A Guide to Essential Thinking, The Third Part:

An Introduction to Logic for People under Fifteen Years Old, at which Time, the Many, Many, Many Generally Available Introductions to Logic can Become Relevant, Unlike the Pictures, which Remain, as in the Previous Two Parts, Irrelevant but, so it Remains Hoped, Interesting

A picture of a sperm whale starting a dive off the coast of Kaikoura, New Zealand

This section is a bit tricky—people's brains and bodies and cognitive abilities develop and change (and sometimes deteriorate) over time, which is why logic is not usually addressed for the under-fifteen crowd (or ever—I almost took a job in Karachi because a university there requires training in logic for all undergraduates, unlike most universities around the world that require no formal training in thinking). So I'm going to make this as easy and relevant as I can, but if this is too tricky, it's fine to put it aside and come back to it in a few months or years.

I don't know—a picture of animals in water, but I don't know which animals or where the water was

Section I: General Principles

A picture of a fence lizard in Arizona

Comparing General and Specific

Logic is about comparing general principles and specific claims or specific facts in order to reach a conclusion, or a third idea that maybe we didn't have access to previously, or to a third idea that wasn't clear or readily available previously. So the main goal is to identify the general principle that applies, or that is in use (these could be different), and then identify the specific facts or claims that relate to that principle, and think about how those facts and claims relate to the general principle.

A picture of a large earthworm out for a squiggle in the rain in Liechtenstein. My foot (the general principle) provides some scale, so we know how about how big the worm is (the specific fact)—unless I have especially tiny or especially huge feet, which I don't. Or, the worm provides a scale so that we have an idea of how big my foot is, but at least among the worms I've encountered, this is an especially huge worm. What counts as a general principle or as a specific claim can vary, depending on use. In this case, I started out with more information about my foot (size 9 shoes), so I made the shoe the general principle. But the worm probably has more information about his size as a worm, so if the worm were writing this, he would probably make the size of my shoe the specific claim.

This point about comparison is important. Most information is only relevant or noticeable or useful or significant because it is compared with something else. I have five apples in the refrigerator. Good for me, but so what? It doesn't matter, and it's not interesting, until I point out that I used to have eleven apples. Something happened to the other six. What? Now we have some reason to be interested. Did I carve them and dry them so they look like shrunken heads? Did I make a small batch of applesauce? Did I pelt someone with them? Whatever happened, we know to look for something that happened because of a change, revealed by comparison across time. Lots of changes are possible. Lots of types of comparisons are possible.

A picture of a moth on an altitude post on Yangmingshan, Taiwan

Beginnings and Endings and Middles

Each set of information that is designed (which should not be conflated with intended) to reach some kind of conclusion has to start somewhere. Assumptions, also known as general principles, in logic, the information that we start with because it's where we want to start, are called axioms. This is also an important point. Axioms are chosen, and people can discuss why and how they've chosen their axioms, but the axioms are still chosen, and the reasons given for such choices might sound really great, but mostly it comes down to personal preference of some kind, and the kind is usually how the axioms let their reasoning patterns turn out (probably a kind of belief bias, in which people evaluate an idea based on how believable it is). I want to go to Kazakhstan, so I'm taking a flight from La Guardia, instead of walking from Bennington. I could start from Bennington on foot, but I wouldn't get to Kazakhstan on foot, so I'm starting by plane from La Guardia. When we get to problems in reasoning, this will be known as circular reasoning, and it's a problem when the circle is especially small. However, reasoning is inherently circular because it starts from axioms that are chosen because of where they can take us, so where we go depends on where we started. How small is too small to be responsible remains a matter of inquiry.

A picture of a snail in Liechtenstein

I should back up the proverbial truck a little bit and explain that axioms are usually so basic that people don't talk about them. I skipped over leaving the apartment to go to the airport; I skipped how I ended up in this town and in this apartment; I skipped everything that happened to make me exist in the first place; etc. There are layers of causes. My real starting point is so basic that I didn't put it into the story, because that would make the story too long. I chose a starting point that seemed relevant in some way to the place I wanted to go. The trip is the point, so I started the story where the trip started. Pointing out, discussing, and trying out different axioms (different starting points) can be enormously productive.

A picture of a red and black insect on some rocks in Arizona

Now we'll skip right to the end. What happens at the end of an organized set of thinking is called a conclusion, and it's the destination we were trying to reach, or a destination that we happened to reach because we really did follow a certain pattern of reasoning from axioms to conclusion without having a specific destination in mind. Kazakhstan is a conclusion in the example I started with. The conclusion is the outcome of comparing general principles and specific facts or claims.

A picture of a starfish that I played with near the coast of Picton, New Zealand. I'm sure that the starfish would have interpreted what I was doing as harassment, not play. It's important to consider perspectives. Is Kazakhstan a successful conclusion? Or Yellowknife? Depends on who we're asking. And, yes, I'm a person who harasses starfish—there, I admitted it.

More specifically, I want to learn weaving in Kazakhstan. Can I get there from La Guardia? Maybe, but now that my conclusion is more specific, I'm going to have to do more specific work on how to get to that conclusion, like finding a way to spend many months in Kazakhstan, maybe learning to speak and understand some Kazakh, finding a fabric artist who's willing to put up with me (I tend to ask a LOT of questions—some people are amused by my inquisitivity, and some people are offended by it, and I'd rather work with someone of the former disposition).

A picture of albatrosses and other pelagic birds off the coast of Kaikoura, New Zealand

Or I might have started walking from Bennington, and I most likely would not reach Kazakhstan (unexpected things do happen sometimes), but I might reach any number of other places. I have a friend who says she has to be careful going on walks with me because she's never sure where we might end up. For that walk, I'd like to say Tierra del Fuego, but maybe Yellowknife would also work, depending on how I walk and where and for how long. So what happens between axioms and conclusions is important: the specific facts or claims, and the methods of comparison, can change the outcome (conclusion).

A picture of another snail. Slugs are the most disgusting creatures on the planet, in my opinion, but slap a shell on one or let it live in salt water, and gastropods become far less disturbing and even interesting. At one point in my life, I wanted to become a marine biologist and work on the neurology of sea cucumbers. Wow—I didn't end up in that place, at least not yet.

The next step beyond axioms, and sometimes several steps away from the axioms, is to state the specific claims or facts. Those statements are called premises, usually spelled premisses in logic, just to be clear that we're doing logic rather than writing normal English or any other language. It's usually a good idea to state one's facts or claims, but not everyone does so. I've spent a lot of time in my life being told people's conclusions as if they are the Truth, with no statements of facts or claims in support of those conclusions, and no acknowledgement of the general principles or axioms. Sometimes, I can figure out what the preferred general principles are, and sometimes I run across facts that might be relevant to conclusions, but at that point, I'm doing most of the work toward reaching someone else's conclusion than that person is, and I'd rather do my own thinking, not theirs. At which point I become resentful of them for expecting me to do that kind of work for them, even though they don't usually recognize that that kind of work needs to be done before spewing conclusions all over the place. Then I begin to think of what they're doing as verbal vomiting, not thinking, and I move on to do my own thinking. I don't need to clean up their messes.

