



## Testing times: regularities in the historical sciences

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### ABSTRACT

The historical sciences, such as geology, evolutionary biology, and archaeology, appear to have no means to test hypotheses. However, on closer examination, reasoning in the historical sciences relies upon regularities, regularities that can be tested. I outline the role of regularities in the historical sciences, and in the process, blur the distinction between the historical sciences and the experimental sciences: all sciences deploy theories about the world in their investigations.

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### 1. The epistemic problem of the historical sciences

At first glance, the historical sciences appear to have a problem unlike that of the experimental sciences. They seem unable to engage in the testing of hypotheses, a process which we normally associate with good science. This problem emerges because of the epistemic task that the historical sciences face. The archaeologist Lewis Binford defines the task thus:

The Archaeologist investigates phenomena that he has reason to believe remain from the past. These investigations are conducted in the present, resulting in all the observational statements generated being contemporary facts. How does an archaeologist convert these contemporary observations or facts into meaningful statements about the past? (Binford, 1981, p. 22)

The events of interest to the historical scientist are unobservable, so they have to infer events from contemporary observations. As Binford notes, historical scientists focus their investigations on phenomena that they 'believe remain from the past', and then attempt to utilise these observation statements in making claims about unobservable past events. The problem is how to infer, test

and choose hypotheses about the past, utilising only contemporary observations.

This problem is not one that is unique to archaeology: geology, cosmology, the 'paleo' sciences like paleobiology and paleoanthropology, and the forensic sciences, all are engaged in making claims about the past, and all of these claims are initially dependent upon contemporary observable physical evidence.

This inability to observe events of interest is further compounded by the focus of many historical sciences. The historical sciences frequently want to provide a causal history for a particular feature of the world. An archaeologist might want to provide a history of a particular archaeological site, or in some cases a particular archaeological find. A forensic scientist wants to provide a history to account for the death of a particular person. A geologist might want an account for the formation of a particular geological feature. Historical scientists are frequently interested in a single, particular event.

In comparison, the experimental sciences are interested in generalities. They want to know the regularities in the world. So, a physicist wants to account for the behaviour of matter generally. This provides the experimental scientist with two distinct advantages; the ability to observe processes of interest, and the ability to

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repeat those observations. A physicist can repeatedly observe the behaviour of objects under the effects of gravity. The chemist can repeatedly observe the solubility of sugar in warm tea. Hypotheses about generalities can be tested through repetition of observations. They can repeatedly observe, and generalise from those observations. Crucially, successful hypotheses will make predictions about future observations.

In marked contrast with the historical sciences, observations can happen in the present, with known starting conditions, the potential for observation of intermediate phases, and so forth. The experimental scientist can even artificially induce situations that recreate the process they seek to investigate to test hypotheses. The upshot is that the experimental scientist can interfere with situations, repeat them with variations, and come to conclusions about what matters to a result by varying starting conditions and contingent factors.

At first glance, the historical scientist seems unable to do any of this. The historical scientist deals with the end results of nature's messy experiments. The task is akin to making sense of Dr Frankenstein's lab long after the protagonists have fled. With no notes to work with, no idea what he was trying to achieve, the historical scientist is faced with a destroyed laboratory, some dirty test tubes, and the task of reconstructing an opaque singular history. Even if the historical scientist generates a hypothesis about the events prior to his investigation of Frankenstein's lab, there is no obvious way of confirming this hypothesis by direct observation of those events. She might posit a hypothesis that there was a lightning strike, but she can never witness that lightning strike, only its effects. Confirmation cannot come via the observation of hypothesised events. It has to be inferred from consequences. It is also worth noting that on this view of the historical sciences I am sketching, the historical sciences do not make predictions. The historical sciences seem to make retro-dictions—claims about the past. Indeed, the very idea of a prediction seems future orientated and not within the historical sciences purview.

The historical sciences then have two difficulties to overcome.<sup>1</sup> They can't directly confirm their hypotheses about the past with observations due to the lack of access to the past. They can't confirm their hypotheses with contemporary observations because they are unique hypotheses about particular times or places. The result is a problem of confirmation. With no ability to observe their objects of enquiry, to repeat observations, or to intervene on processes, there is seemingly no way directly to confirm hypotheses.

