CHAPTER 11

THE EVALUATION OF REASONING

BEFORE YOU BEGIN ...

What is the difference between a good (valid) argument and a correct (true) conclusion?

Can a valid argument have a false conclusion? Can an invalid argument have a true conclusion?

Why is it important to learn to distinguish good or valid arguments from arguments which are invalid?

Can all inferences or reasoning be evaluated in exactly the same way? If not, why not?

How is deductive reasoning different from non-deductive reasoning?

Is it possible for different individuals or different cultures to evaluate reasoning in different ways?

11.1 INTRODUCTION

In the previous chapter, we discussed how to identify reasoning and distinguish it from other kinds of passages. Once you realise that someone is reasoning, you are in a better position to evaluate that reasoning. In general, there are two different things you can focus on when evaluating any reasoning: evaluate the truth of assumptions and evaluate the connection between the premises and conclusion. This chapter will look at these in detail.

11.2 THE EIGHTH PARADIGM OF KNOWLEDGE—KNOWING HOW TO EVALUATE REASONING

Since reasoning is based on assumptions, premises or evidence, the *first* thing you can do is to evaluate the truth or acceptability of the assumptions being used. If even one of the assumptions can be rejected as false or incorrect, the reasoning has no force. Successful justification requires all assumptions to be true. The *second* thing you can do is to evaluate the connection between the truth of the premises, assumptions or evidence and the truth of the conclusion. If the connection between premises and conclusion is very weak, then the argument is unsatisfactory, even if the premises are true.

The steps you need to go through in evaluating reasoning can be explained as follows:

STEP 1: Identify the relevant passage or passages as reasoning.

STEP 2: Identify the conclusion and the premises, assumptions or evidence used to justify the conclusion. (Hint: If you cannot identify either, then the passage probably does not contain reasoning after all.)

STEP 3: Evaluate the truth of the premises. The first important feature of any reasoning is that the premises all are true or acceptable. It is not always easy to determine the truth of the premises, and there are no simple rules to follow, but the more uncertain or doubtful the premises, the less value the argument will have.

STEP 4: Evaluate the connection between premises and conclusion. A good argument must have both true premises and a good connection between the premises and the conclusion. It is common for logicians to call this feature of an argument its VALIDITY.

DEFINITION:
For those who use the term “valid” as a technical term, a VALID ARGUMENT is one in which there is a real connection between the truth of the premises and the truth of the conclusion. An argument that is not valid is also described as INVALID.

As we will see later, it is sometimes easy to show that certain deductive arguments are invalid. However, the validity of non-deductive arguments is harder to determine. In non-deductive arguments the connection between the premises and conclusions is more a matter of degree. Some non-deductive arguments are better than others because there is a stronger connection between the truth of the premises and the truth of the conclusion.

11.3 VALID ARGUMENTS AND VALID STATEMENTS

The term "valid" as defined above is a technical term which has been used for at least 50 years by logicians and philosophers in many countries. In this sense, it *only* applies to *arguments* or *reasoning.* For better or worse, this meaning of the word "valid" has generally been ignored by people who have not been trained in logic.

Most of the time people apply the word "valid" to *statements*, and when they use it in this way it means the same as "true". It is pointless for logicians to insist that people accept their technical meaning of the word "valid", but it is of the highest importance that students realise that there are *two different ways reasoning can fail*.

Reasoning can fail because either:

1. **The premises or assumptions are not true, that is, the premises are not valid.**

OR

2. **The connection between the premises and conclusion is weak or non-existent, that is, the argument is not valid.**

Reasoning must be acceptable in *both* of these two ways to be successful. If it fails to meet either of these two requirements, it can be dismissed.

Extension Reading 1

More on "Valid" and "Sound"

The well-known logician Copi provides a definition of the term "valid" that is somewhat different from ours. This is his definition:

> A deductive argument is valid when its premises, if true, do provide conclusive grounds for its conclusion, that is, when premises and conclusion are so related that it is absolutely impossible for the premises to be true unless the conclusion is true also.
>
> I.M. Copi, *Introduction to Logic*, 1978.

One reason we do not use this definition in this book is that the definition *only* covers the evaluation of *deductive* arguments. Non-deductive reasoning is all non-conclusive, so it is all invalid according to this definition. Most of the reasoning discussed in this book is non-deductive, as is reasoning in everyday life and science, so this definition might lead to more confusion than understanding.

There is also another technical term for arguments that (a) are valid, that is, have a real connection between premises and conclusion, and (b) have true premises. Arguments which meet both of these requirements are called "sound" arguments by logicians and philosophers.

We choose not to encourage the use of this term. To us, it is most important that you understand the distinction between the *two* different ways that reasoning can be evaluated: (1) is there a real connection between the premises and the conclusion? is the reasoning valid? (2) are the premises actually true?

11.4 EVALUATING ARGUMENTS; SOME EXAMPLES

Here are two arguments we can evaluate:

1. All Greeks are human. 2. All humans are mortal. 3. Socrates is a Greek. 4. Socrates is mortal.	1. All pigs have wings. 2. All winged things can fly. 3. Babe is a pig. 4. Babe can fly.

Both of these are arguments written in an IDEALISED form. Normally, arguments are found in prose sentences without the clear structure which identifies premises and conclusion. Idealised arguments have a clearly defined structure.

DEFINITION:
An IDEALISED ARGUMENT is an argument in which each premise is numbered and written on a separate line, while the conclusion is written on the last numbered line and indicated by the word "therefore" or an equivalent symbol.

Arguments do not need to be presented in an idealised form. Indeed, such a method of presenting arguments may discourage all but the most intrepid readers. Presenting arguments in an idealised form is a tool of analysis, but it is *not* a simple or mechanical process. It is a way to present a *logical interpretation* of an argument in prose. Do not be surprised if different people have somewhat different idealised versions (= interpretations) of the same prose argument. Constructing such an idealised argument involves performing STEP 1 and STEP 2 for the analysis of arguments explained above. When you have written a prose argument in an idealised form, the first two of the four steps given in **§11.2** have been carried out.

Since these two arguments are already in idealised form, we can move to STEP 3, the evaluation of the premises. In the argument on the left of the page, all of the premises in lines 1, 2, and 3, are true. The name "Socrates" refers to the Athenian philosopher who taught Plato. In the argument on the right of the page, however, the first two premises are false. The generalisation "All pigs have wings" is false. In fact, no pigs have wings. The generalisation "All winged things can fly" is also false, although it is true that some things with wings can fly, while others cannot. The name "Babe" refers to the fictional talking pig in the movie of the same name, so line 3 is true.

A logician would prefer to continue on to STEP 4 for both arguments, and to be quite thorough we will do so as well, but you could simply stop your evaluation of the argument on the right at this point. Why? A successful argument must have premises which are *all* true *and* a good connection between premises and conclusion. The argument on the right has two false premises, so you know already that it is unsuccessful.

STEP 4 is the evaluation of the connection between the truth of the premises and the truth of the conclusion in each argument. In this case, our task is somewhat easier because both arguments have the same structure. The structure of both arguments is a valid deductive structure in which it is impossible to have all true premises and a false conclusion. Later we will look at different ways the validity of this reasoning can be determined, but arguments of this form may seem "natural" to you already.

