines had died. So we invoke the causal generalization in explaining why the airplane crashed. Causal generalizations have a particular form:

> For any x, if x has the feature(s) F, then x has the feature G

For example:

> For any human, if that human has been fed through an operating wood chipper, then that human is dead.
>
> For any engine, if that engine has no fuel, then that engine will not operate.
>
> For any object near the surface of the earth, if that object is unsupported and not impeded by some contrary force, then that object will fall towards the earth at 9.8 m/s2.

Being able to determine when causal generalizations are true is an important part of becoming a critical thinker. Since in both scientific and every day contexts we rely on causal generalizations in explaining and understanding our world, the ability to assess when a causal generalization is true is an important skill. For example, suppose that we are trying to figure out what causes our dog, Charlie, to have seizures. To simplify, let's suppose that we have a set of potential candidates for what causes his seizures. It could be either:

1. eating human food,
2. the shampoo we use to wash him,
3. his flea treatment,
4. not eating at regular intervals,

or some combination of these things. Suppose we keep a log of when these things occur each day and when his seizures (S) occur. In the table below, I will represent the absence of the feature by a negation. So in the table below, "∼A" represents that Charlie did not eat human food on that day; "∼B" represents that he did not get a bath and shampoo that day; "∼S" represents that he did not have a seizure that day. In contrast, "B" represents that he did have a bath and shampoo, whereas "C" represents that he was given a flea treatment that day. Here is how the log looks:

Day 1	∼A	B	C	D	S
Day 2	A	∼B	C	D	∼S
Day 3	A	B	∼C	D	∼S
Day 4	A	B	C	∼D	S
Day 5	A	B	∼C	D	∼S
Day 6	A	∼B	C	D	∼S

How can we use this information to determine what might be causing Charlie to have seizures? The first thing we'd want to know is what feature is present every time he has a seizure. This would be a necessary (but not sufficient) condition. And that can tell us something important about the cause. The necessary condition test says that any candidate feature (here A, B, C, or D) that is absent when the target feature (S) is present is eliminated as a possible necessary condition of S.[1] In the table above, A is absent when S is present, so A can't be a necessary condition (i.e., day 1). D is also absent when S is present (day 4) so D can't be a necessary condition either. In contrast, B is never absent when S is present–that is every time S is present, B is also present. That means B is a necessary condition, based on the data that we have gathered so far. The same applies to C since it is never absent when S is present. Notice that there are times when both B and C are absent, but on those days the target feature (S) is absent as well, so it doesn't matter.

The next thing we'd want to know is which feature is such that every time it is present, Charlie has a seizure. The test that is relevant to determining this is called the sufficient condition test. The sufficient condition test says that any candidate that is present when the target feature (S) is absent is eliminated as a possible sufficient condition of S. In the table above, we can see that no one candidate feature is a sufficient condition for causing the seizures since for each candidate (A, B, C, D) there is a case (i.e. day) where it is present but that no seizure occurred. Although no one feature is sufficient for causing the seizures

[1]This discussion draws heavily on chapter 10, pp. 220-224 of Sinnott-Armstrong and Fogelin's Understanding Arguments, 9th edition (Cengage Learning).

(according to the data we have gathered so far), it is still possible that certain features are jointly sufficient. Two candidate features are jointly sufficient for a target feature if and only if there is no case in which both candidates are present and yet the target is absent. Applying this test, we can see that B and C are jointly sufficient for the target feature since any time both are present, the target feature is always present. Thus, from the data we have gathered so far, we can say that the likely cause of Charlie's seizures are when we both give him a bath and then follow that bath up with a flea treatment. Every time those two things occur, he has a seizure (sufficient condition); and every time he has a seizure, those two things occur (necessary condition). Thus, the data gathered so far supports the following causal conditional:

Any time Charlie is given a shampoo bath and a flea treatment, he has a seizure.

Although in the above case, the necessary and sufficient conditions were the same, this needn't always be the case. Sometimes sufficient conditions are not necessary conditions. For example, being fed through a wood chipper is a sufficient condition for death, but it certainly isn't necessary! (Lot's of people die without being fed through a wood chipper, so it can't be a necessary condition of dying.) In any case, determining necessary and sufficient conditions is a key part of determining a cause.

When analyzing data to find a cause it is important that we rigorously test each candidate. Here is an example to illustrate rigorous testing. Suppose that on every day we collected data about Charlie he ate human food but that on none of the days was he given a bath and shampoo, as the table below indicates.