What I want to show in this paper is that this view of the historical sciences I have presented overlooks their reliance on regularities. Because the historical sciences do utilise regularities, even when investigating one off, singular events, they gain access to the confirmatory apparatus of the experimental sciences. They have the means to test hypotheses about the past. They can overcome the difficulties outlined above. But in overcoming these problems, the distinction between the historical sciences and the experimental sciences becomes blurred. As we shall see, part of the conclusion I wish to draw is that the historical sciences are not only interested in particular events, nor are they solely interested in making claims about the history of particular things. The historical sciences also seek regularities in the world, and have to do so in order to secure their claims about the past.

The first part of this paper outlines Carol Cleland's response to the charge that hypotheses about a past cause for a particular feature of the world cannot be tested. Cleland provides a framework

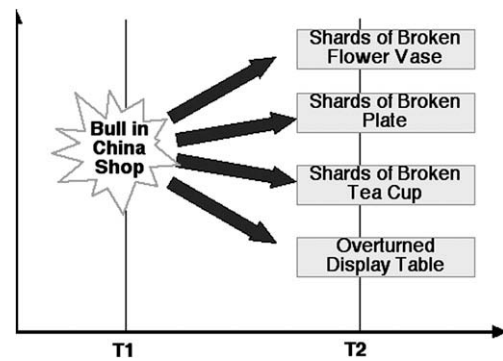


Fig. 1. The single event at time T1, the presence of the bull, disperses into multiple consequences at time T2; the broken pottery, overturned display table, and so forth.

for testing historical hypotheses. It is a different methodology from the experimental sciences but, nevertheless, it works and provides us with increased confidence in claims about the past histories of particular features of the world.

Building on Cleland's analysis, I show how utilising and investigating regularities plays a role in the historical sciences. In particular, I utilise the insights of Peter Kosso whose work on archaeological practice is informative in this context. However, I also take this view further, and argue that part of the historical project is to come to conclusions about general processes; the regularities of the experimental sciences. This is both a means, necessary to secure claims about the past, and an end in itself. The historical sciences share with the experimental sciences a desire to find the regularities and generalities in the world.

## 2. Cleland and the historical sciences

Cleland's starting point is an article by David Lewis (1979), 'Counterfactual dependence and time's arrow'. The key notion that Cleland uses from the Lewis paper is the idea that an event has multiple downstream consequences. Take an event like a bull in a china shop. The results of this event are many; a broken plate, a broken vase, a distraught shop owner, an overturned display table, and so forth (see Fig. 1).

The result is that this single event, the presence of the bull in the china shop, leaves a number of pieces of physical evidence behind. The causal chain disperses from a single event to multiple downstream consequences. What is more, this is frequently going to be the case. 'Whatever goes on leaves widespread and varied traces at future times' (Lewis, 1979, p. 474).

What Cleland takes from Lewis is the possibility that historical scientists can exploit this dispersal of effects as part of a process of evidential reasoning. Because the downstream effects of any event disperse into multiple traces, it can provide a framework for reasoning about the past.

Localized events tend to be causally connected in time in an asymmetric manner. As an example, the eruption of a volcano has many different effects (e.g., ash, pumice, masses of basalt, clouds of gasses), but only a small fraction of this material is required in order to infer that it occurred; put dramatically, one doesn't need every minute particle of ash. (Cleland, 2001, p. 989)

Note that only one trace need be present to infer provisionally a past event: if the volcano had not erupted, then this ash would

<sup>1</sup> There is actually a further problem which I won't deal with here, but is worth noting and deserves attention in its own right. Even if the historical sciences could overcome the difficulties of singularity and lack of observational access to early parts of a causal chain, in many cases, the historical sciences also lack the ability to intervene in events in the same way as the experimental sciences for a further reason—that of scale. Repeating processes that take hundreds of years, or duplicating processes like uplift of tectonic plates, is simply undoable. While some historical events are not at such a scale, many are, particularly in geology where both physical and temporal scale matters.

not be here. However, because of this dispersal of the downstream effects of events into multiple disparate traces, there may be further evidence as well—pumice and other eruption debris for instance. Consequently, we can infer the eruption of the volcano from multiple physical traces. We are not dependent for our claim about the past on one single piece of evidence. In theory at least, we have a great many later facts available to us that are the consequences of a prior fact. The trick then is to utilise these multiple strands of evidence, rather than a single piece.

### 2.1. Using dispersion

As noted earlier, the historical sciences frequently make a claim about the past based upon a particular piece of observable contemporary evidence. They have an explanatory target, an observable fact such as a significant change in the fossil record, an archaeological find, or a land formation, that we wish to give a history for, or evidence that we wish to use to justify some claim about a past event. Now because we can expect past events to have multiple downstream effects, we can use these to discriminate between hypotheses. This is where Cleland provides an account of a particularly historical mode of ‘evidential reasoning’.