Since the argument on the left has met both requirements, we can say that it is a successful argument. Our evaluation of the argument on the right is somewhat different. While it is

unsuccessful because it has two false premises, it has actually met the second requirement. It is still valid, even though some of the premises are false. *If* all the premises in the right-hand argument *were* true, then the conclusion would also have to be true. The premises are not in fact true, but the argument is still valid, nonetheless.

As we explained above, the process of constructing an idealized argument involves LOGICAL INTERPRETATION.

DEFINITION:
LOGICAL INTERPRETATION is the understanding of the semantic meaning of statements or beliefs.

In the previous chapter, we introduced some techniques for recognizing reasoning. When you recognize reasoning, you actually recognize a part of meaning known as the semantic relations between expressions. (See **Chapter 4.**) Some of the main semantic relations are *synonymy* (= same meaning), *contradiction* (= "opposite" meaning) and *entailment* or inference. This process of LOGICAL INTERPRETATION is in some ways similar to the interpretation of the meaning in poetry (**Paradigm 15**).

However, logical interpretation or analysis should not be confused with an examination of grammatical structure. As we noted in **§2.9,** grammatical analysis concentrates on the order and location of the words in a sentence. For example, the two sentences "Your mother loves you" and "You are loved by your mother" are *grammatically different* because they have two different subjects. The logical interpretation of these two sentences will tell us they have the *same meaning,* and they both logically imply the same statement:

Your mother loves you. Someone loves you.	You are loved by your mother. Someone loves you.

Grammatical analysis deals with the syntax, the order and combinations of words, while *logical interpretation* deals with the semantic meaning.

11.5 DOES A GOOD ARGUMENT MEAN A TRUE CONCLUSION?

One of the main goals of reasoning is justification. Reasoning is successful or "good" as justification if all the premises are true or acceptable, and they do in fact support or provide evidence for the conclusion. Notice, however, that successful reasoning does not always guarantee truth. Successful *deductive* reasoning guarantees truth, but successful *non-deductive* reasoning does not.

At this point you might wonder why bother evaluating non-deductive arguments, if they can be "good" or "successful" but still have conclusions which turn out to be false. The question is important and deserves an answer. Good deductive arguments are better than good non-deductive arguments because deductive reasoning delivers what amounts to logical certainty (see **§7.14**). The problem is that while deductive reasoning is quite powerful, it cannot be used in many situations.

Most of the interesting things we want to know in life cannot be justified with this high degree of certainty. Intellectually, we must all learn to make decisions within a framework of beliefs that are not absolutely certain. This means that we need to look for beliefs that seem, after adequate investigation, to be better justified than the alternatives. So, while a belief that is successfully justified using non-deductive reasoning is not *guaranteed* to be true, it is the "best bet" we have.

11.6 DOES A BAD ARGUMENT MEAN A FALSE CONCLUSION?

So, what have you proved when you have shown that an argument is unsuccessful or "bad"? It is important to realise that bad reasoning *can* be used to "justify" claims that are in fact true. Consider these two arguments:

1. All Greeks are human. 2. All humans are mortal. 3. Socrates is a Greek. 4. Socrates is mortal.	1. All Greeks are four-legged. 2. All four-legged people are mortal. 3. Socrates is a Greek. 4. Socrates is mortal.

The argument on the right is still an unsuccessful argument. It is valid but the first premise at least is clearly false. However, the conclusion is true, and is the *same* as the conclusion in the successful argument. When you show that a particular piece of reasoning is bad or unsuccessful, you do *not* thereby show that the conclusion is false or unacceptable. Even if there is no reasoning which successfully justifies a given conclusion, we *cannot* say that the conclusion has been shown to be false. Justification may be our most important indicator of truth, but lack of justification is quite different from lack of truth.

EXERCISE 1 –

FIRST EVALUATION OF REASONING

Evaluate the reasoning in the following passages. Remember the four steps outline above which involve looking at *two* kinds of assessment: the evaluation of premises and the connection between premises and conclusion.

1. Who Killed Kennedy? When President John F. Kennedy was assassinated in Dallas, Texas, an inquiry was set up called the Warren Commission. After much discussion, this commission came to the conclusion that one person, Lee Harvey Oswald, was the only person directly involved in the death of President Kennedy. This became the "official view" of the assassination: Oswald alone fired the fatal shots. From the beginning, this conclusion was not universally accepted. The following statement, taken from a discussion of the Warren Commission Report, is one of many attempts to show the "official view" is impossible:

> Since tests proved that it took at least 2.3 seconds to operate the bolt on Oswald's rifle, Oswald obviously could not have fired three times—hitting Kennedy twice and Connally once—in 5.6 seconds.
>
> "Autopsy on the Warren Commission", *Time* (1966), cited in Copi, 1978

The exact length of time taken to fire the three shots (5.6 seconds) was known because the whole episode was captured on film. The author gives his reasons for thinking that the official view is impossible.

2. Rights For Animals: Non-human animals have emotions that are similar to human emotions. They have feelings of pleasure and pain. They want things and can experience fear. There is no significant difference between humans and many mammals in what they perceive. Both humans and other animals have beliefs about the world, they expect things to happen in the future and they learn from experience. Humans can produce elaborate computer games, which animals cannot, but some birds can navigate thousands of kilometres unaided across the open seas, which humans cannot do.

   Thus, if humans have rights because of their human nature, then animals should have the same rights, since they are essentially the same as we are. If we do not recognise these rights, we are guilty of unjustified discrimination against them.

3. The Human Soul Exists: Scientists now believe that in nature, matter cannot be destroyed without being converted into energy. Not even the tiniest particle can disappear without a trace. Nature does not know extinction—only transformation. Would God have less regard for His Masterpiece of creation, the human soul?

   Werner von Braun, "Science is helping to put a face on God" (1966), cited in Copi, 1978.

4. Anything Can Be Literature: With this reservation, the suggestion that "literature" is a highly valued kind of writing is an illuminating one. But it has one fairly devastating consequence. It means that we can drop once and for all the illusion that the category "literature" is "objective", in the sense of being eternally given and immutable. Anything can be literature, and anything which is regarded as unalterably and unquestionably literature—Shakespeare, for example—can cease to be literature. Any belief that the study of literature is the study of a stable, well-defined entity, as entomology is the study of insects, can be abandoned as a chimera. The reason why it follows from the definition of literature as highly valued writing that it is not a stable entity is that value-judgments are notoriously variable.

   T. Eagleton, *Literary Theory: An Introduction*, 1983.

11.7 NON-DEDUCTIVE REASONING, SIMPLE INDUCTION

We cannot "just see" that the claim "All magpies are black and white" is true. This claim is not a simple descriptive statement that characterises a particular thing at a particular time. It is a universal generalisation about an unlimited number of objects. If we cannot observe all magpies, how can we justify such a generalisation? One way is to use a method known as *simple induction*.

The common feature of non-deductive inference is that the premises do not provide conclusive grounds for the truth of the conclusion. Another way to make much the same point is to say that the conclusion in non-deductive arguments always goes well beyond the evidence in the premises. Deductive reasoning is "safe" but non-deductive reasoning always has some potential risk.

Another important feature of non-deductive reasoning is that its evaluation depends upon some wider understanding of the subject matter about which we reason. Such evaluation often requires a great deal of quite specific knowledge. Thus, part of the "risk" involved in non-deductive reasoning is that it is not always easy to evaluate such reasoning. There are many useful guidelines, but we must realise that the risk of error cannot be completely eliminated.