Day 1	A	∼B	C	D	∼S
Day 2	A	∼B	C	D	∼S
Day 3	A	∼B	∼C	D	∼S
Day 4	A	∼B	C	∼D	S
Day 5	A	∼B	∼C	D	∼S
Day 6	A	∼B	C	D	S

Given this data, A trivially passes the necessary condition test since it is always present (thus, there can never be a case where A is absent when S is present). However, in order to rigorously test A as a necessary condition, we have to look for cases in which A is not present and then see if our target condition S is present. We have rigorously tested A as a necessary condition only if we have collected data in which A was not present. Otherwise, we don't really know whether A is a necessary condition. Similarly, B trivially passes the sufficient condition test since it is never present (thus, there can never be a case where B is present but S is absent). However, in order to rigorously test B as a sufficient condition, we have to look for cases in which B is present and then see if our target condition S is absent. We have rigorously tested B as a sufficient condition only if we have collected data in which B is present. Otherwise, we don't really know whether B is a sufficient condition or not.

In rigorous testing, we are actively looking for (or trying to create) situations in which a candidate feature fails one of the tests. That is why when rigorously testing a candidate for the necessary condition test, we must seek out cases in which the candidate is not present, whereas when rigorously testing a candidate for the sufficient condition test, we must seek out cases in which the candidate is present. In the example above, A is not rigorously tested as a necessary condition and B is not rigorously tested as a sufficient condition. If we are interested in finding a cause, we should always rigorously test each candidate. This means that we should always have a mix of different situations where the candidates and targets are sometimes present and sometimes absent.

EXERCISES

Determine which of the candidates (A, B, C, D) in the following examples pass the necessary condition test or the sufficient condition test relative to the target (G). In addition, note whether there are any candidates that aren't rigorously tested as either necessary or sufficient conditions.

Case 1	A	B	∼C	D	∼G
Case 2	∼A	B	C	D	G
Case 3	A	∼B	C	D	G

Case 1	A	B	C	D	G
Case 2	∼A	B	∼C	D	∼G
Case 3	A	∼B	C	∼D	G

Case 1	A	B	C	D	G
Case 2	∼A	B	C	D	G
Case 3	A	∼B	C	D	G

Case 1	A	B	C	D	∼G
Case 2	∼A	B	C	D	G
Case 3	A	B	C	∼D	G

Case 1	A	B	∼C	D	∼G
Case 2	∼A	B	C	D	G
Case 3	A	∼B	∼C	∼D	∼G

- For each of the following correlations, use your background knowledge to determine whether A causes B, B causes A, a common cause C is the cause of both A and B, or the correlations is accidental.

1. There is a positive correlation between U.S. spending on science, space, and technology (A) and suicides by hanging, strangulation, and suffocation (B).
2. There is a positive correlation between our dog Charlie's weight (A) and the amount of time we spend away from home (B). That is, the more time we spend away from home, the heavier Charlie gets (and the more we are at home, the lighter Charlie is.
3. The height of the tree in our front yard (A) positively correlates with the height of the shrub in our backyard (B).
4. There is a negative correlation between the number of suicide bombings in the U.S. (A) and the number of hairs on a particular U.S President's head (B).
5. There is a high positive correlation between the number of fire engines in a particular borough of New York Cite (A) and the number of fires that occur there (B).
6. At one point in history, there was a negative correlation between the number of mules in the state (A) and the salaries paid to professors at the state university (B). That is, the more mules, the lower the professors' salaries.
7. There is a strong positive correlation between the number of traffic accidents on a particular highway (A) and the number of billboards featuring scantily-clad models (B).
8. The girth of an adult's waist (A) is negatively correlated with the height of their vertical leap (B).

Case 1	A	B	C	D	∼G
Case 2	∼A	B	C	∼D	∼G
Case 3	A	∼B	∼C	D	G

9. Olympic marathon times (A) are positively correlated with the temperature during the marathon (B). That is, the more time it takes an Olympic marathoner to complete the race, the higher the temperature.

10. The number gray hairs on an individual's head (A) is positively correlated with the number of children or grandchildren they have (B).

5.1.1 Causal Reasoning

Inductive arguments are used to support claims about cause and effect. These arguments come in a number of different forms. The most straightforward is what is called enumerative induction. This is an argument that makes a (non-hasty) generalization, inferring that one event or type of event causes another on the basis of a (large) number of particular observations of the cause immediately preceding the effect. To use a very famous example (from the history of philosophy, due to David Hume, the 18th century Scottish philosopher who had much to say about cause and effect and inductive reasoning), we can infer from observations of a number of billiard-ball collisions that the first ball colliding with the second causes the second ball to move. Or we can infer from a number of observations of drunkenness following the consumption of alcoholic beverages that imbibing alcohol causes one to become drunk.