A picture of a duck in Luzern, Switzerland—I prefer the German orthography; Lucerne would also have worked, but I made a choice—I prefer German orthography—and, here's something to notice, different decisions at the beginning might get us to the same place. But if I had just written 'Luzern', you might have been able to figure out, without being told, that I prefer the German orthography. Or you might have assumed that I was wrong, because maybe you didn't know that there were two correct spellings. Or maybe you just don't care. Multiple options. And stating that I prefer the German spelling made all of that clear without expecting much (maybe too much) from readers.

Language and Symbols

Using language and thoughts to learn about or work on language and thinking can be tricky. It's important to be clear on whether we're thinking and speaking/writing, or whether we're thinking about thinking or speaking/writing about speaking/writing.

There are a number of strategies for helping to make the distinction. There's a prefix: metathinking (thinking about thinking), metalanguage (language about language). There is spelling, as with 'premisses' vs 'premises'. There is punctuation, such as the single quotes in the previous sentence that show that I was referring to those words rather than using those words. Sometimes, people use gestures or a tone of voice to indicate that they are referring to words or phrases rather than using them. Sometimes, people use font changes, such as italic or boldface type, to make this distinction. In many fields of inquiry, various symbols can be used to stand in for various aspects of language or thinking.

Sometimes, of course, the distinction is not made, or is not consistently made, or is lost along the way. Essential thinking requires making and maintaining the distinction and understanding the distinction.

A picture of prairie dog pups near the South Rim of the Grand Canyon

When writing premises, they look like declarative sentences. When doing symbolic logic, they look like capital letters: P is a popular one.

Here's a declarative sentence (within a declarative sentence): I'm watching The Simpsons. Let's call 'I'm watching the Simpsons' P. It's like naming something or someone. Here's another sentence: It's almost my bedtime. Let's call 'It's almost my bedtime' Q. Now we can make various relationships between the sentences, or the symbols. So there are two main elements: the statements, and the relationships between the statements. The relationships are what we can do with the statements. So there are things, and actions we can take with those things, or comparisons we can make between those things.

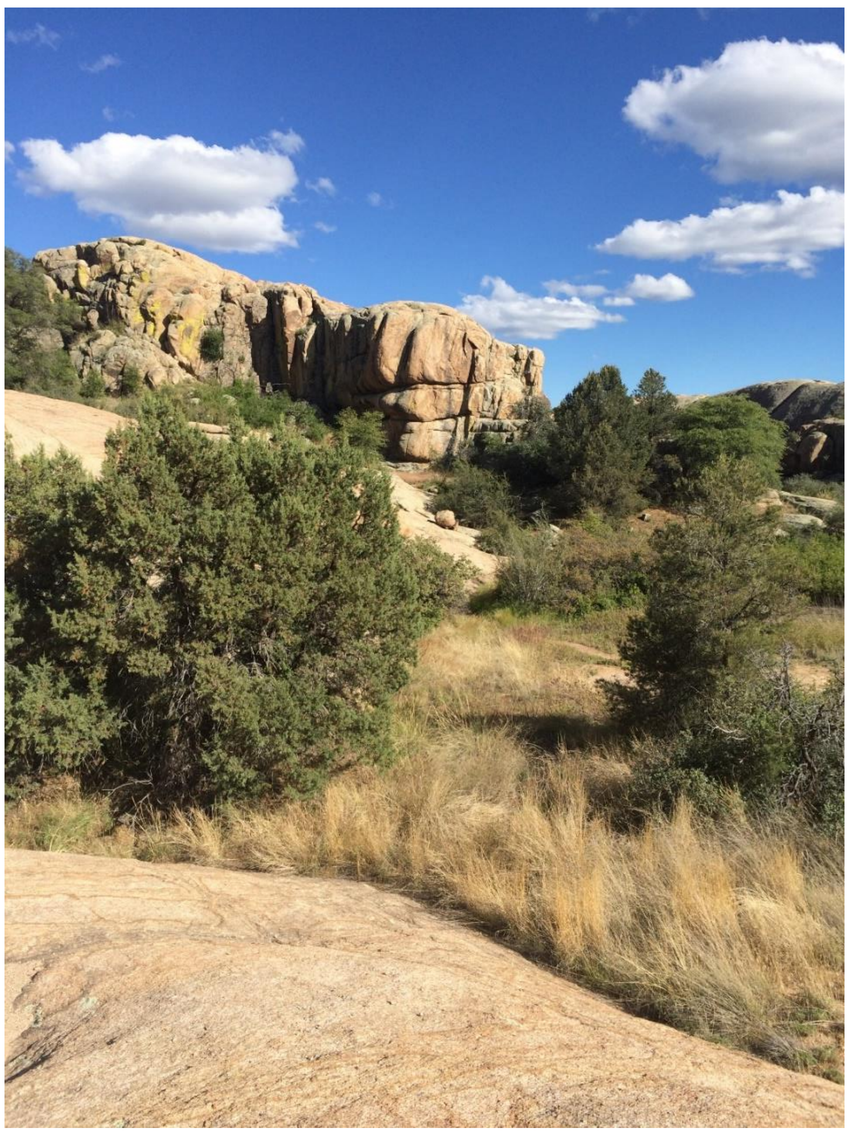
A picture of a crab and the exoskeleton of a small lobster or large shrimp off the coast of Halifax, Nova Scotia.

Here is an important distinction to remember: things are not relationships, and relationships are not things. However, things can be relationships, and relationships can be things, depending on context and purposes. If we turn all of the relationships into things, then we have to keep making other relationships. If we turn all of the things into relationships, then we have to find more things. And going hog wild in one direction or another has been a fun activity for some philosophers. However, a more reasonable and effective approach is to recognize that in some situations, for some purposes, it's pretty clear which is which for what we're trying to accomplish, and in those situations, it's important to be clear about the distinctions, and why we're making those distinctions. Legos are things. Building with Legos is something we can do with Legos, and building is a thing. Building and breaking are things we can do, so doing becomes a relationship, as does the connection between the building and the breaking.

A picture of a snake, probably in Arizona, because that's where I took most of my snake pictures.

There are even relationships that can be applied to single statements, such as how many or how much (quantities), or whether something is what it is or not what it is (negation), or whether the relationship is current, past, future, or whether the relationship just started or is about to start or is ongoing or is about to end, etc: I'm watching the Simpsons, or I'm not watching the Simpsons; I watched the Simpsons; I was watching the Simpsons. All of this writing session is taking place past my bedtime, or some of this writing session is taking place past my bedtime.

A picture of the granite dells in Prescott, Arizona. There is also an image of a mountain lion in the picture, but probably there is too little mountain lion and too much granite so that maybe it would be easier to believe that there is no mountain lion. But the little blip just to the lower right of the boulder on the bare ground was the mountain lion. The experience of seeing the mountain lion was better than the picture of the mountain lion. But it's not a bad picture of the granite dells.



And we can examine and symbolize the information within statements, as well. Maybe 'I' will be the statement, and 'The Simpsons' are P and Q, respectively, and then we can work on the what the relationship of 'watching' really means. The symbols can be applied to any scale of information. Maybe P could stand in for any first-person pronoun in English, or any first-person pronoun in any language. Maybe P could represent a paragraph, or a book, or a TV show. The point is that symbols can represent anything, which is what makes symbols useful, and dangerous. It's not difficult to see that 'P' is not the same as 'I am watching the Simpsons,' but when various aspects of language are used as symbols, people often forget that the symbols are not the thing. Not distinguishing clearly between literal and non-literal language creates lots of difficulties. Not distinguishing clearly between language and meta-language (using language to talk about language) creates lots of difficulties. Human brains are not computers, nor are computers brains, but comparing brains to computers and computers to brains has been a useful approach in some ways, but a lot of people, even people who study brains or computers, forget that these are different, and forget to investigate those differences.