The justification of strict universal generalisations by simple induction or inductive generalisation involves an inference from a number of singular statements to a universal statement or generalisation. A very simple example of an inductive generalisation was given in **§10.19**:

1. This magpie is black and white.
2. That magpie is black and white.
3. All magpies I have ever seen are black and white.
4. All magpies are black and white.

If we represent individuals with lower-case letters such as "a", "b", "c", etc., and use upper-case letters to represent qualities of these individuals, in particular, "M" (magpie), "B" (black) and "W" (white), an inductive generalisation might look something like this:

1. a is M and a is B and W.
2. b is M and b is B and W.
3. c is M and c is B and W.
4. d is M and d is B and W.

...

14. n is M and n is B and W.
15. All M are B and W, or If anything is M, then it is also B and W.

11.8 THE EVALUATION OF SIMPLE INDUCTIVE REASONING

There are three guidelines that are important for the evaluation of inductive generalisations. They are also recommendations about how to collect adequate evidence for such inferences:

Three Guidelines when evaluating inductive generalisations:

1. The number of things observed in order to provide the evidence for the conclusion must be large.

2. The things observed should be investigated in a wide variety of conditions.

3. There must be no known exception or counter-example to the generalisation. If we observe an object e that is M and not N, it is a counter-example to the generalisation that all M are N. If there is a known counter-example to the generalisation in the conclusion, then we must conclude that, strictly speaking, the generalisation is false.

Within the framework for evaluating reasoning introduced in **§11.2** and **§11.3**, these three points are all relevant to the strength of the connection between the premises and the conclusion. Of course, the premises also need to be true for a successful justification using inductive generalisation.

Justifying generalisations is not confined to the world of science. An important practical question faced by manufacturers is knowing that all of the products sold with their name are satisfactory. Companies are expected by law and by their customers to ensure that each bottle of soft-drink, each tin of beans, or each automobile which is sent to a retailer meets a range of standards. However, it is often impossible to check each item individually. Thus, manufacturers must determine *how many* individual products will be tested and *where* such testing should take place in the manufacturing process. To develop a system of quality control involves collecting *enough* evidence about *some* individual items to ensure that *all* reach the necessary standards in a way that is cost-effective. This involves simple inductive reasoning.

EXERCISE 2 –

EVALUATION OF SIMPLE GENERALISATIONS

Find an example of a generalisation which has been justified and evaluate the justification, using the three criteria listed in **§11.8.**

11.9 BEYOND SIMPLE GENERALISATIONS

Understood as strict universal generalisations, most generalisations are false. (Why is it unwise to say: “All generalisations are false”, without even looking at a few samples?) Is there some alternative to generalisations being either true or false? The most common way that scientists deal with this problem is to understand a “generalisation” as a *relative frequency* statement. If a few magpies are albinos, for example, the claim that all magpies are black and white is strictly speaking false. If we say instead that 97% of all magpies are black and white, we make a claim which is more precise and can be evaluated in much the same way as simple generalisations.

In the last 100 years, a number of sophisticated statistical techniques have been developed to approach the justification of these claims. The forms of non-deductive justification used in statistical inference will be discussed in **Chapter 13.**

11.10 INDUCTIVE GENERALISATION AND THE SCIENTIFIC METHOD

It is sometimes claimed that inductive generalisation provides the essential feature of the scientific method. The distinguishing feature of all science is that it uses a scientific method, and the distinguishing feature of the scientific method is the use of inductive generalisation. Such a view is presented in the following passage:

> If we try to imagine how a mind of superhuman power and reach, but normal so far as the logical processes of its thought are concerned,...would use the scientific method, the process would be as follows: First, all facts would be observed and recorded, *without selection* or *a priori* guess as to their relative importance. Second, the observed and recorded facts would be analysed, compared, and classified, without *hypothesis or postulates*, other than those necessarily involved in the logic of thought. Third, from this analysis of the facts, generalisations would be inductively drawn as to the relations, classificatory or causal, between them. Fourth, further research would be deductive as well as inductive, employing inferences from previously established generalisations.
>
> A.B. Wolfe, quoted in A. Chalmers, *What is this thing called science?*, 1982.

Few philosophers of science today would accept the idea that the central feature of the scientific method is the use of inductive generalisation. Certainly, it is not easy to give a perfectly adequate definition of science and the scientific method, but it is generally accepted by philosophers of science that there is more to science and the scientific method than this.

One of the reasons philosophers do not accept this account of science is that some of the claims made by scientists are not actually generalisations or relative frequency statements. There are two reasons for this. First, according to one popular account of cause and effect in nature (explained in **§15.14**), causes, causal laws and generative mechanisms do not involve a strict universal connection between cause and effect in all circumstances. Second, as we will see in **Chapter 16,** observations and generalisations in science are structured in terms of theoretical concepts. Thus, a sophisticated science needs theories, concepts, and causal laws, as well as observations and generalisations. If there is more to science than generalisations, then there must be more to the scientific method than making inductive generalisations from observations of particular things.

11.11 NON-DEDUCTIVE REASONING — ANALOGICAL INFERENCE

As the name implies, analogical reasoning is reasoning that is based on an analogy or similarity between things. If you always purchase products which are made by a certain manufacturer because they have been good in the past, you rely on an analogical inference that the other products will be good as well. To understand more about analogical inference, it is best to start with an example from the work of the philosopher Thomas Reid, who lived from 1710 to 1796:

> We may observe a very great similitude between this Earth which we inhabit, and the other planets, Saturn, Jupiter, Mars, Venus, and Mercury. They all revolve around the Sun, as the Earth does, although at different distances and different periods. They borrow all their light from the Sun, as Earth, and by that means, must have a like succession of day and night. Some of them have moons, that serve to give them light in the absence of the Sun, as our moon does to us. They are all, in their motions, subject to the same law of gravitation, as the Earth is. From all this similitude, it is not unreasonable to think that those planets may, like our Earth, be the habitation of various orders of living creatures.
>
> Thomas Reid, *Essays on the Intellectual Powers of Man.*

The conclusion in this passage is that there may be living creatures on the other planets in our solar system. The evidence for this claim is that the other planets are similar to us in at least seven respects.

Even though you may find that, with today's knowledge, the premises Reid gives are more or less irrelevant to the conclusion, this kind of reasoning is quite common. Similar but much more sophisticated arguments can now be constructed to justify the conclusion that there are living organisms elsewhere besides Earth. (See **Exercises 7, 8,** and **9**.) Using similar reasoning a biologist can infer simply from the structure of the skull of an animal that it is the skull of a marsupial because all other species of marsupials we know of have the same structures in their skulls. It can be concluded from the similarity between the skull of the new species, and the skulls of known marsupial species, that the new animal is also a marsupial.

One of the most important uses of analogical reasoning is found in medical research. Many experiments that are used to investigate the causes and potential cures of human illnesses are in fact carried out on other animals. What is the relevance to humans of research on the causes of cancer in mice? None, unless you assume that there is enough relevant similarity between biological processes in the two different species to justify conclusions about humans based on research carried out on mice.