This is all well and good, so far as it goes.[2] It just doesn't go very far. If we want to establish a robust knowledge of what causes the natural phenomena we're interested in, we need techniques that are more sophisticated than simple enumerative induction. There are such techniques. These are patterns of reasoning identified and catalogued by the 19th century English philosopher, scientist, logician, and politician John Stuart Mill. The inferential forms Mill enumerated have come to be called "Mill's Methods", because he thought of them as tools to be used in the investigation of nature–methods of discovering the causes of natural phenomena. In this section, we will look at Mill's Methods each in turn (there are five of them), using examples to illustrate each. We will finish with a discussion of the limitations of the methods and the difficulty of isolating causes.

The Meaning(s) of 'Cause'

Before we proceed, however, we must issue something of a disclaimer: when we say the one action or event causes another, we don't really know what the hell we're talking about. OK, maybe that's putting it a bit too strongly. The point is this: the meaning of 'cause' has been the subject of intense philosophical debate since ancient times (in both Greece and India)–debate that continues to this day. Myriad philosophical theories have been put forth over the millennia about the nature of causation, and there is no general agreement about just what it is (or whether causes are even real!).

We're not going to wade into those philosophical waters; they're too deep. Instead, we'll

[2]Setting aside Hume's philosophical skepticism about our ability to know that one thing causes another and about the conclusiveness of inductive reasoning.

merely dip our toes in, by making a preliminary observation about the word ‘cause’–an observation that gives some hint as to why it’s been the subject of so much philosophical deliberation for so long. The observation is this: there are a number of distinct, but perfectly acceptable ways that we use the word ‘cause’ in everyday language. We attach different incompatible meanings to the term in different contexts.

Consider this scenario: I’m in my backyard vegetable garden with my younger daughter (age 4 at the time). She’s “helping” me in my labors by watering some of the plants.[3] She asks, “Daddy, why do we have to water the plants?” I might reply, “We do that because water causes the plants to grow.” This is a perfectly ordinary claim about cause and effect; it is uncontroversial and true. What do I mean by ‘causes’ in this sentence? I mean that water is a necessary condition for the plants to grow. Without water, there will be no growth. It is not a sufficient condition for plantgrowth, though: you also need sunlight, good soil, etc.

Consider another completely ordinary, uncontroversial truth about causation: decapitation causes death. What do I mean by ‘causes’ in this sentence? I mean that decapitation is a sufficient condition for death. If death is the result you’re after, decapitation will do the trick on its own; nothing else is needed. It is not (thank goodness) a necessary condition for death, however. There are lots of other ways to die besides beheading.

Finally, consider this true claim: smoking causes cancer. What do I mean by ‘causes’ in this sentence? Well, I don’t mean that smoking is a sufficient condition for cancer. Lots of people smoke all their lives but are lucky enough not to get cancer. Moreover, I don’t mean that smoking is a necessary condition for cancer. Lots of people get cancer–even lung cancer–despite having never smoked. Rather, what I mean is that smoking tends to produce cancer, that it increases the probability that one will get cancer.

So, we have three totally ordinary uses of the word ‘cause’, with three completely different meanings: cause as necessary condition, sufficient condition, and mere tendency (neither necessary nor sufficient). These are incompatible, but all acceptable in their contexts. We could go on to list even more uses for the term, but the point has been made. Causation is a slippery concept, which is why philosophers have been struggling for so long to capture its precise meaning. In what follows, we will set aside these concerns and speak about cause and effect without hedging or disclaimers, but it’s useful to keep in mind that doing so papers over some deep and difficult philosophical problems.

[3] Those who have ever employed a 4-year-old to facilitate a labor-intensive project will understand the scare quotes.

Mill's Methods

John Stuart Mill identified five different patterns of reasoning that one could use to discover causes. These are argument forms, the conclusions of which involve a claim to the effect that one thing causes (or is causally related to) another. They can be used alone or in combination, depending on the circumstances. As was the case with analogical reasoning, these are patterns of inference that we already employ unreflectively in everyday life. The benefit in making them explicit and subjecting them to critical scrutiny is that we thereby achieve a metacognitive perspective–a perspective from which we can become more self-aware, effective reasoners. This is especially important in the context of causal reasoning, since, as we shall see, there are many pitfalls in this domain that we a prone to fall into, many common errors that people make when thinking about cause and effect.