A picture of a moth on a painted concrete block somewhere.

Here are some examples of relationships: It's past my bedtime, and I'm (still) watching the Simpsons (P ^ Q). It's past my bedtime, or I'm watching the Simpsons (P v Q). It's not past my bedtime (~P). It's not past my bedtime, and I'm watching the Simpsons (~P ^ Q). It's not past my bedtime, and I'm not watching the Simpsons (~P ^ ~Q). It's not past my bedtime, or I'm not watching the Simpsons (~P v ~Q). It's not past my bedtime, so I'm watching the Simpsons (~P → Q). It's past my bedtime, so I'm not watching the Simpsons (P → ~Q). If it's my bedtime, I am absolutely not watching the Simpsons (Q iff P): the direction of this relationship gets a little squirrely, but we'll leave those complications for another year.

A picture of flying fish, or swimming clouds, or fish swimming in water that the clouds are reflecting from.

I recommend building a chart of the relationships and symbols. You would need two levels of the chart, like this:

	combination	choice	negation	causation (tricky here)	absolute causation (very tricky)
Symbol					

I didn't label the category for the top line. I'm sure you can figure out the assumption I was making to make a category of the items on the top line.

A picture of a walking stick in Flagstaff, Arizona

There are other relationships, depending on the kinds of information we're using. If we are considering history or time in general, it might be useful to have relationships about what happened before or after something else happened or during some time period: comparisons across time or within durations. If we are considering quantities of something, it might be useful to have relationships about or comparisons between more or less or equal or equal across some domain of comparison (proportional) or another or missing. If we are comparing sizes or shapes, it might be useful to have relationships about same or similar or effectively the same for what we're trying to do (equivalence) or different or opposite or more different in some way or less different in some way, etc. If we are considering information, we might want relationships for general and specific and exact and precise. If we are considering color, we might want relationships for hue and intensity and saturation. If we are considering music or sound, we might want relationships about louder or quieter and higher and lower and timbre. If we are considering exercise, we might want relationships about strenuosity or form or range of motion or endurance. There are non-word symbols for all of these relationships, in addition to words, and as we learn more in various domains of inquiry, we learn more of the symbols that are common because they help us to get the task done more efficiently (unless we forget to distinguish clearly between symbols and the things symbolized). How many relationships can you think of?

A picture of a peacock in a public park in Poland

A picture of a duck on a post, which is part of a fence that is not much higher than the water, in a stagnant body of water, next to a patch of grass, near a tree, that used to have leaves, some of which have fallen on the water, in front of the duck, who is not currently eating, who is not a crow, who is not a squid, etc. Lots of relationships and ways to compare specific claims or facts. How many relationships can you identify from that monstrous sentence? Don't forget the punctuation. (For bonus, made-up points (to be carefully distinguished from make-up points): the 'the' about 'the duck' is a relationship—what kind?)

Another important point is to notice that logic is involved in every domain of inquiry. Every domain has general principles, specific facts or claims that they consider as part of their domain, and relationships that are tools to help make the comparisons between the principles and the claims. The humanities (art, literature, history, music, etc.) are taking a hit in this century because people prefer numerical comparisons to other kinds of comparisons. But that's a choice, based on preference, and the choice is not often well defined or well defended, and the opposition to using other kinds of relationships does not often say anything relevant, or even particularly accurate, about the kinds of principles and claims and comparisons used in other fields. And the whole program gets even more absurd when people try to count qualities, rather than quantities, in order to apply numerical comparisons to non-numerical information. How many compassions are there? Are there fewer compassions than stingeynesses? The language makes the absurdities obvious, but people often lose track of the absurdities because they forget what their symbols symbolize, and don't want to distinguish between relevant relationships and irrelevant relationships.

A picture of an iridescent beetle in some grass. Where? I don't remember.

Section II: Deduction—Hafta

A picture of birds on a beach, on a day when all visible and standing birds were each using only one foot to stand

There are three so-called "laws of thought." They're not really laws, and they're not always only about thinking, but they're good principles to remember so that one can follow them or not, as the essential thinking task requires.

A picture of an Egyptian goose. Not sure where I found this one because, at the time of this writing, I have not been to Egypt, but they are used for farming now, so this one could have been in many places, but this particular goose was in only one place.

1st law (principle): If a statement is true, then it is true. Seems obvious enough, and keep in mind that this is still a comparison, between a thing and itself. I wouldn't get too attached to any idea of 'truth', however, because there are many ideas of truth, and that's part of what needs to be investigated in essential thinking. Identity is an important idea, though. The goose is a goose. Stonehenge is Stonehenge.

A picture of a crow using a major megalithic site as a place to sit, and probably to do other things that birds do.

As George Orwell has pointed out, "To see what is in front of one's nose needs a constant struggle" (from an essay called, "In Front of Your Nose"). Identity is trickier than it seems at first glance. Yes, the hand in front of my face is the hand in front of my face, but the words we use to label things can also obscure or illuminate whatever is in front of my face. Or my nose. For example, let's consider the seemingly obvious hand in front of my face. What counts as my hand? Are the fingers part of the hand or extensions from the hand or their own body parts? Is the wrist part of the hand or its own body part? Where does the hand stop/start in relation to the wrist or arm? Various languages have answered these questions in various ways. In some languages, fingers have their own individual names, and people treat them like their own body parts, not as parts of the hand. English has a lot of terms for joints, and some languages don't have so many, so the wrist is part of the hand, or the whole arm-hand has a single term. The thing is the thing, but we have to be really careful about what we mean by the thing, and what other people mean by the thing.

A picture of a moth on flowers somewhere on the North American prairie

Given that words can shift meanings, depending on who is using them and in what contexts (where is the 'front' of a piece of bread or a round cup, for example?), it's important to be clear about what we mean by the key words that we use, and sometimes down to the not-so-key words. A former president, while trying to distract people, noted that 'is' can have different meanings. He was right, but people were not adequately distracted by a very good point. Distraction or not, it's important to define words and terms ('term' is a more general label for a verbal label of any kind; 'terms' can be more than one word, such as 'Murphy bed').

A picture of a black slug on a road in Wales

Interlude: Definitions

So let's take a little detour from the three laws of robotics, I mean, the three laws of thought (if you don't already enjoy the works of Isaac Asimov, why not start?) and review some ways to define terms. I'll put these in alphabetical order, not because that's the order they need to be in but because it's a convenient order at the moment.

There are two major kinds of definitions: intensional and extensional. Extensional definitions list everything that fits the definition (animals we're thinking about at the moment: starfish, mongoose, and gray whale). Intensional definitions provide general principles or concepts that apply to all of the uses or members of a category (prime natural numbers).