Not all analogies involve inference, however. Many analogies are used to illustrate or explain a point. These uses of analogy are related to the use of metaphor and simile, where a comparison is made between two things to draw our attention to some feature that they have in common. For example, in the following passage the analogy being made is not used to prove or justify anything.

> Feminists decided to examine the institution of marriage as it is set up by law in order to find out whether or not it did operate in women's favour. It became increasingly clear to us that the institution of marriage "protects" women in the same way that the institution of slavery was said to "protect" blacks—that is, that the word "protection" in this case is simply a euphemism for oppression.
>
> Sheila Cronan, "Marriage" (1973), cited in Copi, 1978.

The central feature of analogies, whether they are inferences or not, is similarity. The logician

Copi explains the form of analogical inferences as follows, where *a*, *b*, *c* and *d* are objects, while P, Q and R are qualities or attributes of these objects:

1. *a*, *b*, *c* and *d* all have P and Q.
2. *a*, *b* and *c* all have R.
3. *d* also has R.

EXERCISE 3 –

IDENTIFICATION OF ANALOGICAL REASONING

All of the following passages contain analogies. Distinguish those which contain analogical arguments from those which make non-argumentative uses of analogy. If the passage contains an argument or reasoning, indicate the conclusion (a, b, c, etc.). If it does not contain an argument, it will not have a conclusion.

1. Racists violate the principle of equality by giving greater weight to the interests of members of their own race when there is a clash between their interests and the interests of those of another race. Sexists violate the principle of equality by favouring the interests of their own sex. Similarly, speciesists allow the interests of their own species to override the greater interests of members of other species. The pattern is identical in each case.

   Peter Singer, *Animal Liberation* (1976), cited in Copi, 1978.

   a) Racists violate the principle of equality by giving preference to members of their race over individuals of other races.
   b) Sexists violate the principle of equality by giving preference to people of the same sex as themselves.
   c) Speciesists violate the principle of equality by giving preference to members of their own species over individuals of other species.
   d) This passage does not contain an argument or justification.

2. We have said that normal persons have little motivation to prompt special efforts at self-study. The same is true of arithmetic. If motivation were not supplied from parents and school pressure, there would be little learning of mathematics. By analogy, it seems possible that children could be motivated and trained to use their mental skills to solve *emotional* problems. They get almost no training in this important skill at the present time.

   J. Dollard and N. Miller, *Personality and Psychotherapy* (1950), cited in Copi, 1978.

   a) Normal persons have little motivation to prompt special efforts at self-study.
   b) If motivation were not supplied from parents and school pressure, there would be little learning of mathematics.
   c) Children can be motivated and trained to use their mental skills to solve emotional

problems.

d) This passage does not contain an argument or justification.

3. The best reason for thinking that BSE —mad cow disease—will not infect people is that scrapie—mad sheep disease—never has. Scrapie is BSE, except that it appears in a different species and has been around for at least 250 years. In all that time sheep-eaters exposed to scrapie have been no more demented than the rest of the population. Thus cow-eaters exposed to BSE, the argument goes, will also remain healthy.

"Science and Technology", *The Economist* (1990), cited in Copi, 1992.

a) BSE, mad cow disease, will not spread to people from eating infected cattle.
b) Scrapie, mad sheep disease, has not spread to people from eating infected sheep.
c) Scrapie has been around for 250 years.
d) This passage does not contain an argument or justification.

4. Perhaps the most startling discovery made in astronomy this century is that the universe is populated by billions of galaxies and that they are systematically receding from one another, like raisins in an expanding pudding.

M. Rees and J. Silk, "The Origins of Galaxies", *Scientific American* (1969), cited in Copi, 1978.

a) The universe is populated by billions of galaxies.
b) These galaxies are systematically receding from one another, like raisins in an expanding pudding.
c) This passage does not contain an argument or justification.

5. It is important that we make clear at this point what definition is and what can be attained by means of it. It seems frequently to be credited with a creative power, but all it accomplishes is that something is marked out in sharp relief and designated by a name. Just as the geographer does not create a sea when he draws boundary lines and says: the part of the ocean's surface bounded by these lines I am going to call the Yellow Sea, so too the mathematician cannot really create anything by his defining.

Gottlob Frege, *The Basic Laws of Arithmetic* (1884), cited in Copi, 1992.

a) Definitions are credited with creative power.
b) Definitions mark something out and give it a name.
c) A geographer does not create a sea by drawing lines on a map and naming it the Yellow Sea.
d) Mathematicians do not create anything by their definitions.
e) This passage does not contain an argument or justification.

6. It seemed to us that the synchronous behaviour of malaria parasites, all coming to cell division at the same time every 24 hours or a multiple thereof, was remarkably like the behaviour of microfilariae, all entering or leaving the peripheral blood at the same time every 24 hours. Microfilariae are carried from one patient to another by mosquitoes, which suck blood mostly at night, and the swarming of the microfilariae in the peripheral blood is arranged to coincide with this time of sucking blood. The biological purpose of the cycle of the microfilariae is clearly to help them encounter mosquitoes and so get transmitted to new patients. Since malaria is also carried from one person to another by mosquitoes, it seemed to us that the periodic behaviour of the malaria parasites in the blood was similarly designed somehow or other to facilitate transmission by mosquitoes.

F. Hawking, "The Clock of the Malaria Parasite", *Scientific American* **(**1970), cited in Copi, 1978.

a) The synchronous behaviour of malaria parasites, all coming to cell division at the same time every 24 hours or a multiple thereof, is remarkably like the behaviour of microfilariae, all entering or leaving the peripheral blood at the same time every 24 hours.
b) Microfilariae are carried from one patient to another by mosquitoes, which suck blood mostly at night, and the swarming of the microfilariae in the peripheral blood is arranged to coincide with this time of sucking blood.
c) Since malaria is also carried from one person to another by mosquitoes, it is possible that the periodic behaviour of the malaria parasites in the blood was similarly designed somehow or other to facilitate transmission by mosquitoes.
d) This passage does not contain an argument or justification.

EXERCISE 4 –

ANALOGIES

1. Find and photocopy a passage which contains an analogy used for illustration. Provide adequate references for the passage.

2. Find a passage which contains analogical reasoning. Provide adequate references for the passage.

11.12 EVALUATION OF ANALOGICAL INFERENCES

There are four factors that need to be taken into account when evaluating evidence for the conclusion of an analogical inference. Again, as in the case of inductive generalisation, these four points are all relevant to the strength of the connection between the premises and the conclusion. The premises also need to be true for a successful justification using analogical inference.

Four factors to consider when evaluating analogical inferences:

1. The number of objects between which the similarity or analogy holds.
2. The number of qualities or attributes that the objects have in common.
3. The number of qualities or attributes in which the objects differ.
4. The relevance of the resemblance explained in the premises to the resemblance alleged in the conclusion.

This last factor is quite important, and it needs more explanation. The relevance referred to is *causal* relevance. The question we need to ask of an analogical inference is this: is there likely to be significant *causal* connection between the similarities noted in the premises and the similarity alleged in the conclusion?

A simple example of how causal relevance is important can be seen in the following two examples of reasoning. Suppose you are interested in buying a 1980 Datsun 1600 from a used-car dealer, and you would like to know roughly how much petrol it consumes. Your friend suggests that you use analogical reasoning by examining the mileage of other similar cars as follows: Since the car you wish to purchase is dark blue, with white seats and four doors, they propose that you ask people with similar cars built in 1980 what mileage they get.

