Hamilton College
Russell Marcus
rmarcus1@hamilton.edu

Class 20 - Laws of Nature

I. Explanations and laws

Our goal in this second half of the course is to look at the laws of nature and their status.
Laws of nature are important because they are the backbone of the traditional view of scientific explanation, and explanation in general.
The traditional view of explanation is that it proceeds according to the deductive-nomological, or D-N, model, which Hempel discusses.
'Nomological' means law-like.
D-N explanations are deductive in that a specific phenomenon, the explanandum, is derived, using just logic, from laws and initial conditions.
D-N explanations start with general covering laws, and specific facts.
The laws say that every time certain circumstances are realized, specific phenomena will occur.
So, if we want to know why this swan is white, we might appeal to the general law that all swans are white, and the specific fact that this is a swan.

Both the general laws and the specific conditions mentioned in the general laws must be present, in order to have a D-N explanation.
If we do not have specific conditions, we are left without application of the laws in any particular case.
If we do not have general laws, then we have an empty explanation.
For an example of a non-explanation, consider the claim, to which Mandik referred in his talk, that opium puts people to sleep because it has the dormitive virtue.
The phrase 'dormitive virtue' comes from *Le Malade Imaginaire* by Molière, who was mocking doctors.
We need general laws about how opium interacts with our body in order to have a real explanation.
In fact, the best laws will be those of the highest level.

Hempel discusses some very general covering laws: of reflection of light, Kepler's laws of planetary motion, Newton's more general laws of motion and gravitation.
The initial conditions are, generally, empirical observations.
In the Leverrier Neptune case, Newton's general laws and the planets that were known at the time did not yield the particular observed phenomena, which were irregularities in the motion of Uranus.
So, Leverrier posited an unobserved condition, a planet beyond Uranus which could cause those motions.
From Newton's laws and the posited planet, the irregular motions of Uranus follows, deductively.
Later, Neptune was observed, and confirmed the posit.

II. Picking out the laws

There are many statements which look like laws, but which are not really laws.
One way to pick out a law is by its general, or unviersal, character.
But, general statements need not be laws.
Hempel considers, 'All rocks in this box contain iron'.
This statement is general, but it is not a law.
A law must support counterfactual conditionals, or subjunctive conditionals, p 56.
It must predict something about the next rock in the box.
That a person in a room is first-born will confirm the hypothesis that all persons in a room are first-born.
But, it will not increase our confidence that future people in the room will be first-born.

Even if a general statement does predict truly all further specific instances, it may not be a law because it does not support counterfactuals.
Hempel considers 'All bodies consisting of pure gold have a mass of less than 100,000 kilograms'.
He says that that claim is entirely predictive, since there are no masses of pure gold greater than 100,000kg.
But, there could be such masses.

The general form of a statement can be misleading.
The claim 'all gold spheres are less than one mile in diameter' is not a law, since there could be larger gold spheres.
But 'All uranium spheres are less than one mile in diameter' is a law, since uranium has a critical mass guaranteeing the claim.
The two statements are close on the surface.
They are identical grammatically.
We need to appeal to the ability of the statement to support counterfactuals, where accidental generalizations do not.
There could be, in some sense of 'could', a gold sphere of more than one mile in diameter, whereas there could not be one of uranium.
Notice that lawhood thus seems to relate to possibility.
But, saying that laws support counterfactuals whereas accidental generalizations do not support counterfactuals does not solve the problem.
It merely puts a label on the problem.
That is, how do we know if a generalization will support counterfactuals?
We will have to know what can and can not happen.
We are back to claims about possibility.
That is, picking out scientific laws in this world seems to depend on our ability to know about other possible worlds!
And, in order to know what can and can not happen, we have to know what the laws of nature are.

The least contentious claims about other possible worlds, about modal claims, are those of logic and mathematics.
Surely, if we know anything about other possible worlds, we know that the laws of logic hold there.
For, the laws of logic and mathematics are necessary truths, statements which are true in all possible worlds.
What if the laws of nature were also necessary?
Then, we would need no explanation of the reasons that laws support counterfactuals.

The laws would be true in any possible world, too, just like mathematics and logic.
Necessitarians about laws of nature claim that, say, mass is not the property it is unless it has the causal powers it has, and obeys the laws that it does.
Similarly, many of you urged that we would not be the people we are unless we had the properties we do in fact have.
Another way of putting that claim is that all my properties are necessary.
Necessitarians threaten some of our intuitions about possibility, but they make the epistemology of the laws easier.
We need some account of our mathematical knowledge, anyway.