A picture of a starfish in shallow water in the Laguna de San Ignacio

Demonstrative definitions indicate directly in some way what a term means. An obvious example of a demonstrative definition is pointing to the cat I'm talking about, rather than explaining which cat I'm talking about. When demonstrative definitions are possible, they can save a lot of time. However, sometimes people try to indicate more or less with a demonstration than they can, which requires the interlocutor to figure out what the person means, at which point, the demonstration has failed.

A picture of a gray whale touching my hand in the Laguna de San Ignacio

Functional definitions provide the cause or purpose of a thing, activity, or process. The road exists so that cars can travel along it. It is a road because cars travel along it. The road happened to provide a warm place for this rattlesnake to bask. We herded the rattlesnake off the road so that another car would not hit the snake. A possible problem with functional definitions is that they treat a process as a crucial part of whatever is being defined. Yes, I can pound nails with a hammer, but if I decide to pound nails with a rock, does that make the rock a hammer? Maybe, but we'd need to change what we mean by 'hammer'.

A picture of a rattlesnake on a road in Baja California Sur

Lexical definitions are statements or descriptions of the meanings of terms as the terms are generally used. General use can arise from a number of directions, and dictionaries vary in the approach: etymological definitions show how terms came to mean what they mean over time; synonymous definitions provide terms that are roughly equivalent to the term being defined. It's important to remember the general use. These kinds of definitions arise out of the uses of languages, and languages are what they are because of the ways that people use those languages, and because of the ways in which languages affect what people conveniently think about. What words mean in a language gets very complicated very quickly, and languages change, which introduces another complication. Lexical definitions are useful in many cases, but their origins and possibilities have to be kept in mind.

A picture of a spotted dove in Hawai'i

Precising definitions narrow down lexical definitions for a specific purpose. If we look at definitions in dictionaries, many of them have multiple senses or definitions, and maybe only one of them is what we need. I like ‘get’ as an instance: a quick search in a non-technical dictionary provides 8 senses of that word, including some that are no longer in common use. ‘Get’ can mean ‘understand,’ as in ‘I get it’. It can mean ‘acquire’, as in ‘I have to get groceries’. Both are perfectly good uses of the term ‘get’, but we probably don’t intend both of those meanings every time we use the word. If I were to precise the definition of ‘get’, I’d just pick one sense or meaning. Today, I pick the archaic noun, referring to an animal’s offspring: The mare’s white socks will be passed to her get.

A picture of smaller gastropods on a larger gastropod’s shell

Stipulative definitions define a term the first time it occurs. New terms often arise when people are doing research because people need labels for what they are describing or analyzing that has not been described or analyzed previously. I made a term: narragraph. It refers to words or other markers that indicate in speech the spoken equivalent (broadly) of paragraph markers in writing.

A picture of a gastropod making what looks like punctuation in the sand in the Laguna de San Ignacio

Theoretical definitions arise from a set of ideas within which a term occurs or is used. 'Object' means something different when used within linguistics or language analyses (a term for certain syntactic or semantic relationships) from what it means when used within archaeology (a thing that might have been dug up). If we want to do linguistics, we have to be clear about what we mean by 'object' in certain contexts. If we want to do archaeology, we have to be clear about what we mean by 'object' in certain other contexts. One difficulty with theoretical definitions is that terms come with baggage: using a certain term in certain fields can import meanings that a person might not want to include, or there might be multiple definitions within any given field, and it's not always clear which theory is behind the use of the term. 'Socialism' is a good example: most people know something about what they want to say when they use the term 'socialism', but very few can actually define it or distinguish it from other possible definitions of the term. Sometimes, disagreements occur because people are using the same term to refer to different ideas. 'Socialism' is still a good example.

A picture of a raven on the car in Petrified Forest National Park

What's left: encyclopedic (explanatory) definitions provide more information to explain or describe the term being defined. Persuasive definitions try to kill two birds with one stone, so to write, by defining and convincing simultaneously. Entertaining definitions attempt to use humor or drama to make the definition more memorable or noticeable. Basically, there are genres of definitions, or definitions aiming for specific outcomes.

A picture of a collared lizard in Petrified Forest National Park

Back to the laws

2nd law (principle): No statement can be both true and false. I'm working before my bedtime today. Either I am, or I'm not. This principle is about preventing contradictions, and it again makes a comparison, between what is factual or accurate and what is not. In fact, I have several hours to go before my bedtime, so the statement about working before my bedtime is accurate.

A picture of some kind of echinoderm on a beach in Hawai'i

3rd Law (principle): each statement is either true or false. This principle makes a related but different comparison between accurate and inaccurate. We can't have both (2nd), and we must have one (3rd). As with the second, the principle is useful in many situations but might not be useful in all situations, particularly as we learn more to do more. Some logics have at least a third option: maybe there is an indeterminate option, or a neither option, or a little bit of both option, depending on the complexity of the material to be evaluated. What do we do with the three principles? We remember them because they're useful for the sort of thinking we're working on at the moment because they are the assumptions that make this kind of logic make sense. They also underlie other logics, as well, because other logics change one or more of these in various ways.

A picture of more echinoderms, underwater on rocks along the coast of Hawai'i

Within deduction, there are several characteristics to understand, notice, and compare. The first of these is quality. Statements are positive or negative. In more advanced versions of logic, this is more complex. This is a sentence. This is not a sentence. Guess which one is positive and which one is negative. And if we want to have even more fun, we can think about what's going on with the second sentence. Self-reference is a tricky one.

A picture of a mongoose in Hawai'i

But we're not having more advanced courses, so we have to deal with language, which is actually much more complex. The police officer shot a generally innocent person in the back. Logically, that's a positive sentence, but for linguistic pragmatics, it's not. Few people would consider shooting generally innocent people from any angle a positive action. So there are various kinds of positivity. And some words contain negativity, so that we don't have to add a no or a not or an un-. 'The police officer refrained from shooting a generally innocent person' is for meaning purposes equivalent to 'The police officer did not shoot a generally innocent person', but the first one is positive in logic and the second on is negative. So once we start thinking essentially about these ideas, we start to notice more than the relatively simple introductory material, and when translating sentences into symbols, which we will not do at this point, these kinds of distinctions matter.

A picture of a reef shark off the coast 'Oahu

The next characteristic to consider is quantity. We don't have a lot of choices here, either, in formal logic, but fortunately, we have lots of choices because we speak languages. The choices are some, all, and none. I ate all of the cookies before I bought some of the fruit at the store. I bought none of the crackers. More formally, these words usually come first: All of the cookies were ones that I ate; None of the crackers were bought by me; Some of the fruit at the store was what I bought. This becomes clunky in English (and other languages), but it's good to be aware of the trickiness now.

A picture of a tiny mantis in Virginia

Languages have more options, most of which end up categorized as ‘some’ if we’re doing formal logic but that don’t quite overlap with ‘some’ in actual use, which means that formal logic is a loss of information because it gloms a lot of distinct information into the same category. In English, we have most and more than half, and lest we imagine that those are equivalent, let me direct our attention to several fun articles (Berkeley Lingusitics Society, Ariel, 2003, pp. 17-30; same material in Language, 2004, 80.4.658-706; and more information from Solt in Language, 2016, 92.1.65-100). Here’s more evidence that linguists getting all excited about material that seems obvious to everyone else. And let’s not ask too many questions about why I know about all of these articles. We also have ‘not that much’, ‘a few’, ‘several’, ‘both’, ‘a lot’, ‘too much’, etc. I’m sure we could think of more if we wanted to drag this out for what remains of the day.