Most of us would realise that while your friend has good intentions, this is *not* a good way to proceed. However exact your data was, and however many cars you examined, there would be no good connection between the "data" and your conclusion about the mileage of the Datsun 1600 because the similarities are not causally relevant to the mileage of cars. You would need to examine the mileage of cars made in roughly the same years with the same size motor, if you wish to make a reliable estimate based on relevant evidence rather than sheer guess-work. Both of these analogical inferences might look the same on paper, but one will be reliable while the other will not.

This means that we cannot evaluate analogical inferences satisfactorily without having a significant amount of causal knowledge. Our evaluation of the inference will be based on a range of more or less implicit assumptions. The fact that they are implicit does not mean that they are mistaken. We have a problem if they are both implicit *and* mistaken.

Put another way, we cannot evaluate analogical inferences without a range of *other* beliefs about how the world works. Such evaluation presupposes a wider system of knowledge. In fact, this same point applies to inductive generalisations as well. Point 2 in **§11.8** demands observations of objects in a "wide variety of conditions" to ensure that the connection between the truth of the premises and the truth of the conclusion is good. The problem is: how do we know what is wide and what is narrow? We need to know which conditions *might be* causally relevant here as well. The phrase should probably read "a wide variety of conditions that might be causally relevant to the connection between P, Q and R".

Extension Reading 2

Super-Pill to Get Students' Brains into Gear

By Jeremy Laurance in London.

A new generation of drugs capable of turning ordinary students into first-class honours graduates could be available within five years, according to scientists. An international conference on the use of drugs to enhance cognitive function has been told that more than 200 chemical compounds that will boost memory and learning ability are being developed by pharmaceutical companies in a race to find an effective treatment for Alzheimer's disease and other kinds of dementia.

Some scientists believe that these "memory pills" will also lift normal mental performance to "super-normal" levels. Animals given the drugs have shown remarkable improvements in learning.

Speaking after the conference, James McGaugh, director of the Centre for the Neurobiology of Learning and Memory at the University of California, said that, on the basis of animal experiments, drugs with strong memory-enhancing capabilities in humans would be developed. "Some of my colleagues disagree about the likely magnitude of the change, but if it happens in laboratory animals why shouldn't it happen in humans?" he said.

Only one cognitive enhancer, Tacrine, is licensed for the treatment of Alzheimer's disease, but its effects are modest—slowing mental deterioration by about six months—and its side effects, such as liver damage, severe.

Other drugs with fewer side effects are becoming available, and the early trials of a new class of cognitive enhancers, called ampakines, that have a different mechanism of action are claimed to have produced remarkable effects in humans.

Professor McGaugh said the new drugs were likely to have wide appeal in a competitive commercial world among students sitting exams and ambitious workers wishing to give themselves an edge over rivals. The time to take a memory pill will be while learning or revising, not outside the examination room.

The drugs work by improving memory processing at the time the information is acquired, enhancing the transition from short to long-term memory; not by improving recall. In animal experiments, rats taught to avoid one part of a maze by being given mild electric shocks remembered the information up to a month later if they were given the drug, compared with others that had forgotten within 24 hours.

Biologist Steven Rose, of Britain's Open University, who chaired the conference organised by the CIBA Foundation in London, said about 140 so-called smart drugs were sold by mail order and in bars in California but none was effective and some were hazardous.

The Times, quoted in *The Australian*, 1997.

EXERCISE 5–

EVALUATION OF ANALOGICAL REASONING—THE SUPER-PILL FOR STUDENTS

Examine the reasoning in **Extension Reading 2** and answer the following questions:

1. Why do scientists believe that drugs can be developed which would improve students' performance?

2. What important assumptions are used to justify this conclusion? Are these assumptions

acceptable?

3. Do the statements by James McGaugh justify the claim made by the author, Jeremy Laurance, that "A new generation of drugs capable of turning ordinary students into first-class honours graduates could be available within five years"? If not, why not?

11.13 ANOTHER DIFFERENCE BETWEEN DEDUCTIVE AND NON-DEDUCTIVE REASONING

In **§10.16** and **§11.7** we discussed one difference between deductive and non-deductive reasoning. To repeat:

1. **<u>Deductive</u> reasoning has a conclusive connection between the truth of the premises and the truth of the conclusion.**

2. **In <u>non-deductive</u> reasoning, however good, the connection is not conclusive.**

There is another importance difference as well.

1. **The evaluation of <u>deductive</u> inferences depends on logical relations between the premises and conclusions which hold independently of our other beliefs.**

2. **The evaluation of <u>non-deductive</u> inferences requires a reasonable amount of knowledge about how the world works.**

Determining the form or structure of a deductive argument may tell us that it is valid. But this alone will not work with non-deductive reasoning. An understanding of what things may be causally relevant to other things is necessary to evaluate both induction and analogical inferences. Evaluation of both kinds of reasoning can be complex, but they are complex for different reasons.

11.14 THE POWER OF SIMPLE GENERALISATIONS AND ANALOGICAL REASONING

Simple generalisation and analogical reasoning is powerful. Suppose you find some bones while walking in the remote part of a park. How do the police know that these are the bones of a human? From the examination of many different animals and humans, experts have a quite clear idea what part of the body the bone comes from, and the differences between animal and human bones. This is a case of knowledge about all human bones, all sheep bones, etc., based on generalisation from a range of individual humans and animals that have been examined previously.

Another example: It is said that some places which are now dry land were once at the bottom of the sea. How do we know that? We find rocks now on dry land that are identified as limestone. These rocks consist of material which has the same shape and is the same chemical composition as broken shells of organisms that still exist now. However, we observe now that these

organisms only live at the bottom of the sea. From this we conclude by simple inductive generalisation that the limestone now on dry land must have been deposited at some previous time while it was under water.

Some logicians are inclined to overlook the significance of analogical reasoning in everyday life and science. To give you some idea of how it can be used, we will sketch a few more examples (see **Extension Reading 3**).

Extension Reading 3

Anological Reasoning in Everyday Life and Science

When we find unusual patterns on rocks and caves, how do we know they are "paintings"? When the patterns are thousands of years old and the area is now uninhabited by humans, we cannot rely on the memory of any living person. But we can reason by analogy as follows: Since the patterns we observe now are similar to patterns we have seen humans put on other objects, we can conclude these were also produced by humans at some time in the past.

What are fossils? Fossils are rocks that *resemble* bones or the other parts of organisms. How do we know that a stone with a certain shape was a part of a skull and once contained the brain of an animal that belong to a species that no longer exists? We conclude this because it resembles the skulls of animals belonging to different species that do exist and we observe that those skulls contain their brains. This involves both simple generalisation and inference by analogy between species that are often quite different.

It is said that millions of years ago on Earth there were certain simple forms of life and they evolved into the life forms that exist today. How can we know this? We will later examine other evidence for the theory of evolution but analogy could well have played a part in both the formulation and the justification of this theory by its originator, Charles Darwin (1809-1882). Darwin lived in England in the 19th C. English farmers had been engaged in extensive animal breeding with horses, cattle, dogs, etc., for centuries. Such breeding involves *artificial* selection for certain characteristics. Darwin himself was not only aware of these methods, he was himself quite interested in breeding pigeons.