Method of Agreement I've been suffering from heartburn recently. Seems like at least two or three days a week, by about dinnertime, I've got that horrible feeling of indigestion in my chest and that yucky taste in my mouth. Acid reflux: ugh. I've got to do something about this. What could be causing my heartburn, I wonder? I know that the things you eat and drink are typical causes of the condition, so I start thinking back, looking at what I've consumed on the days when I felt bad. As I recall, all of the recent days on which I suffered heartburn were different in various ways: my dinners ranged from falafel to spaghetti to spicy burritos; sometimes I had a big lunch, sometimes very little; on some days I drank a lot of coffee at breakfast, but other days not any at all. But now that I think about it, one thing stands out: I've been in a nostalgic mood lately, thinking about the good old days, when I was a carefree college student. I've been listening to lots of music from that time, watching old movies, etc. And as part of that trip down memory lane, I've re-acquired a taste for one of my favorite beverages from that era–Mountain Dew. I've been treating myself to a nice bottle of the stuff with lunch now and again. And sure enough, each of the days that I got heartburn was a day when I drank Mountain Dew at lunch. Huh. I guess the Mountain Dew is causing my heartburn. I better stop drinking it.

This little story is an instance of Mill's Method of Agreement. It's a pattern of reasoning that one can use to figure out the cause of some phenomenon of interest. In this case, the phenomenon I want to discover the cause of is my recent episodes of heartburn. I eventually figure out that the cause is Mountain Dew. We could sum up the reasoning pattern abstractly thus:

> We want to find the cause of a phenomenon, call it X. We examine a variety of

> circumstances in which X occurs, looking for potential causes. The circumstances differ in various ways, but they each have in common that they feature the same potential cause, call it A. We conclude that A causes X.

Each of the past circumstances agrees with the others in the sense that they all feature the same potential cause–hence, the Method of Agreement. In the story above, the phenomenon X that I wanted to find the cause of was heartburn; the various circumstances were the days on which I had suffered that condition, and they varied with respect to potential causes (foods and beverages consumed); however, they all agreed in featuring Mountain Dew, which is the factor A causing the heartburn, X.

More simply, we can sum up the Method of Agreement as a simple question:

> What causal factor is present whenever the phenomenon of interest is present?

In the case of our little story, Mountain Dew was present whenever heartburn was present, so we concluded that it was the cause.

Method of Difference Everybody in my house has a rash! Itchy skin, little red bumps; it's annoying. It's not just the grownups–me and my wife–but the kids, too. Even the dog has been scratching herself constantly! What could possibly be causing our discomfort? My wife and I brainstorm, and she remembers that she recently changed brands of laundry detergent. Maybe that's it. So we re-wash all the laundry (including the pillow that the dog sleeps on in the windowsill) in the old detergent and wait. Sure enough, within a day or two, everybody's rash is gone. Sweet relief!

This story presents an instance of Mill's Method of Difference. Again, we use this pattern of reasoning to discover the cause of some phenomenon that interests us–in this case, the rash we all have. We end up discovering that the cause is the new laundry detergent. We isolated this cause by removing that factor and seeing what happened. We can sum up the pattern of reasoning abstractly thus:

> We want to find the cause of a phenomenon, call it X. We examine a variety of circumstances in which X occurs, looking for potential causes. The circumstances differ in various ways, but they each have in common that when we remove from them a potential cause–call it A–the phenomenon disappears. We conclude that A causes X.

If we introduce the same difference in all of the circumstances–removing the causal factor–we see the same effect–disappearance of the phenomenon. Hence, the Method of Difference. In our story, the phenomenon we wanted to explain, X, was the rash. The varying circumstances are the different inhabitants of my house–Mom, Dad, kids, even the dog–and the different factors affecting them. The factor that we removed from each, A, was the new laundry detergent. When we did that, the rash went away, so the detergent was the cause of the rash–A caused X.

More simply, we can sum up the Method of Difference as a simple question:

> What causal factor is absent whenever the phenomenon of interest is absent?

In the case of our little story, when the detergent was absent, so too was the rash. We concluded that the detergent caused the rash.

Joint Method of Agreement and Difference This isn't really a new method at all. It's just a combination of the first two. The Methods of Agreement and Difference are complementary; each can serve as a check on the other. Using them in combination is an extremely effective way to isolate causes.