If we have two distinct hypotheses about the relation between a past fact and a particular piece of observable evidence, then we can use other downstream effects to discriminate between two hypotheses. Therefore, should we wish to discriminate between hypotheses  $H_1$  and  $H_2$  for an explanatory target  $e_1$ , we can use other pieces of evidence to discriminate between them. Because downstream effects disperse, there should be other pieces of evidence that allow us to make a choice between the alternative hypotheses. Figure 2 shows two hypotheses with the same explanatory target or piece of physical evidence. The two hypotheses have distinct signatures of downstream effects besides that of the explanatory target. Investigating the presence or absence of these alternative pieces of evidence will help us to eliminate one hypothesis in favour of the other.

Cleland’s analysis of the historical sciences and their use of this asymmetry matches closely the thinking of some historical scientists themselves. In 1996 the Australian geologist George Seddon wrote a lecture entitled ‘Thinking like a geologist’ that mirrors some of Cleland’s thinking (Seddon, 1996). Although not as explicit as Cleland, Seddon highlights cases of what he regards as good geological practice. In so doing, Seddon outlines occasions when geologists discriminated between multiple working hypotheses by utilising multiple lines of evidence. Hypothesised past causes should have ‘testable corollaries’ (ibid., p. 491) in the form of specific signatures of downstream effects.

There are links here too with the work of Alison Wylie. Wylie has suggested that archaeologists exploit multiple lines of evidence as a means of bolstering confidence in hypotheses about the past (Wylie, 1989, 2002b,c). Wylie utilises the cabling metaphor of Pierce to suggest that these independently investigated processes allow for confidence in hypotheses even when ‘no one line of argument is sufficient on its own to secure an explanatory or interpretive conclusion’ (Wylie, 2002a, pp. 162–163). Collectively, this dispersal of consequences from prior events provides multiple lines of evidence that can be independently assessed. Consequently, while any single line of evidence may provide tentative support for a hypothesis, collectively they are more persuasive. The possibility of thinking about multiple lines of evidence in a Bayesian fashion should be obvious. And Merrilee Salmon sketched this possibility in the early 80s (Sal-

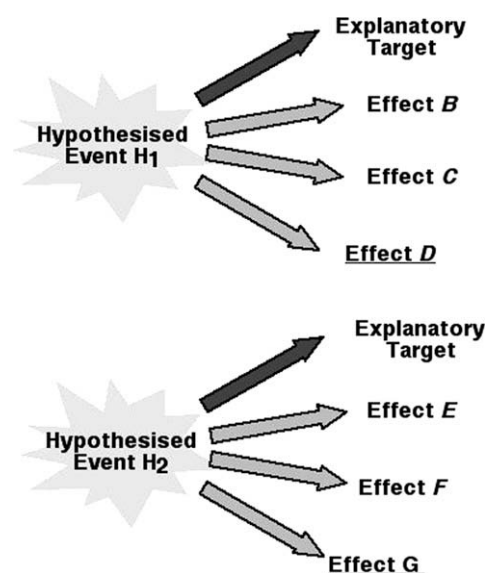


Fig. 2. Rival Hypotheses for the same explanatory target. The explanatory target is identical in each case, but have differing hypothesised causes. In principle, each hypothesis should have a different ‘signature’ of downstream consequences that can be used to distinguish between hypotheses.

mon, 1982). Cleland, however, provides an alternative confirmatory strategy, to which we now turn.

### 2.2. The search for the smoking gun

What is important for Cleland’s analysis, and I think she is right about this, is that some subsequent facts might serve as a ‘smoking gun’ that clearly discriminates between hypotheses.

Take the case of the bull in the china shop. Now we might have enough pieces of evidence to point correctly to a bull being the source of the damage. But which of the two bulls that we know live out the back of the china shop? Which bull owner should we sue for damages? At this point further pieces of evidence might discriminate between hypotheses even more. Farmer Black’s fence might show signs of damage, while Farmer Brown’s fence remains in good repair. The evidence of the fence’s damage at this point not only increases the probability of Farmer Black’s bull being the culprit, it also seems actively to decrease the probability that worthy Farmer Brown is at fault.