Darwin might well have reasoned as follows: We know that humans can develop different breeds of domestic animals, which are in fact more diverse than many species of animals in nature. If humans are known to be able to develop differences in animals by artificial selection, this gives us some reason to think that animals in nature develop differences in a way that is similar to this, and can be described as *natural* selection.

EXERCISE 6 –

ANALOGICAL REASONING AND THE EVOLUTION OF BIRDS

One of the many questions raised by the Theory of Evolution is this: From what kind of animal did the first bird evolve? Any answer to such a question is highly speculative, but there are a few clues. We can see that the claws of the oldest known fossil bird are curved. The task requires you to explain what you can conclude about the origin of birds from this observation together with what you can find out through further investigation of what is known about living and extinct birds.

EXERCISE 7 –

EVALUATION OF ANALOGICAL REASONING—LIFE BEYOND EARTH 1

Evaluate the analogical reasoning found in the passage by Thomas Reid in **§11.11** using the criteria explained in **§11.12**.

Extension Reading 4

Why on Earth?

On the basis of astronomical studies and the explorations carried out by unmanned space vehicles, it appears that Earth alone among the planets of our solar system supports life. The conditions on Earth are ideal for living systems based on carbon-containing molecules. A major factor is that Earth is neither too close to nor too distant from the Sun. The chemical reactions on which life—at least as we know it—depends require liquid water, and they virtually cease at very low temperatures. At high temperatures, the complex chemical compounds essential for life are too unstable to survive.

Earth's size and mass are also important factors. Planets much smaller than Earth do not have enough gravitational pull to hold a protective atmosphere, and any planet much larger than Earth is likely to have so dense an atmosphere that light from the sun cannot reach its surface. The Earth's atmosphere blocks out many of the most energetic radiations from the Sun, which are capable of breaking the covalent bonds between carbon atoms. It does, however, permit the passage of visible light, which made possible one of the most significant steps in the evolution of complex living systems.

Helena Curtis, *Biology,* 1983.

EXERCISE 8 –

EVALUATION OF ANALOGICAL REASONING—LIFE BEYOND EARTH 2

Evaluate the analogical reasoning found in **Extension Reading 4** using the criteria explained in **§11.12**.

Extension Reading 5

Jupiter Moon Reveals Oceans and Ingredients of Life

Making a giant step in the search for life beyond Earth, NASA scientists announced yesterday the discovery of an extraterrestrial ocean buried beneath the frozen surface of Europa, one of the moons of Jupiter.

Liquid water is the key ingredient for life as we know it. While NASA scientists do not have proof, they say life stands a good chance of existing on this moon. If so, they are fairly sure another mission would find it. Evidence for the ocean came from finely detailed pictures of Europa's alien landscape just beamed back from the Galileo spacecraft. These revealed a jumble of "icebergs" and flat-topped blocks of ice that may have twisted and turned from the motion of an underlying liquid or a muddy slush. In search for liquid water, "it looks as though we've found the smoking gun," said planetary scientist Michael Carr, of the US Geological Survey. "This is the first ocean discovered since the one Balboa discovered (the Pacific) five centuries ago," said planetary scientist Richard Terrile, of NASA's Jet Propulsion Laboratory in Pasadena. "There may be more water on Europa than on all the oceans of the Earth"—a lot considering Europa is about the size of the Earth's moon.

Though nothing has been detected swimming there yet, "the main ingredients are there," said project geologist Ronald Greeley from the University of Arizona. These were liquid water, a source of heat and organic chemicals such as hydrocarbons, alcohols, sugars and amino acids."Put these ingredients together on Earth and you get life within a billion years," said NASA scientist Mr Terrile.

Earlier observations had shown that the ice crust of Europa was made from water, but to harbour life, scientists realised there had to be at least some water in liquid form. Even a frigid body of water covered in 1.5km of ice might be a friendly enough environment. In Antarctica, perennially frozen lakes are slimy with living things and ecosystems flourish in the coldest, blackest parts of the oceans. Pictures taken from last decade's Voyager spacecraft also showed cracks in Europa's ice that hinted at water beneath. In December, the late Carl Sagan said in a television interview that he thought we stood a good chance of finding water, and then life, on Europa.

Not until Galileo took its high-resolution pictures last February, after flying within 580km of Europa, could scientists see enough detail to say for sure. The highest resolution pictures show an area of striated blocks, the stripes in each one pointing in different directions. These blocks, estimated to be around a kilometre thick, had been turned in different directions, perhaps by underlying currents in an underlying ocean. Shadows showed that other blocks were tilted into the shape of icebergs. It looked like the crust of ice over parts of the Arctic Ocean, said Northwestern University oceanographer Max Coon.

Though the spacecraft only examined two 95km patches of Europa's surface, researchers suspect that much of the rest of it would show similar features indicating water's presence.Whether this water is warm, frigid, salty or fresh, and whether life exists or not will have to wait until scientists can land a probe and use robotic equipment to test samples. The scientists say that the basic building blocks for the origin of life, organic chemicals, probably came to Europa from comets, which once rained down on its surface. Comets, such as the now—visible Hale-Bopp, are rich in organic – though not living – matter. Comets may also have delivered the starting materials of life to Earth.

The heat necessary for life might come from suspected underwater volcanos that appear to be repaving the surface of Europa with smooth ice, or from the movement of tidal currents induced by Jupiter. University of Washington oceanographer John Delaney said he hoped life would be found on Europa. "My personal view is completely irrelevant, but I'm sure there is life there," he said.

The Philadelphia Inquirer, quoted in *The Advertiser*, 1997.

EXERCISE 9 –

EVALUATION OF ANALOGICAL REASONING —LIFE BEYOND EARTH 3

Evaluate the analogical reasoning found in **Extension Reading 5** using the criteria explained in **§11.12.**

EXERCISE 10 –

THE GLOBAL WARMING DEBATE — VON HELMHOLTZ 'S ARGUMENT

Examine the passage by Hermann von Helmholtz presented in **§10.9** and evaluate his reasoning.

1. What observations does he use to support his case?

2. What is his conclusion?

3. What assumptions does he use to support his conclusion?

4. Are his observations and assumptions acceptable?

5. Assuming they are correct, do his observations and assumptions justify his conclusion?

Extension Reading 6

Riddle of Melting Ice Pack

A Tasmanian scientist has discovered that between the late 1950s and the early 1970s, a huge expanse of Antarctic sea ice went missing: in fact, enough to cover about 75 percent of the Australian mainland. Bill de la Mare, a mathematical biologist of Australia's Antarctic Division in Hobart, says the recent catastrophic decline of elephant seals and penguins in some sub-Antarctic islands could be linked to the sudden decline in annual sea ice cover. His discovery, published in the international research journal, *Nature,* last week, comes as an unpleasant surprise for climatologists.

Dr. de la Mare's discovery has highlighted a serious flaw in the supercomputer-based models climatologists are developing to analyse the potential climatic impact of global warming.There have been almost no reliable data on sea ice trends in the era before the first satellite images in the early 1970s, and satellite imagery shows that, despite local variations, sea ice cover has remained approximately static since 1973. Dr. de la Mare conceived the ingenious idea of using proxy data. He sifted through whaling records from the Antarctic since 1931, knowing that whalers hunted species like blue, humpback and minke whales that feed close to the edge of the sea ice. Whaling ships kept precise data on where they took the whales, recording a precise midday positional "fix" in logbooks.