A picture of many tropical fish off the coast of Hawai’i

Two other characteristics are distribution and existence. We'll not worry too much about these at the moment, but we might enjoy thinking about them between now and whenever we find a more advanced introduction to logic. Distribution is about whether a term applies to all or nothing in a category. All of the dogs peed on the carpet: peeing on the carpet is distributed over dogs. None of the dogs peed on the carpet: not peeing on the carpet is distributed over dogs. Notice that negation doesn't change distribution. Existential import makes claims about the existence of something. In English, 'there is/are' provide existential import. 'There is a giraffe over there' makes a claim about the existence of a giraffe at some location. 'There are bison depicted in the photograph below' makes a claim about existing elements of a picture. All kinds of things can be claimed to exist, including ideas and imaginary entities, so we shouldn't be too attached to physical existence as the only kind of existence. Existential import is about the claim, not about the type of existence that is claimed. That's a different discussion.

A picture of bison and some Ponderosa pines near the North Rim of the Grand Canyon

With these characteristics (negation, quantity, etc.), syntactic direction matters. 'All lizards are reptiles' is not equivalent to 'all reptiles are lizards'. There are also turtles, for example, and we wouldn't want to leave them out. With negatives, scope matters, too. 'The lizard below is not red' is quite different from 'the lizard that is not below is red'. Formal logic can make some of these orderings and scopes more clear, but it can also obscure the effects of orders and scopes in the languages that we use every day. And when moving between language and formal symbolisms, it is important to understand how languages structure information, and how logic structures information. These structurings are also not the same, and it's easy to lose track of those differences when moving between and among different ways of working with ideas.

A picture of a lizard who decided to bask along a trail where I was taking a birthday hike.

Because deduction is about the hafta's of thinking, people have documented various ways in which, if we accept the premises, the conclusion hasta be true or accurate or desirable or whatever we're aiming for. There are many fewer ways to hafta reach a conclusion than there are ways to go incredibly awry, and because this is an introduction, and because we already reviewed a lot of problems that can arise, we'll do the hafta structures here. Out of 256 possible combinations of the four ways to be a statement in traditional logic, there are fifteen structures that are 'unconditionally valid'. These work (they're valid). These hafta work. There are nine structures that are 'conditionally valid'. They might work, if certain conditions are met. And all the rest make a real mess, if we let them get loose in our thinking.

A picture of a relatively large larva on a rotting log in Flagstaff, Arizona. It was about four inches long. This one and the other ones

I found in the rotting log were among the largest larvae I have ever seen. Large woodpeckers seem to enjoy eating them.

Here are four ways to be a statement:

A: All X is/are Y

E: No X is/are Y

I: Some X is Y

O: Some X is not Y

There are other ways to be statements, including the one that I just used: ‘there is/are, is not/are not’, and ‘for each/every/all…’, and ‘if…then…’, and ‘it’s necessary that…’ and ‘it’s possible that’, but we’ll skip most of that now and work with conditionals (if/then). The others require their own extensions of logic, so we’ll skip those for now and assume that, at some point in our lives, we’ll study logic in more detail and depth and variety. The capital letters don’t matter as such, but they are traditional ways to categorize and label types of statements, so there that is.

A picture of a barbary macaque on the Rock of Gibraltar

With the unconditionally valid structures, each rule has to be followed precisely. We don't just get to throw whatever we want to together and call it unconditionally valid. There are four possible arrangements of information within the statements, as we build toward the three statements, a syllogism, the last of which is unconditionally valid.

1: MP, SM, so SP

2: PM, SM, so SP

3: MP, MS, so SP

4: PM, MS, so SP

The letters as such don't matter, but it's important that if 'P' shows up in more than one place, it's exactly the same 'P' each time that it shows up. If the 'P' gets a little squirrely, or shifts in any way, that makes a problem called equivocation, and the syllogism fails.

A picture of storks nesting in Faro, Portugal

Now we can play with the letters and numbers:

The Unconditionally Valid:

1: AAA, EAE, AII, EIO

2: AEE, EAE, EIO, AOO

3. AII, IAI, OAO, EIO

4. AEE, IAI, EIO

A picture of an insect on the sand near Faro, Portugal

I'm going to violate my usual rule of not introducing technical terms unnecessarily. This term is entirely unnecessary at this point: sorites. It's what happens when two or more syllogisms are combined sequentially, usually while leaving out the third statement of the non-ending syllogisms. We will also have noticed that EIO is unconditionally valid in each of the four patterns. So, if we combine two of these, leave off the first 'O', we end up with EIEIO, which is a valid sorites. Old McDonald Had a Farm, or maybe he had a logic clinic.

A picture of a crab walking along a clay beach near Faro, Portugal

Back to our regularly scheduled program. I'll do a few of these, and then for the fun of it, you can do the others as practice.

For 1:

EIO: No pens (M) are rulers (P); Some feathers (S) are pens (M); so, Some feathers (S) are not rulers (P). Seems obvious. In my experience, very few feathers are rulers. Have you ever seen a feather-ruler?

EAE: No glass jar (M) is a box (P); All of my almond-butter containers (S) are glass jars (M); so, No glass jars (M) are boxes (P). Again, this seems obvious. I have seen glass boxes, but they are not jars. Some of this falls out of the meanings of terms, or could, if we did logic as semantic analysis, and vice versa.

So the other two options for 1. are AAA and AII. Remember to put the Ms, Ps, and Ss where they ought to go, and to use the statement structures as given by the letters.

A picture of sheep on the slopes of Almería in the Sierra Nevada Mountains of Spain

For 2:

AEE: All linguists (P) are weirdos (M); no popular people (S) are weirdos (P); so, no popular people (S) are linguists (M).

AOO: All live houseplants (P) need to be watered (M); some plastic plants (S) do not need to be watered (M); so, some plastic plants (S) are not live houseplants (P).

Two left in 2: EAE and EIO.

A picture of a beetle on the on the slopes of Almería in the Sierra Nevada Mountains of Spain. I did not make it to the top of the mountain. I walked until the snow became treacherous, and then I walked back. The week before I was there, a hiker had been lost in a crevasse in the snow, and had not been found by the time I went out for a walk.

For 3:

IAI: Some universities (M) offer logic classes (P); all universities (M) offer classes (S); so, some offered classes (S) are logic classes (P).

OAO: Some books (M) are not in English (P); all books (M) are intended to be read (S); so, some books that are intended to be read (S) are not in English (P).

There are two left in 3: AII and EIO. Bonus points if you can make an EIEIO sorites, but of course, the points are imaginary, much like most methods of measuring status.

A picture of a bee in the garden of the Alhambra in Spain. ‘The al’ is redundant, but that’s the way it works in English, and equivalently in Spanish: ‘El al’

For 4:

IAI: Some insects (P) are beetles (M); all beetles (M) are animals who have six legs (unless injured) (S); so, some animals who have six legs (unless injured) (S) are insects (P).

EIO: No CEO (P) is underpaid (M); some underpaid people (M) are janitorial staff (S); no janitorial staff (J [P]) are promoted to CEO (K [M]); some people who are promoted to CEO (K [M}) are greedy people (L); so, some greedy people (L) are not janitorial staff (J [M]). EIEIO: can you figure out what the missing O would be? It's between the first EI and the second EI, and it will help make the transition between those two EIs clearer if you can figure out what's missing.