The point to take from this is that downstream consequences cannot only support hypotheses; they can discredit them as well. Take multiple observations of evidence:  $[o^a, o^b, o^c]$ . Now take two hypotheses,  $H_1$  and  $H_2$ . If  $H_1$  accounts for  $[o^a + o^b]$  but is incompatible with  $[o^c]$ , and  $H_2$  accounts for all three observations  $[o^a + o^b + o^c]$ , then  $[o^c]$  is the ‘smoking gun’ that discriminates between two hypotheses about a historical event. This one downstream effect not only supports one hypothesis, it works against the alternative hypothesis.

Geologists and other historical scientists can then ‘test’ historical hypotheses by making observations of currently existing physical traces. The ‘test’ is which hypothesis best accounts for multiple pieces of physical evidence. The methodology is to find a ‘smoking gun’, or guns, that unambiguously points to one hypothesis, and potentially discredits the other. The ideal smoking gun clearly supports one hypothesis over another. Further, in some case it also actively undermines confidence in alternatives.<sup>2</sup>

<sup>2</sup> As something of a sociological aside, some historical scientists still cling to a Popperian conception of science, and it is not hard to see why at this point in our discussion. Smoking gun reasoning in the historical sciences is common, and discrediting one hypothesis over another can be construed as falsifying a hypothesis. However, under the Popperian scheme of things, falsification of a hypothesis doesn’t seem to increase the probability of alternative hypotheses, and as we saw in the bull case, we seemed to have good reasons for increasing our confidence in one hypothesis over another.

This practice is, and I agree whole heartedly with Cleland on this, robust, and a good account of the reasoning that historical scientists do engage in. In fact, it is probably one of the dominant strategies in the forensic sciences. The hypothesis that best accounts for the physical evidence gathered eliminates one potential causal agent over another. It is almost classic Sherlock Holmes, eliminating hypotheses that are unsupported by evidence. So up to this point, I agree with Cleland. This is the strategy that geologists and the historical scientists either can, or do, engage in for certain types of claims. The Seddon article seems to come to a similar conclusion in terms of research in geology. When confronted by an observation, geologists look for evidence that discriminates between alternative hypotheses that account for that observation. They eliminate one hypothesis in favour of another by looking beyond the immediate piece of evidence, the explanatory target, to other downstream consequences. They effectively generate further hypotheses that can be subjected to testing by observations. They search for smoking guns.

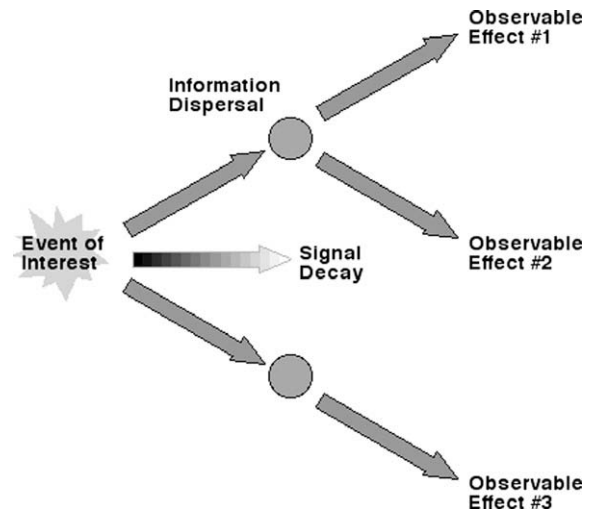
### 3. The requirement for background theories

Cleland's account of the evidential reasoning of the historical sciences assumes that there is a relationship between a particular piece of observable evidence and the particular past cause of that evidence. There are regularities between a prior fact, and later facts. In the example that Cleland uses, competing hypotheses about the extinction of the dinosaurs, there is an assumption that a meteor strike comes with certain consequences. There is an assumption that along with the extinction of the dinosaurs, shocked quartz and iridium layers in the geological record are direct evidence of, or at the least related to, a meteor strike. But what allows us to say that a meteor will have certain results? How do we know all this? What makes us think that a meteor strike will have a distinctive set of downstream consequences? This is where we can begin to see that the historical sciences are much more integrated with the experimental sciences than we would initially suppose. Cleland provides us with a distinctive mode of reasoning for the historical sciences, but the historical sciences rely implicitly upon the same foundations as the experimental sciences. The historical sciences use background theories—theories about regularities—to secure the relationship between a hypothesis and a past cause.

#### 3.1. Archaeology for instance

Much of Cleland's discussion focuses on geology and paleobiology, but at this point, it is worth bringing back into the discussion a different historical discipline—archaeology. The relationship between observable evidence and a past cause may on some occasions be very messy indeed. Consequently, the relationship between a particular observation and a particular past cause may itself require investigation. So the question here becomes, how does one secure this relationship? It seems we are back in the position we started in, asking questions about the relationship between observable evidence and unobservable past causes. Cleland's account of historical reasoning is still missing something.