This data provided Dr. de la Mare with irrefutable evidence that the limit of annual sea ice cover around Antarctica has retreated 311 km. southwards in less than half a century. It is not only the extent of the retreat that surprises climatologists, but its abruptness, as it means that most of the loss occurred in less than two decades. The problem for today's climate models is that the retreat occurred at a time when some climatologists actually feared the world might be descending into another glacial period.

Dr de la Mare's findings challenge climatologists to explain why sea ice retreated so rapidly during the period before the warming trend resumed. His own suspicion is that a pronounced change in the oceanic circulation around Antarctica went undetected, and the sea ice is being melted mainly from below, by warmer surface waters.

Graeme O'Neill, *The Sunday Mail*, 1997.

EXERCISE 11 –

THE GLOBAL WARMING DEBATE — ANTARCTIC SEA ICE

Examine the article "Riddle of Melting Ice Pack" reproduced in **Extension Reading 6** and answer the following questions:

1. What conclusion does Bill de la Mare justify?

2. What events does Bill de la Mare explain?

3. What does Bill de la Mare use as evidence to justify his conclusion?

4. What kind of reasoning does he use to justify his conclusion?

Extension Reading 7

Climate Records Reveal Steady 150-Year Warming Trend

From sources as diverse as newspaper archives, transportation ledgers and religious observances, scientists have amassed lake and river ice records spanning the Northern Hemisphere that show a steady 150-year warming trend.

The study, which includes 39 records of either freeze dates or breakup dates from 1846 to 1995, represents one of the largest and longest records of observable climate data ever assembled. University of Wisconsin-Madison climatologist John Magnuson led a team of 13 co-authors who contributed to the report, published in today's issue of the journal *Science.*

Sites ranged from Canada, Europe, Russia and Japan. Of those, 38 indicate a consistent warming pattern. The average rate of change over the 150-year period was 8.7 days later for freeze dates; and 9.8 days earlier for breakup dates. A smaller collection of records going well past 150 years also shows a warming trend, at a slower rate.

"We think this is a very robust observation: It is clearly getting warmer in the Northern Hemisphere," says Magnuson. "The importance of these records is that they come from very simple, direct human observations, making them very difficult to refute in any general way."

The findings also correspond to an air temperature increase of 1.8 degrees Celsius over the past 150 years. A temperature change of 0.2 degrees Celsius typically translates to a one-day change in ice-on and ice-off dates. Freeze dates were defined in the study as the observed period the lake or river was completely ice-covered; the breakup date was defined as the last ice breakup observed before the summer open-water phase.

"Of course, 10,000 years ago the Midwest was covered by ice, so we know it's getting warmer," he says. "What's troubling and scary to people is that these rates in recent decades are so much faster." Climate models have predicted a doubling of total greenhouse gases in the next 30 years or so, a change that could potentially move the climate boundaries for fish and other organisms northward by about 300 miles, approximately the length of the state of Wisconsin, Magnuson says.

The records in this study represent the longest and most intact of 746 records collected through the project. Some individual records are of astonishing lengths, with one dating back to the 9th century, another to the 15th century and two more to the early 1700s.

For example, Lake Suwa in Japan has a record dating back to 1443 that was kept by holy people of the Shinto religion. The religion had shrines on either side of the lake. Ice cover was recorded because of the belief that ice allowed deities on either side of the lake— one male, one female—to get together.

Lake Constance, a large lake on the border of Germany and Switzerland, has a peculiar record dating back to the 9th century. Two churches, one in either country, had a tradition of carrying a Madonna figure across the lake to the alternate church each year it froze. Another finding in the study, based on the 184 ice records from 1950 to 1995, showed the variability in freeze and breakup dates increased in the last three decades. Magnuson says it might be related to intensification of global climate drivers such as the El Niño/La Niña effects in the Pacific Ocean.

Magnuson says the ecological effects of global warming are only beginning to be studied. But studies already exist that have shown the northern ranges of some butterflies and birds have been extending northward.

B. Mattmiller, UniSci — *Daily University Science News,* 2000.

EXERCISE 12 –

THE GLOBAL WARMING DEBATE — CLIMATE RECORDS

Extension Reading 7 above presents a summary of a recent justification for the claim that temperatures have not remained constant in the last 150 years.

1. How is this claim supported?

2. What are the central assumptions used in this justification?

3. Evaluate the acceptability of these assumption, as best as you can.

Extension Reading 8

British Scientists Believe the Birth of Several Huge Antarctic Icebergs during the Past Few Years has been Caused by Global Warming but an Australian Expert Disagrees.

The heat is on in the coldest continent. Everywhere, there are signs of warming.

Could Antarctica be providing a preview of human-induced global warming next century? The huge tabular iceberg that broke free from the Prince Gustav iceshelf early this year was one of several giant icebergs that have split during the past decade from the iceshelves fringing the long narrow arc of land where Antarctica's "tail" curves toward South America.

The size of these icebergs beggars the imagination: the tabular iceberg that came off the Larsen iceshelf in 1992 was so large that, had it been centred on Adelaide, it would have spanned the distance between Cleve, on Eyre Peninsula, and Keith, in the South-East.

The new Prince Gustav iceshelf iceberg, named A25, is smaller, about 100km long, but British glaciologists have calculated that it contains about 400 billion tonnes of ice. Researchers with the British Antarctic Survey believe the birth of A25 signals the death of the Prince Gustav iceshelf which, at 70 degrees south is among the most northerly of the continent's iceshelves.

They are concerned by the suddenness of the break-up. Last summer, for the first time since man began exploring the frozen continent, the thick ice blanketing King George VI Sound, between Alexander Island and the Antarctic mainland, broke up. Sea ice is already patching the breach but the repair is only temporary. In summers to come, the break-up of the iceshelf is likely to create a navigable channel through the sound.

London's *Daily Express* quotes BAS glaciologist Dr. David Vaughan as saying: "We really thought the iceshelf was a permanent feature; so permanent that the iceshelf is included in maps of the area. For it to collapse in a matter of months is incredible."

Other huge icebergs, between 50km and 100km long, have broken off the nearby Larsen Filshner and Ross iceshelves since the mid-1980's but Australian glaciologist Dr. Joe Jacka, of the Co-operative Research Centre for Antarctic Studies in Hobart (CRCAS) is more sanguine about what the phenomenon might portend.

"Some scientists have claimed in recent months that it is indicative of warming on the Antarctic Peninsula." Dr. Jacka says. "But big icebergs break off the Antarctic iceshelf all the time. It's a natural process." Glaciologists don't even know what is causing the giant icebergs to break free from the Antarctic iceshelf.

One theory attributes the process to melt-waters pouring off the mountainous spine of the Antarctic Peninsula and flowing into crevasses on the icesheet; as this water freezes and expands, the theory suggests, it acts as a wedge, splitting the icesheet along the crevasse lines. Dr. Jacka doubts this theory.