There's only one left in this pattern for you to do: AEE.

A picture of a lizard on a sidewalk in Malta

Notice that these unconditionally valid syllogisms seem obvious. That's one basis on which deductive logic has been criticized: the stuff that hasta work is obvious, so what does it really get us? It has been my observation that actually putting material into structures that work does not always lead to obvious results, however. I don't necessarily think about the differences between jars and boxes. Of course, they are not the same, but did I think about why not? I did not, until I did the syllogism that I included in the section on 1 previously. As Arthur Conan Doyle noted elsewhere, "there is nothing more deceptive than an obvious fact". Yes, jars are not boxes. I now have questions about that that I did not have previously, and I'm generating more and better questions, which is a huge component of essential thinking.

A picture of a moth on a plant along the Finger Lakes Trail

On another hand, and I might become a jellyfish if I'm not careful, what seems obvious can be very informative. Automated theorem proving (proving mathematical theorems via computer programs) got off to a rip-roaring start using only modus ponens (if A, then B; A; so, B) to the extent that there's now an area of investigation in proof theory about whether anything can be proven without modus ponens. At this point, the question does not have a definite answer. Maybe we should turn the modus ponens computers loose on the question.

A picture of a jellyfish in a tidal pool near Malta; if a jellyfish used the expression, 'on the other hand', which part would the jellyfish be referring to, and why?

Another aspect of these valid forms to notice is that they follow certain patterns.

1. If there's a negative premise (no, is/are not), then the conclusion has to be negative.
2. If there is a particular premise (some, some not), then the conclusion has to be particular.
3. If both premises are positive (all is/are, some is/are), then the conclusion has to be positive.

These patterns are kind of like the law of entropy for information. We cannot get different kinds of information from another kind of information, and we cannot get more information from less information.

A picture of a millipede on a rock along the Finger Lakes Trail

So now we need to do what the computers can do: the valid propositional forms. I'm not going to make a big to-do about syllogisms or syllogistic forms or syllogistic statements vs conditionals. Most of the time, it's fairly straightforward to move between the two kinds of structures (All cats are mammals → if it's a cat, then it's a mammal; Some mammals are not cats → if it's a mammal, then it might not be a cat, etc.: you can figure out a couple of the etcs.), and when it isn't, those are cases well beyond what we're doing here.

A picture of a fly on a dashboard

Modus Ponens (affirmational mood): If A, then B; A; so, B. If the fly is on the flower, then it's not on a tree. The fly is on the flower, so the fly is not on the tree. This is easy. Any computer can do it. What's tricky for people is that we often want to reverse the order: If A, then B; B, so A: oops—that's wrong. That's the formal fallacy known as affirming the consequent. Don't do that. I had an example of this in a previous section, but it's such a common problem that I'm including another example here. If it's hot, I will wear my sun hat. I'm wearing my sun hat, so what's the weather like? If you think the weather is hot: WRONG! The weather might be hot, but it might not be. We have no information about the weather based on the fact that I'm wearing a sun hat, because I didn't say anything about what would happen if the weather was not hot. We mustn't conclude anything from a lack of information, and we have to keep very close track of what information we have and what information we do not have. Just so we know, I often wear sun hats on sunny days, whether the weather is hot or cold or any other option.

A picture of a wild carrot bloom with a fly on it (I chose the plant as the focus today, so as to avoid plant-blindness, which is a cognitive phenomenon, fairly common but not universal, in which animate things are usually the attentional and grammatical focus, and the plants and other inanimate items are backgrounds).

Modus Tollens (denial mood): If A, then B; not B, so not A. If it's hot outside, I'll wear my sun hat. I'm not wearing my sun hat, so it's not hot outside. (Yes, there are ways to get around this, too: maybe I'm lying, or maybe I forgot my hat, for example, but if I told the truth and I'm being responsible, both of which we have to assume to make deduction work, then we do have some information about the weather based on whether I'm wearing my sun hat.) People like to reverse this one, too, but don't do it: that would be the fallacy of denying the antecedent. If A, then B; not A, so not B: oops, that's wrong. If it's hot outside, I'll wear my sun hat. It's not hot outside, so I'm not wearing my sun hat. WRONG! Again, I didn't specify what would or wouldn't happen if it were not hot outside, so we can't just fill in that information.

A picture of a seagull with a fish near one of the Great Lakes

Hypothetical Syllogism: If A, then B; if B, then C; so if A, then C. Notice that this is kind of an extended modus ponens. If it's hot outside, I'll wear my sun hat; if I wear my sun hat, my hair will be mashed down; so if it's hot outside, my hair will be mashed down. There's no direct relationship between hot weather and mashed-down hair, which is why we need the three steps and why we need to remember multiple layers of causality. Modus tollens would work here, too, but we'd have to start at the end. My hair is not mashed down, so I'm not wearing my sun hat; I'm not wearing my sun hat, so it's not hot outside. We could deny the B (I'm not wearing my sun hat) and deny A, too (it's not hot outside), but we cannot deny C based only on a denial of B, because that would be denying the antecedent in the 'if B then C' relationship. There might be other ways my hair could become mashed down.

A picture of a crab on a beach

Disjunctive Syllogism (choices, 'or'); A or B; not A; so, B. Either this frog is in Alaska or this frog is in Maine; this frog is not in Alaska; so, this frog is in Maine. The either/or in this example is a false bifurcation: there are lots of places this frog could have been. But for the purposes of the example, it was necessary to pick two. Picking options is allowed, so long as we keep in mind that there are rarely cases in which only two options are an inherent part of what we're looking at. Zero and non-zero is one example, and if we really want a clear two-choice option, the positive and the negative are a good way to create them: books and non-books (that's a huge category); things that are alive and things that are not alive (notice that 'not alive' might not exclusively be 'dead'). We have to be careful with characteristics: things that are yellow/tall/warm, and things that are not yellow/warm/tall. Yellow/warm/tall are gradational categores, with some things being more or less yellow/warm/tall compared to other things, and compared to whatever standard is providing the best-case of being yellow/warm/tall. I'm tall compared to most frogs. I'm not tall compared to mature redwood trees.

A picture of frog on granite in Acadia National Park

Constructive Dilemma (building a choice): A or B; if A, then C; if B, then D; so, C or D. I'm going to call Patricia, or I'm going to call Barbara. If I call Patricia, I will see about arranging a visit with Patricia. If I call Barbara, I will find out when Barbara's moving. So, I will see about arranging a visit with Patricia or I will find out when Barbara's moving. This one is a combination of disjunctions and modus ponens. As usual, we can mess with it based on other valid options. I might deny finding out when Barbara is moving, which would force C, and would cancel B, for example. How else might we mess with this?

A picture of a moth on a gas pump

Destructive Dilemma (building a choice of negatives): If I call Patricia, I will see about arranging a visit with Patricia; if I call Barbara, I will find out when Barbara is moving. I will not see about arranging a visit with Patricia, or I will not find out when Barbara is moving. So, I will not call Patricia, or I will not call Barbara. This one works because… (if you said ‘modus tollens’, you get all of the imaginary bonus points).