It is true, as Derek Turner (2005) notes, that the nature of any dispersal of consequences might be such that it becomes unrecoverable. There could well be cases where there is local underdetermination of prior facts by later facts, simply because the nature of



**Fig. 3.** Because of signal decay and various other transformative effects, historical scientists need to understand a great deal how events of interest leave traces, and how reliably. In the above instance, an event of interest has left multiple effects, and Effect #1 and #2 are the result of further dispersal following on from the initial event of interest. One consequence of the event of interest has decayed, and is no longer recoverable by contemporary observers. Effect #3 has transformed, but is still recoverable assuming one knows the transformative process.

the dispersal is such that it is beyond recovery by current scientific processes or because the consequences of facts are inaccessible.<sup>3</sup> The signals of events can simply degrade with time. Elliott Sober (1991) suggests something similar, namely that some historical processes are not information preserving in ways that matter to the historical sciences. There is no getting around the fact that downstream consequences will in some cases disperse in ways that mean they will be irrevocably lost.

In some cases, intervening processes don't just disperse consequences, but transform the contemporary evidence in ways that erase prior processes. The nice clean picture of the dispersion of downstream effects outlined earlier can be much more complicated (see Fig. 3). Nevertheless, the possibility remains that we will have access to enough contemporary facts to discriminate between hypotheses about prior facts.

The quote from Lewis Binford at the beginning of this paper makes explicit the relationship between observable consequences and unobservable past causes on which the historical scientists rely. One of the results of thinking through this relationship is that archaeology attempted to come to grips with the relationships between observable data and inferences about the past. Rather than rely on ad hoc reasoning about particular cases, Binford advocated researching regularities between observations and past causes. This research became known as Middle Range Theory (Binford, 1982; Raab, 1984).

Middle Range Theory (MRT) is research attempting to find regularities in the way that archaeological sites came about, and to find regularities between observable remains and the behaviours of past peoples. But the reason MRT is particularly interesting is that a good part of this involved archaeologists doing something that is supposedly in the realm of the experimental sciences; they do experiments, engage in observations of contemporary processes, and try to find regularities in the world.<sup>4</sup>

<sup>3</sup> Derek Turner points out that some features of the past are locally underdetermined by contemporary phenomena. So something like a dinosaur's colouration is unknowable due to the dispersion of consequences in such a way that they are unrecoverable. However, the collection of refracted light from the period of the dinosaurs could, one supposes, in principle contain the information that would allow us to reconstruct dinosaur colouration. In practice, recovering this information would be impossible, but this is an extreme case. Part of what is at issue here how is we can tell when something is knowable about the past and how we can tell when it isn't, and this leads us inevitably to general claims about the world and its processes.

<sup>4</sup> This is also sometimes referred to as Actualistic Research, and such research also occurs in other historical sciences, such as geology.

Some of the research of Kathy Schick and Nicholas Toth are nice examples of such work (Schick & Toth, 1993). Schick and Toth, among many others, actively researched and experimented to clarify the relationships between various causal mechanisms and what they observed. In part, they are securing their claims about the past from false positives. For instance, if an archaeologist wants to claim that the marks left on bones are the result of Hominin tool use, and not a scavenging canine, one way to protect against false positives is to conduct experiments to see what kind of marks dogs and human tool users leave on bones, and to compare them. This strategy of protecting ones claims from false positives is something that Cleland (2002) claims the experimental sciences do. But it should be obvious that the historical sciences need to do this as well. They need to have a good understanding of general causal relationships that are going to form their evidence, and inform their analyses.

But note what has happened here. We have moved from talking about the confirmation of a particular hypothesis about a particular feature of the world, to talk of generalities and regularities. After all, this repeated observation and this testing assumes there are underlying regularities in the way past facts determine later observable facts. Our evidential reasoning has started to include talk of processes, and to include repeatable experiments for verification of claims. The gap between the experimental sciences and the historical sciences is shrinking. Consequently, the disadvantages that the historical sciences faced are also blurring. Once the historical sciences start being interested in generalities as tools for understanding the past, the confirmatory apparatus of the experimental sciences becomes available.