The Joint Method is an important tool in medical research. It's the pattern of reasoning used in what we call controlled studies. In such a study, we split our subjects into two groups, one of which is the "control" group. An example shows how this works. Suppose I've formulated a pill that I think is a miracle cure for baldness. I'm gonna be rich! But first, I need to see if it really works. So I gather a bunch of bald men together for a controlled study. One group gets the actual drug; the other, control group, gets a sugar pill–not the real drug at all, but a mere placebo. Then I wait and see what happens. If my drug is a good as I think it is, two things will happen: first, the group that got the drug will grow new hair; and second, the group that got the placebo won't grow new hair. If either of these things fails to happen, it's back to the drawing board. Obviously, if the group that got the drug didn't get any new hair, my baldness cure is a dud. But in addition, if the group that got the mere placebo grew new hair, then something else besides my drug has to be the cause.

Both the Method of Agreement and the Method of Difference are being used in a controlled study. I'm using the Method of Agreement on the group that got the drug. I'm hoping that whenever the causal factor (my miracle pill) is present, so too will be the phenomenon of interest (hair growth). The control group complements this with the Method of Difference. For them, I'm hoping that whenever the causal factor (the miracle pill) is absent, so too will be the phenomenon of interest (hair growth). If both things happen, I've got strong confirmation that my drug causes hair growth. (Now all I have to do is figure out how to spend all my money!)

Method of Residues I'm running a business. Let's call it LogiCorp. For a modest fee, the highly trained logicians at LogiCorp will evaluate all of your deductive arguments, issuing Certificates of Validity (or Invalidity) that are legally binding in all fifty states. Satisfaction guaranteed. Anyway, as should be obvious from that brief description of the business model, LogiCorp is a highly profitable enterprise. But last year's results were disappointing. Profits were down 20% from the year before. Some of this was expected. We undertook a renovation of the LogiCorp World Headquarters that year, and the cost had an effect on our bottom line: half of the lost profits, 10%, can be chalked up to the renovation expenses. Also, as healthcare costs continue to rise, we had to spend additional money on our employees' benefits packages; these expenditures account for an additional 3profit shortfall. Finally, another portion of the drop in profits can be explained by the entry of a competitor into the marketplace. The upstart firm Arguments R Us, with its fast turnaround times and ultra-cheap prices, has been cutting into our market share. Their services are totally inferior to ours (you should see the shoddy shading technique in their Venn Diagrams!) and LogiCorp will crush them eventually, but for now they're hurting our business: competition from Arguments R Us accounts for a 5% drop in our profits.

As CEO, I was of course aware of all these potential problems throughout the year, so when I looked at the numbers at the end, I wasn't surprised. But, when I added up the contributions from the three factors I knew about–10% from the renovation, 3% from the healthcare expenditures, 5% from outside competition–I came up short. Those causes only account for an 18% shortfall in profit, but we were down 20% on the year; there was an extra 2% shortfall that I couldn't explain. I'm a suspicious guy, so I hired an outside security firm to monitor the activities of various highly placed employees at my firm. And I'm glad I did! Turns out my Chief Financial Officer had been taking lavish weekend vacations to Las Vegas and charging his expenses to the company credit card. His thievery surely accounts for the extra 2%. I immediately fired the jerk. (Maybe he can get a job with Arguments R Us.)

This little story presents an instance of Mill's Method of Residues. 'Residue' in this context just means the remainder, that which is left over. The pattern of reasoning, put abstractly, runs something like this:

We observe a series of phenomena, call them X1, X2, X3, , Xn. As a matter of

> background knowledge, we know that X1 is caused by A1, that X2 is caused by A2, and so on. But when we exhaust our background knowledge of the causes of phenomena, we're left with one, Xn, that is inexplicable in those terms. So we must seek out an additional causal factor, An, as the cause of Xn.

The leftover phenomenon, Xn, inexplicable in terms of our background knowledge, is the residue. In our story, that was the additional 2% profit shortfall that couldn't be explained in terms of the causal factors we were already aware of, namely the headquarters renovation (A1, which caused X1, a 10% shortfall), the healthcare expenses (A2, which caused X2, a 3% shortfall), and the competition from Arguments R Us (A3, which caused X3, a 5% shortfall). We had to search for another, previously unknown cause for the final, residual 2%.