A picture of an insect on a screen in Enfield, New York

Finally, there is DeMorgan's Law, which is not necessarily a valid propositional form but a way to shift propositions to a different form. It's kind of like translating. If I can speak both English and Brazilian Portuguese, there might be times when I'd like to say something in Brazilian Portuguese (esto cansado) and other times when I'd like to say basically the same thing in English (I'm tired). DeMorgan's makes that translation for certain logical forms. Not (A and B) → not A or not B; Not (A or B) → not A and not B. DeMorgan's distributes negation. It's not the case that I'm calling Patricia and that I'm calling Barbara, so I'm not calling Patricia, or I'm not calling Barbara. It's not the case that I'm calling Patricia or that I'm calling Barbara, I'm not calling Patricia, and I'm not calling Barbara. It is important to remember never, ever to think that not (A and B) is equivalent to not A and not B. The parentheses provide groupings, and the groupings matter. Within the grouping (within the parentheses), negation applies to both terms and changes the relationship between the two terms. These groupings are less clear in English, in part because we're not always careful in common use about how words affect relationships between words, but that's a different discussion. If the parentheses work for you, use the parentheses. If dependent clauses work for you, use dependent clauses. If something else works for you, use whatever works.

A picture of a grasshopper on grass

It is important to remember that although deductive reasoning's valid conclusions are necessary given the structures involved, those conclusions can be shifted based on starting points. In addition, many people think that because deductive reasoning's valid conclusions are necessary, it is better to start with the general and move to the particular, so they start with the idea they like and then find evidence to support that. That is not deductive reasoning. That kind of move is confirmation bias, and it tends to deemphasize information that possibly provides a different perspective or would lead to different conclusions.

A picture of shearwater chicks in and near an in-ground nest

Section III: Abduction—Coulda

A picture of a lizard in Palo Duro Canyon State Park

Abductive reasoning is not usually included in introductory logic, but because thinking creatures of various species do this kind of thinking frequently, I'm including a few notes on it here. Abductive logic is about making a good guess about what's happening based on a fact or set of facts. I arrived 24 hours late and am exhausted and spending the day in bed. We might reasonably surmise that I spent two days in American Airlines' purgatory. In fact, if you thought that my being so late and so exhausted meant that I probably spent two days in American Airlines' purgatory, you were correct.

A picture of a kingsnake in Prescott, Arizona

Abductive logic is not hafta logic because many pieces of information or sets of information can have multiple reasonable guesses about what's behind them. I'm nauseous, tired, and have a headache. Maybe I spent two days touring the airports of the US east coast courtesy of American Airlines, or maybe I have food poisoning, or maybe I'm pregnant, or maybe I ate something that I can't digest well.

A picture of a crayfish in a drainage ditch in Kaua'i

Basically, abductive logic is about making a good guess. We do our best with this kind of reasoning, but we have to remember that we're just guessing until we have more information. Sometimes, abductive reasoning can provide the background needed to search for more information. When we do that, we need to look for all kinds of additional information, not only information that confirms what we've already guessed. Check my schedule: did I spend two days dealing with American Airlines problems? Then that's the most likely explanation.

A picture of a large crab in 'Oahu: we fed hotdogs to the crabs. There were several crabs around, and after one piece of hotdog, all of the crabs ran away. What is our best guess about why the crabs, who had been enjoying hotdogs, would suddenly run away from hotdogs? We surmised that they were no longer hungry. Our best guess was wrong. The crabs ran away because an enormous crab, the size of a dinner plate, and at least ten times the size of the smaller crabs, had decided to come for a piece of hotdog. More information got us a better guess: the smaller crabs ran away from the bigger crab, not away from the food.

But if we want to be sure that airline incompetence is all my problems are, we would also need to test for the other options or ask more questions about what I've been up to lately, in order to acquire more information. I only have one head, so I only have one headache at a time, but there might be two or more sources of that headache, such as exhaustion and illness and pregnancy and food problems.

A picture of a wedge-tailed shearwater chick awaiting dinner in a nesting burrow off the coast of 'Oahu

Abductive reasoning is a way to move forward with incomplete information. It's the reasoning process that happens between the data points and hypotheses in inductive logic. As long as we remember that the information is incomplete, and look for ways to find more information and more relevant information, abductive reasoning is useful. If we forget that our best guess is just a guess and neglect to look for more information, we can miss important information, such as the existence and hunger of a much larger crab, or we might look for only information that confirms what we already think, thus making ourselves victims of confirmation bias.

A picture of a lizard on a tree in 'Oahu

Section IV: Induction—Sposta

A picture of thousands of tiny flies on rocks around the Great Salt Lake

Inductive reasoning is basically the scientific method, and there is a lot of material elsewhere on that, and on how it works and doesn't work and what people expect it to do vs what it actually does. So this section will be a quick introduction, with strong encouragement to look at more information. Philosophers of science have provided a lot of good material on inductive reasoning (Thomas Kuhn and Karl Popper are good places to start: Popper's uses of 'falsification'/'falsifiability' don't indicate quite what most people use those terms to indicate).

Inductive reasoning starts with particular instances (information, data, data points) and moves toward general principles (theories, laws, patterns). Conclusions in inductive reasoning are probable or likely, rather than necessary.

A picture of a western tiger swallowtail in Jordanelle State Park, Utah

Deductive reasoning moves from general to particular. Going the other way in deductive reasoning is a formal fallacy. Inductive reasoning moves from particular to general, and that direction needs a lot of support, because the conclusions are not haftas. There can be a variety of kinds of support: sequential, causal, linguistic, quantitative, aesthetic, personal, motivational, etc. But the case needs to be made, in whatever ways work in a given field of inquiry.

A picture of a bird in Utah

As soon as I use terms like ‘probably’ or ‘likely’, statistics comes into consideration. It remains important to remember that there are many kinds of observations to start with, and many kinds of information to use to support ideas, not just quantitative observations and information. Probability outside of quantitative information is defined and used in different ways, and we need to remember to look for what people are doing with terms and concepts rather than making assumptions that we aren’t clear about. It’s also important to remember that quantitative information can be manipulated and misunderstood and misused as much as any other kind of information. Mark Twain’s/Lord Beaconsfield’s comparative scale for manipulated information is a useful mnemonic device for remembering to use essential thinking on quantitative information as well as on other kinds of information: “There are three kinds of lies: lies, damned lies, and statistics”. There’s a terrific book about essential thinking about statistics: *How to Lie with Statistics*, by Darrell Huff.

A picture of a dinosaur track in Utah

For inductive reasoning, we need to collect lots of observations, lots and lots, until we start to notice patterns. For example, most red newts have spots on each side of their spines, behind their heads and before their tails. It would be irresponsible to pick up one newt and conclude that most or all newts have such spots. One thing is not a pattern. One thing can be a source for good description, however. Maybe we've just encountered our very first red newt. We observe that newt closely and describe everything we notice about that newt and hold open the possibility of more observations later. These kinds of close, systematic, descriptive observations are an excellent starting point for many kinds of studies, and these kinds of close, systematic, descriptive observations are often neglected, to the detriment of everything that follows what should have been based on the description. Being clear about what we're examining is a crucial first step, if not the most glamorous.