### 3.2. Securing observations in the sciences

To link observable facts to an unobservable process, we need to be able to say why an observable fact is a necessary consequent of a historical process. These past historical processes are in effect theoretical postulates, and as Peter Kosso points out, many scientists engage in making claims about theoretical entities based on inferences from observable consequences, without actually observing the entities themselves. Physicists routinely postulate entities or processes based on observations of consequences rather than on direct observations. Kosso sees observation in the sciences generally as one of information transmission, from the entity or process of interest, to the final observer. Consequently, that informational link between postulated cause and observation has to be secured. 'Observation in science or any other responsible form of knowledge must be accountable . . . no claim is above the requirement of justification' (Kosso, 2001, p. 45).

This matters whether the process transmits information via some scientific apparatus, or the distant past. An observation via an electron microscope assumes an account of the physics involved, and the possibilities by which the final output of this process may be distorted. Brain imaging is another good example, with a great deal of background theory about the production of images that can be observed, and theory informing the final observations (Roskies, Forthcoming). In effect, an account of the background theories behind such technologies plays an analogous role as Middle Range Theory in Archaeology; outlining the link between the object or processes of interest, and final observations. Such background theories include accounting for potential losses and transformation of information in the intervening transformative stages, plus an account of what such information actually tells us.

The links between observations and postulated causes or processes assume regularities in the ways that information transforms. In the historical sciences, observations of regularities can come from a number of sources. Many come from experiments conducted with the same attention to detail as the experimental sciences. In fact, much research in science generally has gone into

methods and tools that can then be deployed in the historical sciences. The historical sciences can effectively piggyback on work in the experimental sciences, when not actively engaging in their own experimental work.

Now so far, all I have pointed out is that our understanding of the downstream effects of a particular event is dependent upon our understanding of the general mechanisms that support the causal chains required. Cleland assumes an understanding of the relationship between a past cause and its downstream consequences. The evidential reasoning presented by Cleland is incomplete without an account of how the historical sciences use an understanding of past processes in general to make claims about particular events or processes. Cleland even acknowledges this role of experimental research.

This is not to deny that prototypical historical research often involves laboratory work. It is important, however, to be clear about what is actually being investigated in the lab. Most often it is the evidentiary traces, which frequently require sharpening or analysis in order to be identified and properly interpreted. (Cleland, 2002, p. 484)

At this point, it looks as if any research done by the historical sciences on such regularities is a means to an end. They need to investigate such regularities that are peculiar to their discipline in order to have the tools necessary to choose between alternative hypotheses. They can do this using the methods of the experimental sciences. They explore regularities, test them, and make observations utilising these regularities. The experimental sciences deploy testing and observations to enable them to secure claims about generalisations. The historical sciences deploy the same tools to secure localised claims about particular events. The testing secures them against false positives, such as mistaking carnivore activity for hominin activity. We could stop here. We have answered many of the epistemic worries that we outlined in the beginning of the paper. Cleland provides the mechanisms to deal with localised hypotheses about particular events and observations. And in working through Cleland's analysis, Kosso's emphasis on the need to secure observations has clearly shown that regularities are important. The synthesis of these two ideas shows that the historical sciences have the means to deal with the concerns outlined earlier. They can repeat observations across many instances, and they can engage in experiments to determine the relation between earlier determinants and later ones. Already then, we can see that the historical sciences are much less disadvantaged than advertised at the beginning of this paper. Equally, the distinction between the historical and experimental sciences is blurred. All sciences investigate regularities. What I want to argue now is that we can go further than Cleland or Kosso have. The historical sciences are not just interested in events and accounting for the presence of particular things, and their investigations of regularities is not solely concerned with securing observations. A good part of the historical project is akin to the experimental sciences; they are interested in regularities as an end in itself, and not just a means.

### 4. Process types and process tokens

Cleland and Seddon are primarily talking about events—the extinction of the dinosaurs, the history behind a particular feature of the landscape, and so on. The evidential reasoning they outline is only concerned with events and talking about single nodes in causal chains. Cleland takes the historical sciences to have this distinctive feature. She has almost defined the historical sciences this way.

Thus, the hypotheses of prototypical historical science differ from those of classical experimental science insofar as they

are concerned with event-tokens instead of regularities among event-types. (Cleland, 2002, p. 480)

Thus far, I have said little about what I mean by regularities. One thing that I do not mean is that we should conceive of these regularities as laws, or even law-like. An investigation into the effects of a dog gnawing a bone versus the effects of de-fleshing by a stone tool does not seem to be getting to any fundamental law-like properties of the world that hold at all time and all places. There might be some carving at nature's joints going on, but it is literal rather than metaphorical. Nevertheless, there is something right in thinking that reference to this experimental work gives us an increased confidence in particular claims about the past. As Sandra Mitchell (2000) notes, regularities only need to be stable enough to work over a particular number of circumstances.