Method of Concomitant Variation Fact: if you're a person who currently maintains a fairly steady weight, and you change nothing else about your lifestyle, adding 500 calories per day to your diet will cause you to gain weight. Conversely, if you cut 500 calories per day from your diet, you would lose weight. That is, calorie consumption and weight are causally related: consuming more will cause weight gain; consuming less will cause weight loss.

Another fact: if you're a person who currently maintains a steady weight, and you change nothing else about your lifestyle, adding an hour of vigorous exercise per day to your routine will cause you to lose weight. Conversely, (assuming you already exercise a heck of a lot), cutting that amount of exercise from your routine will cause you to gain weight. That is, exercise and weight are causally related: exercising more will cause weight loss; exercising less will cause weight gain.

(These are revolutionary insights, I know. My next get-rich-quick scheme is to popularize one of those fad diets. Instead of recommending eating nothing but bacon or drinking nothing but smoothies made of kale and yogurt, my fad diet will be the "Eat Less, Move More" plan. I'm gonna be rich!)

I know about the cause-and-effect relationships above because of the Method of Concomitant Variation. Put abstractly, this pattern of reasoning goes something like this:

> We observe that, holding other factors constant, an increase or decrease in some causal factor A is always accompanied by a corresponding increase or decrease in some phenomenon X. We conclude that A and X are causally related.

Things that "vary concomitantly" are things, to put it more simply, that change together. As A changes–goes up or down–X changes, too. There are two ways things can vary concomitantly: directly or inversely. If A and X vary directly, that means that an increase in one will be accompanied by an increase in the other (and a decrease in one will be accompanied by a decrease in the other); if A and X vary inversely, that means an increase in one will be accompanied by a decrease in the other.

In our first example, calorie consumption (A) and weight (X) vary directly. As calorie consumption increases, weight increases; and as calorie consumption decreases, weight decreases. In our second example, exercise (A) and weight (X) vary inversely. As exercise increases, weight decreases; and as exercise decreases, weight increases.

Either way, when things change together in this way, when they vary concomitantly, we conclude that they are causally related.

The Difficulty of Isolating Causes

Mill's Methods are useful in discovering the causes of phenomena in the world, but their usefulness should not be overstated. Unless they are employed thoughtfully, they can lead an investigator astray. A classic example of this is the parable of the drunken logician.[4] After a long day at work on a Monday, a certain logician heads home wanting to unwind. So he mixes himself a "7 and 7"–Seagram's 7 Crown whiskey and 7-Up. It tastes so good, he makes another–and another, and another. He drinks seven of these cocktails, passes out in his clothes, and wakes up feeling terrible (headache, nausea, etc.). On Tuesday, after dragging himself into work, toughing it through the day, then finally getting home, he decides to take the edge off with a different drink: brandy and 7-Up. He gets carried away again, and ends up drinking seven of these cocktails, with the same result: passing out in his clothes and waking up feeling awful on Wednesday. So, on Wednesday night, our logician decides to mix things up again: scotch and 7-Up. He drinks seven of these; same results. But he perseveres: Thursday night, it's seven vodka and 7-Ups; another blistering hangover on Friday. So on Friday at work, he sits down to figure out what's going on. He's got a phenomenon–hangover symptoms every morning of that week–that he wants to discover the cause of. He's a professional logician, intimately familiar with Mill's Methods, so he figures he ought to be able to discover the cause. He looks back at the week and uses the Method of Agreement, asking, "What factor was present every time the phenomenon was?" He concludes that the cause of his hangovers is 7-Up.

Our drunken logician applied the Method of Agreement correctly: 7-Up was indeed present every time. But it clearly wasn't the cause of his hangovers. The lesson is that Mill's Methods are useful tools for discovering causes, but their results are not always definitive.

[4] Inspired by Copi and Cohen, p. 547.

Uncritical application of the methods can lead one astray. This is especially true of the Method of Concomitant Variation. You may have heard the old saw that "correlation does not imply causation." It's useful to keep this corrective in mind when using the Method of Concomitant Variation. That two things vary concomitantly is a hint that they may be causally related, but it is not definitive proof that they are. They may be separate effects of a different, unknown cause; they may be completely causally unrelated. It is true, for example, that among children, shoe size and reading ability vary directly: children with bigger feet are better readers than those with smaller feet. Wow! So large feet cause better reading? Of course not. Larger feet and better reading ability are both effects of the same cause: getting older. Older kids wear bigger shoes than younger kids, and they also do better on reading tests. Duh. It is also true, for example, that hospital quality and death rate vary directly: that is, the higher quality the hospital (prestige of doctors, training of staff, sophistication of equipment, etc.), on average, the higher the death rate at that hospital. That's counterintuitive! Does that mean that high hospital quality causes high death rates? Of course not. Better hospitals have higher mortality rates because the extremely sick, most badly injured patients are taken to those hospitals, rather than the ones with lower-quality staff and equipment. Alas, these people die more often, but not because they're at a good hospital; it's exactly the reverse.