He finds more plausible the idea that a slight rise in ocean temperature is causing frozen salt water adhering to the bottom of the icesheet to melt, resulting in the icesheets thinning out and collapsing under their own weight. The icesheets consist of frozen fresh water that originally fell as snow over the mainland; as the snow accumulates, the icesheet flows off the land and grinds across the continental shelf until the water is deep enough for the iceshelf's natural buoyancy to float it off the underlying rocks.

The low temperature of the ice causes sea water to freeze on to the base of the icesheet, thickening it so that it fills the gap between the icesheet and the rocky sea floor.

Dr. Jacka says that because salt water freezes and melts at a lower temperature than fresh water, a small rise in water temperature could take it past its melting threshold— deprived of its saltwater prop, the icesheet would sag, crack and break free. "But I don't believe this theory either," says Dr. Jacka. "Just because parts of the iceshelf break off in several localities doesn't convince me we are seeing global warming. Some glaciologists would agree with me, others would disagree. But if it happens 10 times next year, or if the rate clearly increases over the next decade, I might change my mind."

Dr. Jacka says there is little doubt that Antarctica is seeing a genuine warming trend: the only question is whether it is just another transient episode in the ebb and flow of natural climate variation or an abnormal trend triggered by the enormous amounts of greenhouse gases that humans have been dumping into the atmosphere since the industrial revolution.

Dr. Jacka and CRCAS colleague Dr. Bill Budd, formerly of Melbourne University, have been analysing annual mean temperatures from recording stations on the Antarctic continent and in the Southern Ocean and have found a pronounced warming trend.

"Since 1945, when monitoring first began in the Southern Ocean, temperatures have risen at a rate equivalent to 1.3 degrees per century," Dr. Jacka says."Without exception, every station in the Southern Ocean has seen a rise in temperature, so we can assume it represents a much broader warming trend and not some localised effect."

"For the Antarctic continent itself, the rise in annual mean temperature since the mid-1950's, when monitoring first began, has been equivalent to a 2.4 degree rise. Again, the trend is uniform, except for two measuring stations—at Australia's Mawson Base and at Russia's neighbouring Molodezhnaya Base."

"And we think we can explain the absence of the trend at these two bases in terms of their proximity to a region off the coast that generates polar cyclones." The more pronounced warming trend on the Antarctic continent is consistent with predictions by global-circulation models that greenhouse-induced warming will be most pronounced at polar latitudes. A simple explanation, says Dr. Jacka, is that tropical regions cannot get much warmer, so surplus heat must be distributed toward the poles. The net effect is to reduce the temperature gradient between equator and the poles; temperate regions warm up but polar regions become even warmer. A consequence of this effect is that the signs of global warming will appear first in the polar latitudes. In the northern hemisphere, a brown haze of industrial pollution that drifts into the Arctic from the heavily populated regions of Europe, Asia and North America may be masking an underlying temperature rise by reflecting solar radiation back into space. Antarctica, free of such pollution, offers itself as the "canary" for global warming.

The fact that no reliable temperature records are available for the Antarctic before 1945 is a problem. Dr. Jacka says the data set is simply not long enough to see where the present trend sits within the natural pattern of climate variation.

However, the temperature trend in the Antarctic is embedded within a global pattern of rising temperatures—and the global trend has been particularly marked during the past 15 years. Last year was the

warmest this century, and the eight warmest years this century have occurred since 1982. Mr. Barrie Hunt, the head of the Drought Research Centre at the CSIRO division of Atmospheric Research in Aspendale, recently completed an analysis that asked where the recent trend sits within the "envelope" of climate variation over the past 400 years. The short answer is that it does not. At no time in the past four centuries has the temperature risen so rapidly over such a short interval. But the data still do not permit climatologists to establish a definite link between the trend and rising concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

Anybody who dismisses the threat of global warming on the grounds that a rise of a few degrees will have a trivial impact on biological systems, including those of economic interest to human beings, should read a recent study by two South African biologists of how the recent warming trend has affected life on tiny, remote Marion Island, in the southern Indian Ocean.

Marion Island and neighbouring Prince Edward Island lie about 12 degrees north of the Antarctic Circle, a few degrees below the latitude of Hobart, but still well outside the region of most pronounced warming.

Dr. V. R. Smith, a botanist with the University of the Orange Free State, in Bloemfontein, and Dr. S. L. Chown, an entomologist at the University of Pretoria, have been studying the sparse ecological web on Marion Island. Small island ecosystems tend to be very simple everywhere in the world, even without the frigid winter blast of the Roaring 40s operating as another severe constraint on biological diversity. Marion Island has become warmer and drier during the past 21 years. Monthly temperature calculations showed a temperature rise of about 12 per cent between 1971 and 1992. Higher temperatures produced higher evaporation and soil moisture has declined by 28 per cent since 1968.

The house mouse, *Mus musculus,* an alien introduced to the island by visiting mariners in the early 1800s, has been able to extend its breeding season by 54 days, so that the average female mouse now produces 7.27 litters in a season, nearly two more generations a year than in 1971. The mice have boomed. By 1979-1980, their numbers were up by 41 per cent and by 1991-1992 by 92 per cent. There are no mice on neighbouring Prince Edward Island.

Marion Island had no mammals before the arrival of the house mouse, which now competes for food with a bird, the sheathbill, *Chionis major.* With the mice in plague numbers, sheathbill populations have plummeted since the 1970's.

Similar ecological changes are undoubtedly occurring on oceanic islands everywhere in the southern hemisphere; they are almost certainly occurring also in temperate regions of Australia, Tasmania, New Zealand, South America and Africa as the warming trend distorts the structure and functioning of ecosystems.

Graeme O'Neill, *The Advertiser,* 1995.

EXERCISE 13 –

THE GLOBAL WARMING DEBATE – ANTARCTIC ICEBERGS

Carefully read the article reproduced in **Extension Reading 8** at least twice, then answer the following questions.

1. How does Dr Joe Jacka disagree with researchers of the British Antarctic Survey, such as Dr David Vaughan, about the break-up of the Prince Gustav iceshelf? What are the two different points of view?

2. What are the two different explanations presented in the article of the giant icebergs' breaking free from the Antarctic ice shelf?

3. What evidence is presented in the article which supports the hypothesis that temperatures in the Antarctic region are increasing?

4. Is there any evidence presented in the article which is apparently inconsistent with the hypothesis that temperatures in the Antarctic region are increasing? If so, what is it?

5. How are the changes in the temperatures in the Antarctic region connected to the hypothesis of a greenhouse-induced global warming?

6. Is there any evidence presented in the article which is apparently inconsistent with the hypothesis that the recent variation in Antarctic temperatures are within the range of normal climate variation? If so, what is it?

7. The last part of the article consists of a report on the work of the botanists, Dr V.R. Smith and Dr S.L. Chown. What specific conclusions do they come to about the ecology of Marion Island?

8. What changes have occurred on Marion Island in the last 25 years? What changes have occurred on Prince Edward Island in the last 25 years? What justifies these claims about the two islands? What explains these differences between the two islands?

11.15 SUMMARY

In this chapter, we have described the two ways that reasoning must be evaluated and shown how these tests can be applied to simple deductive arguments. First, the truth or acceptability of all the premises or assumptions needs to be examined. Second, the connection between the premises and conclusion needs to be examined. If both of these elements of the reasoning are successful, then the reasoning itself is successful as a justification. If it fails on either element, then it is unsuccessful and proves nothing.