A straightforward way of thinking about such localised regularities is to distinguish between process types and process tokens. Any particular occurrence of canine damage to a bone has enough similarities with other such instances to be considered a token of a process type. An experiment with a contemporary canine tells us something about the world; it tells us about canines and the type of marks they leave in the world. That's why we see the contemporary 'experiment' as informative about the marks archaeologists see.

Cleland maintains that this interest in regularities is primarily directed towards 'sharpening' the 'evidential traces' and that historical scientists are not concerned directly with 'regularities among event-types' (2002, p. 480). So while we have blurred the distinction between the historical sciences and the experimental sciences, this distinction, and interest in particular tokens as opposed to event types, remains. Yet, this distinction is also less obvious than it would initially appear.

Historical scientists also investigate process types, and are actively interested in regularities across event types. Take a geological example like the eruption of a particular volcano. A particular event like this can be seen as unique, something singular. However, it can also be seen as something that shares features with other volcanoes. Any particular volcano is a token of a common type. We can then understand a particular volcano by comparison with other volcanoes. In so doing, we acknowledge the fact that volcanic activity is widespread throughout time, and that there may be a unified account of volcanoes generally. We might be in a position to investigate volcanic activity as a process. Once some understanding of a process is in place, we can appeal to it in our account. We do not just account for a volcano by appeals to a particular history; we also account for it by appeals to the general process of volcanic activity. In effect, our standardised picture of volcanic activity provides a model for interpreting a particular instance of volcanic activity. An account of the history of a volcano specifies common volcanic 'parts' such as magma, crust, tectonic plates and so on, and specifies interactions between these parts to account for volcanic activity. This common account of a process acts as a starting point or template for investigation. The standard model for volcanic activity specifies the relevant variables of interest and provides a fairly uniform set of principles for understanding volcanic activity.

Biology in particular utilises these standardised accounts of processes. One way to read Philip Kitcher's analysis of Darwinian biology is that Darwin provided a unifying framework for the framing of questions about events. An understanding of the Darwinian process provides a standardised schemata for framing what are effectively historical enquires.

The introduction of the new schemata sets new questions for biology in that, after Darwin, naturalists are given the tasks of (i) finding the instantiations of the Darwinian schemata; (ii)

finding ways of testing the hypotheses that are put forward in instantiating Darwinian schemata; (iii) developing a theoretical account of the processes that are presupposed in Darwinian histories. (Kitcher, 1995, p. 33)

In evolutionary studies, where we have an unobservable past cause of an adaptation of an organism, we see the adaptations of individual organisms as instantiations of a general process. Our understanding of the process guides us in what to look for as confounding factors and alerts us to potential false positives and false negatives. It is our background understanding of the Darwinian process that gives us confidence in any statement about the past we wish to make. We can check our hypotheses about an adaptation by reference to a common process that we think is operative in both situations.

Thus, our understanding of the paleontological record is not built *de novo* from the observations of fossils, but constructed on the foundations of our knowledge of the contemporary natural world and the deployment of a general regularity.

Successful deployment of this model in historical contexts also provides additional support for the general model. The analysis of individual events provides empirical tokens for event types. A hypothesis about a common historical process gains credence every time it is successfully used to explain local instantiations of events. Processes provide frameworks for the understanding of localised tokens. It is this reference to the operation of common processes that does the confirmatory work in evolutionary biology, coupled on occasion with the elimination of alternatives through Cleland's mechanism.

## 5. Theories and predictions

The view of the sciences I am advancing here is one that is more unified in its methodology and tools than outlined earlier. As we have seen, the historical sciences implicitly rely on regularities and so forth when making claims about the past. Kosso's analysis blurs the distinction between observations in the historical sciences and the experimental sciences. Moreover, they explicitly investigate these regularities.

However, some of the regularities used by the historical sciences do not just assist in observation as background theories linking observations to past causes. In many cases, the theories are to the fore. They are being explicitly tested by application in historical contexts. Theories utilised by the historical sciences are themselves being tested by their application in historical settings as much as they are in experimental settings. And often, such foreground theories make quite explicit claims; they effectively make predictions about what we should see in the record of the past.