Spurious correlations–those that don't involve any causal connection at all–are easy to find in the age of "big data." With publicly available databases archiving large amounts of data, and computers with the processing power to search them and look for correlations, it is possible to find many examples of phenomena that vary concomitantly but are obviously not causally connected. A very clever person named Tyler Vigen set about doing this and created a website where he posted his (often very amusing) discoveries.[5] For example, he found that between 2000 and 2009, per capita cheese consumption among Americans was very closely correlated with the number of deaths caused by people becoming entangled in their bedsheets:

These two phenomena vary directly, but it's hard to imagine how they could be causally related. It's even more difficult to imagine how the following two phenomena could be causally related:

So, Mill's Methods can't just be applied willy-nilly; one could end up "discovering" causal connections where none exist. They can provide clues as to potential causal relationships,

[5] http://tylervigen.com/spurious-correlations. The site has a tool that allows the user to search for correlations. It's a really amusing way to kill some time.

but care and critical analysis are required to confirm those results. It's important to keep in mind that the various methods can work in concert, providing a check on each other. If the drunken logician, for example, had applied the Method of Difference–removing the 7-Up but keeping everything else the same–he would have discovered his error (he would've kept getting hangovers). The combination of the Methods of Agreement and Difference–the Joint Method, the controlled study–is an invaluable tool in modern scientific research. A properly conducted controlled study can provide quite convincing evidence of causal connections (or a lack thereof).

Of course, properly conducting a controlled study is not as easy as it sounds. It involves more than just the application of the Joint Method of Agreement and Difference. There are other potentially confounding factors that must be accounted for in order for such a study to yield reliable results. For example, it's important to take great care in separating subjects into the test and control groups: there can be no systematic difference between the two groups other than the factor that we're testing; if there is, we cannot say whether the factor we're testing or the difference between the groups is the cause of any effects observed. Suppose we were conducting a study to determine whether or not vitamin C was effective in treating the common cold.[6] We gather 100 subjects experiencing the onset of cold symptoms. We want one group of 50 to get vitamin C supplements, and one group of 50–the control group–not to receive them. How do we decide who gets placed into which group? We could ask for volunteers. But doing so might create a systematic difference between the two groups. People who hear "vitamin C" and think, "yeah, that's the group for me" might be people who are more inclined to eat fruits and vegetables, for example, and might therefore be healthier on average than people who are turned off by the idea of receiving vitamin C supplements. This difference between the groups might lead to different results between the how their colds progress. Instead of asking for volunteers, we might just assign the first 50 people who show up to the vitamin C group, and the last 50 to the control group. But this could lead to differences, as well. The people who show up earlier might be early-risers, who might be healthier on average than those who straggle in late.

The best way to avoid systematic differences between test and control groups is to randomly assign subjects to each. We refer to studies conducted this way as randomized controlled studies. And besides randomization, other measures can be taken to improve reliability. The best kinds of controlled studies are "double-blind". This means that neither the subjects nor the people conducting the study know which group is the control and which

[6]Despite widespread belief that it is, researchers have found very little evidence to support this claim.

group is receiving the actual treatment. (This information is hidden from the researchers only while the study is ongoing; they are told later, of course, so they can interpret the results.) This measure is necessary because of the psychological tendency for people's observations to be biased based on their expectations. For example, if the control group in our vitamin C experiment knew they were not getting any treatment for their colds, they might be more inclined to report that they weren't feeling any better. Conversely, if the members of the group receiving the vitamin supplements knew that they were getting treated, they might be more inclined to report that their symptoms weren't as bad. This is why the usual practice is to keep subjects in the dark about which group they're in, giving a placebo to the members of the control group. It's important to keep the people conducting the study "blind" for the same reasons. If they knew which group was which, they might be more inclined to observe improvement in the test group and a lack of improvement in the control group. In addition, in their interactions with the subjects, they may unknowingly give away information about which group was which via subconscious signals.