A picture of a red newt on niece A's hands, near the Finger Lakes Trail

But once we've looked at dozens or hundreds or thousands or red newts, we can start to notice a pattern. How many things it takes to notice a pattern or justify a pattern is open to discussion. We should also remember that when we notice one pattern, we might not be noticing other patterns. So the initial data (all of the newts we looked at on that hike) should be available for more consideration, when possible. When it's not possible to review the initial data (the newt in the picture is probably long dead and would be very difficult to find again in any case, but we do have a picture), it's important to have access to more, similar data (more newts in the same part of the world).

A picture of a millipede on a trail (where? I don't know)

When looking at data, we have to be clear about what's available as data, and what is included or not included and why. And the data that's included usually depends on an idea that we have about what it's important to demonstrate. So inductive reasoning begins with particular information, but the information is chosen based on bigger ideas. There has to be this kind of interplay between larger and smaller levels of information, and as long as we're clear about where we are in the process, this is not a problem. If we are not clear about what is happening at various levels of information or about which level we're working with, problems can arise, including problems of not recognizing opinions (a bigger idea) and facts (the basic information that opinions should be based on).

A picture of a weird fish in a creek near the Finger Lakes Trail

For example, if we wanted to make observations about newts, we need to look at only newts. The weird fish wouldn't be included as part of our set of basic information. If we wanted to make observations about animals who live near/in water along the Finger Lakes trail, the weird fish in the previous picture would count, but the enormous salamanders who live in China would not be included. If we want to make observations about the number of spots on red newts who have spots, we could ignore any red newts who do not have spots. If we want to know about average numbers of spots on red newts in general, we would need to include newts without spots, and red newts in various locations. If we want to make observations about animals with spots, we could include the red newts and maybe this spider, depending on what we decide we mean by 'spots.' And so on.

A picture of a spider on a lean-to along the Finger Lakes Trail

Generally, the smaller we can make the set of data, the more manageable the reasoning process is, keeping in mind that one thing is not a pattern. We can look at positioning of spots on all red newts found along a 10-kilometer stretch of the Finger Lakes trail on a day in late June a day after a rainy day when it rained at least a centimeter. Now we have some limits on what we're looking at (temporal, meteorological, opportunity, distance, position-of-spots), so we know when we're done looking and can start labeling patterns.

A picture of a tobacco (?) hornworm on grape leaves

While we're collecting data, we're looking for patterns. Eventually, we need to label our patterns in some way. These labels are hypotheses, or guesses about data we collected (the result of abductive reasoning). We've noticed something: maybe the newts' have symmetrical patterns on each side of the spine. Maybe the spots farther from the head are farther from the spine. Maybe the spots bulge away from the spine parallel to the newts' bellies. So we say that, whatever it is that we've noticed. We might also make guesses about why the spots are that way: camouflage, particularly well-fed/under-fed newts, etc. These would also be hypotheses.

A picture of a crayfish in Treman State Park

Once we have some hypotheses or guesses, we have to go back for more information. If we have access to our original collection of information (another good use of good description), we can compare our guesses to what we already found, but we also need to look for more information: more newts, more places, more different conditions (drier/wetter days, better/worse food supply for the newts, etc.). One place where many thinkers go wrong is in using the collection of more data to confirm the hypotheses they've made (confirmation bias strikes again!). It's fine to look for more information of the sort we already have, but we also have to look specifically for information that is different from the information we have and that might contribute differently to the hypotheses we have. Proving oneself wrong is not considered glamorous in this day and age, but it's one of the most productive moves available to an essential thinker.

A picture of doves in 'Oahu

When there have been a number of cycles between hypotheses and more information, often involving other thinkers, hypotheses can be strengthened into theories. It's important not to stretch beyond the information that was examined, however. There has been an uproar in the world of cognitive psychology recently because many hypotheses that had been assumed to be strong enough to be theories have been shown to be only hypotheses. It is not responsible to generalize from freshman psychology majors in North America to adults, children, non-students, non-North Americans. We actually have very little information about those other people, relative to cognitive psychology. If the theories had been stated to be about freshman psychology students in North America, the theories would be strong. The same thing happens in other fields of inquiry. We can't generalize from information about mice to information about people, until we collect the information about both mice and people. We can't generalize to people from information about cockroaches, until we do the research with people (in at least once instance, that generalization worked).

A picture of a magpie in Utah

When it becomes difficult to find exceptions, a theory can be strengthened to a law. Again, that leap should not be made too quickly, and it should not be made beyond the data that has been collected and analyzed. We have a 'law' of gravity that can be messed with under certain conditions. The law applies to most of us under most circumstances, which justifies the term 'law.' But there is more interesting information to be collected about other circumstances, and assuming the 'law' in domains where the data is still being collected and examined is not so responsible, but might be a useful place to start, for comparison.

A picture of a rock serving as furniture for a crab near 'Oahu

Over time, some patterns of generalization have been recognized. Predictive generalization is a generalization toward the future, based on what happened in the past or is happening now: I've taken a lot of naps in the past, and I expect to continue to need to take naps. Statistical generalization is a kind of predictive generalization: if 8/10 of the newts have spots, we'd expect the next newt to have an 80% chance of having spots. If we keep looking at newts and find that 85/100 have spots, we'd expect the next one to have an 85% chance of having spots.

A picture of ospreys on a sign near Laguna de San Ignacio

Past generalization is about something that happened in the past based on later or current events: Uncle John is now dead, so he must never have been alive. Oops. That doesn't always work. Things change over time, so the present is not always the best way to understand the past, nor the past the best way to understand the present. But none of this information should be dismissed until change-over-time has been accounted for. Past and present do provide good information, when used appropriately. Analogical generalizations are a kind of past generalization in which identified patterns suggest the possibility for additional patterns: I'm a 47-year-old North American woman who does linguistic analysis and writes introductions to essential thinking, so maybe other 47-year-old North American women do linguistic analysis and write introductions to essential thinking. Or maybe not. One is not a pattern. But we might be able to find patterns about 47-year-old North American women, such as that we're not getting enough sleep. I know lots of people my age who aren't getting enough sleep, but I haven't checked with all of them, so I won't make a universal claim.

A picture of a fish in tidal pool, probably near 'Oahu, given the way I usually organize my pictures (past inference)

Causal generalization is about possible causes based on initial conditions: Many people with male-pattern baldness have heart problems, so maybe baldness causes heart problems. The glitch with this pattern is that single effects (heart disease) can have multiple causes and overlapping causes, and some single causes can have multiple effects (colds give me both congestion and headaches), and some events that show up in sequence are not related causally at all: maybe something causes both hair loss and heart disease. Maybe there's no connection other than sequence between the morning I forgot to brush my teeth and my car battery being dead when I tried to start the car later. Or maybe those share a common cause: I might be negligent about basic maintenance for myself and my stuff.

A picture of birds ground-feeding on ʻOahu

So—three main ways of thinking: large to small (deductive), incomplete to guess (abductive), and small to large (inductive). Maybe there are more thinking patterns you can imagine and would like to develop. Each of the three covered here have their place, but what I'd like to emphasize from this section is that each of these ways of thinking needs to interact with the others in order to do the best essential thinking. Each has strengths and weaknesses, and if we use those strengths and weaknesses appropriately, we can do lots of interesting and responsible thinking about most information.

A picture of many fish in shallow water