To demonstrate this, consider Cleland's showcase example of smoking gun reasoning, the extinction of the dinosaurs. Part of the reason that the extinction of the dinosaurs required explaining was that Darwinian theory in a sense predicts that evolutionary changes would be slow, and as a consequence predicts that the fossil record would demonstrate this. Research into the extinction of the dinosaurs is in part protecting Darwinian theory from the false negatives of the fossil evidence. The meteor hypothesis carries weight as a past cause because of a whole lot of additional downstream consequences of a meteor impact. But this is not the entire story. Part of the security of the claims about a meteor is an independent set of theories about the way the world works. Non-geologists have good reasons to think that any individual meteor is actually a token event of a particular process type. It is not a one-off event conjured up to account for the difficult data of the fossil record. The reason we think that positing a meteor impact is not unreasonable is that while a meteor impact is something outside the realm of standard Darwinian thinking, it is a fairly stan-

ard event within the domain of cosmology and the time-frames it works with. Even if one of the subsequent effects of a particular meteor token, the extinction of the dinosaurs, is distinctive and non-standard within the realm of paleobiology and requires further causal linking, meteors as a particular type of thing in the world are rather mundane. Meteor events are part of the process of accretion of matter in local gravity wells. The surface of the moon tells us that these meteor events are not unusual. Part of the confidence we have in meteor events as potential causes comes from this understanding of processes and not just from the elimination of one cause over another. An independent theory of a general process, the accretion of matter in gravity wells, is utilised to protect another theory, Darwinian gradualism, from the false negative of the fossil record.<sup>5</sup>

To see this, take an alternative world, where the orbits of all celestial bodies were stable, and collisions and accretion in gravity wells were outside the realm of the natural order of things. In such a world, positing a meteor strike as a cause for anything would be odd to say the least. In a world of stable orbits, a meteor strike would be something resembling a miracle, and any account of the past that included meteor events would need rather exceptional evidence. It would require an account of how, in a world of stable orbits, a meteor event occurred.

In this light, much historical research can be seen in the same way that Cleland views the experimental sciences, as trying to protect against false positives and false negatives.

Much of the activity that goes on in classical experimental science may be interpreted as attempts to protect the target hypothesis from misleading confirmations and disconfirmations. (Cleland, 2002, p. 477)

The deployment of theories in the historical sciences frequently has a similar character. We possess general models and theories of how the world works, and the investigation of the past is an attempt to reconcile these general theories with the evidence we have of past processes. The historical sciences actively engage in prediction, the prediction of consequences not yet seen, and in the prediction of what the past should look like. Theoretical ecology is a good example here. Although theoretical ecology and its models are applied to current ecosystems, it makes claims about the past and the future of interactions. There is a single body of knowledge that gets deployed across various temporal locations.

## 6. Summary

I have argued in this paper for three things. One, that we cannot understand the historical sciences without understanding the role of background theories. Two, this reliance on background theories gives the historical sciences access to the confirmatory mechanisms of the experimental sciences. The historical sciences experiment, observe, and extrapolate from contemporary data, and this observation and experimentation feeds into a general understanding of the world and its causal structure. This understanding of causal relationships, and the background theories the sciences in general use, is deployed to make statements about temporally inaccessible parts of the world. In part then, these first two points are an argument for a synthesis between the machinery of Carol Cleland that allows us to isolate a particular historical event, and the insight of Kosso that acknowledges the role of regularities in observations.

However, I have further argued for a third point, that the historical sciences are as interested in understanding the general causal

structure of the world as much as any other branch of science. The historical sciences, and evolutionary biology is a fine exemplar here, are interested in general patterns of causation and change in the past. Theories about how the world works are not just part of the background in the historical sciences, they are very much to the foreground in research. Historical investigations are in a very real sense tests of predictions that our theories of the world make. We utilise the machinery of looking for smoking guns, and isolating events, as a means of reconciling our theories about how the world works with the evidence from the past.

The best way to understand the historical sciences is to see them deploying well understood regularities, particular process types, across multiple tokens, either as a means to secure relationships with evidence, or as a general pattern of explanation. This is why introductions to the historical sciences frequently use models of change and processes that are general, and broadly applicable across multiple instances. The tools required to make claims about the past are the same as the tools required to make predictions about the future. We need to understand how one fact relates to another fact, regardless of whether this relationship is in the past, present, or future. And to do this, we draw upon a general understanding of the causal structure of the world. Science then is a unified project in understanding how the world works, regardless of whether it is the world of the past, present, or future.

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<sup>5</sup> Alison Wylie (2002c) makes the point that this provides extra support for a hypothesis, in that observations, while theory laden, may well be driven by independent theories.