Hence, the gold standard for medical research (and other fields) is the double-blind controlled study. It's not always possible to create those conditions–sometimes the best doctors can do is to use the Method of Agreement and merely note commonalities amongst a group of patients suffering from the same condition, for example–but the most reliable results come from such tests. Discovering causes is hard in many contexts. Mill's Methods are a useful starting point, and they accurately model the underlying inference patterns involved in such research, but in practice they must be supplemented with additional measures and analytical rigor in order to yield definitive results. They can give us clues about causes, but they aren't definitive evidence. Remember, these are inductive, not deductive arguments.

EXERCISES

1. What is meant by the word 'cause' in the following–necessary condition, sufficient condition, or mere tendency?
   (a) (a) Throwing a brick through a window causes it to break.
   (b) (b) Slavery caused the American Civil War.
   (c) (c) Exposure to the cold causes frostbite.
   (d) (d) Running causes knee injuries.
   (e) (e) Closing your eyes causes you not to be able to see.

2. Consider the following scenario and answer the questions about it:

   - Alfonse, Bertram, Claire, Dominic, Ernesto, and Francine all go out to dinner at a local greasy spoon. There are six items on the menu: shrimp cocktail, mushroom/barley soup, burger, fries, steamed carrots, and ice cream. This is what they ate:

   - Alfonse: shrimp, soup, fries
   - Bertram: burger, fries, carrots, ice cream
   - Claire: soup, burger, fries, carrots
   - Dominic: shrimp, soup, fries, ice cream
   - Ernesto: burger, fries, carrots
   - Francine: ice cream

   - That night, Alfonse, Claire, and Dominic all came down with a wicked case of foodpoisoning. The others felt fine.

   (a) (a) Using only the Method of Agreement, how far can we narrow down the list of possible causes for the food poisoning?

   (b) (b) Using only the Method of Difference, how far can we narrow down the list of possible causes for the food poisoning?

   (c) (c) Using the Joint Method, we can identify the cause. What is it?

3. For each of the following, identify which of Mill's Methods is being used to draw the causal conclusion.

   (a) (a) A farmer noticed a marked increase in crop yields for the season. He started using a new and improved fertilizer that year, and the weather was particularly ideal–just enough rain and sunshine. Nevertheless, the increase was greater than could be explained by these factors. So he looked into it and discovered that his fields had been colonized by hedgehogs, who prey on the kinds of insect pests that usually eat crops.

   (b) (b) I've been looking for ways to improve the flavor of my vegan chili. I read on a website that adding soy sauce can help: it has lots of umami flavor, and that can help compensate for the lack of meat. So the other day, I made two batches of my chili, one using my usual recipe, and the other made exactly the same way, except for the addition of soy sauce. I invited a bunch of friends over for a blind taste test, and sure enough, the chili with the soy sauce was the overwhelming favorite!

(c) (c) The mere presence of guns in circulation can lead to higher murder rates. The data are clear on this. In countries with higher numbers of guns per capita, the murder rate is higher; and in countries with lower numbers of guns per capita, the murder rate is correspondingly lower.

(d) (d) There's a simple way to end mass shootings: outlaw semiautomatic weapons. In 1996, Australia suffered the worst mass shooting episode in its history, when a man in Tasmania used two semiautomatic rifles to kill 35 people (and wound an additional 19). The Australian government responded by making such weapons illegal. There hasn't been a mass shooting in Australia since.

(e) (e) A pediatric oncologist was faced with a number of cases of childhood leukemia over a short period of time. Puzzled, he conducted thorough examinations of all the children, and also compared their living situations. He was surprised to discover that all of the children lived in houses that were located very close to high-voltage power lines. He concluded that exposure to electromagnetic fields causes cancer.

(f) (f) Many people are touting the benefits of the so-called "Mediterranean" diet because it apparently lowers the risk of heart disease. Residents of countries like Italy and Greece, for example, consume large amounts of vegetables and olive oil and suffer from heart problems at a much lower rate than Americans.

(g) (g) My daughter came down with what appeared to be a run-of-the-mill case of the flu: fever, chills, congestion, sore throat. But it was a little weird. She was also experiencing really intense headaches and an extreme sensitivity to light. Those symptoms struck me as atypical of mere influenza, so I took her to the doctor. It's a good thing I did! It turns out she had a case of bacterial meningitis, which is so serious that it can cause brain damage if not treated early. Luckily, we caught it in time and she's doing fine.

Chapter 6

Chapter 6

Chapter 7

Chapter 7

Chapter 8

Chapter 8

Chapter 9

Chapter X

Chapter 10

Chapter X

Chapter 11

Chapter X

Chapter 12

Chapter X