Picking out the laws of nature will take up much of our time in the rest of the course.
First, we need to look at another kind of scientific explanation.

III. Probabilistic Explanation

The traditional conception of explanation involves deduction, strictly.
But, not all laws are completely universal, and so supportive of necessary deductions from initial conditions.
Some laws are merely probabilistic.
Hempel considers laws covering radioactive decay, p 66.
In such cases, the laws and the initial conditions only allow us to infer, to some degree of probability, an event.
But, what degree of probability should we give to the inference?
On what will our assignment of probabilities depend?

Consider the probability of getting a six on a roll of a die.

There are two ways of determining the probability.
In the first way, we consider that each of the possible outcomes is equiprobable, or symmetric.
Then, we assign a probability of 1/6.
In the second way, we roll the die some large number of times and assign the statistical outcomes.
This second method is called determining the relative frequency.
We expect that the two methods will converge, as the number of rolls in the second method increases.
But, that is because we have independent reasons to believe that the die is fair, and that each outcome is equiprobable.
In actual scientific practice, we do not know that outcomes are symmetric.
“Some very plausible symmetry assumptions...have been found not to be generally satisfied at the subatomic level” (62).
So, we are left with only the method of relative frequencies.

Notice that the whole pattern of confirmation and disconfirmation shifts with probabilistic explanation.
In the D-N model, a false prediction necessitates abandoning some premise.
In the light of recalcitrant evidence, we can give up a law or we can re-examine our observations of initial conditions.
But, since the prediction followed deductively from the premises, we know that something had to have gone wrong in the deduction.
On the other hand, in the case of probabilistic, or statistical, laws, particular observations are not strictly

deduced.
So, disconfirming evidence seems impossible.
For example, symmetry considerations lead us to believe that heads and tails are equally probable, and predict a result of heads with ½.
But, repeated results of tails don't, at least for a while, make us give up the premises of that prediction.
At some point, we start to suspect that the coin is unfair.
But, there is no logical refutation of the symmetry assumption.
We look to statistics to determine the likelihood of various results.
But, even a fair coin could land on one side any number of times in a row.
(Compare with the beginning of Stoppard's 'Rosencrantz and Guildenstern are Dead'!)

The central distinction between probabilistic explanation and D-N explanation is that D-N explanation yields predictions logically, whereas probabilistic explanation yields predictions statistically.
"We may distinguish D-N from probabilistic explanations by saying that the former effect a deductive subsumption under laws of universal form, the latter an inductive subsumption under laws of probabilistic form" (68).

IV. Other difficulties

In addition to the problem of confusing laws with accidental generalizations, there are other significant difficulties in determining and characterizing the laws.
One of those problems involves induction.
(See §III of the class notes for November 4 for some remarks on induction; selections from Hume and from Goodman are on the website.)
Hume's problem of induction was that experience could not yield any laws, it could only yield conjunctions of events in the past.
Since we do not observe the laws of nature, we have to infer them in some way.
Godman's new riddle of induction shows that we have difficulties even formulating those laws.
Hempel is giving us a procedure for testing the laws, in conjunction with observation.
But, he does not give us an explanation for how we justify formulating those laws, against Goodman, or extending them to unobserved phenomena, against Hume.

On the other hand, the problems of induction seem to be merely philosophical.
We do know how to formulate laws, how to distinguish laws from accidental generalizations and from, as David Lewis describes Goodman's predicates, "hoked-up gerrymanders".
Perhaps the lesson to be learned from Goodman is not that we have no justification of the laws, but that since we do, and since the notion of law is tied inextricably to the notion of counterfactuial conditioanls, then we must have knowledge of modalities, of other possible worlds.

Other problems with the laws might similarly be merely philosophical.
Consider the question of truth.
It seems clear that scientific explanation aims at truth.
But, explanations need not refer to true laws in order to be explanatory, p 55.
And, laws need not have true instances, p 57

V. Preview of the rest of the course

Here are some questions one might ask about scientific laws:

1. How do we distinguish between laws of nature and accidental generalizations?
2. Can we know the laws, or do the problems of induction prevent our justifying them?
3. Are the laws necessary or contingent?
4. Are there laws of nature in special sciences, like biology or psychology? Or, are they to be found only in the most fundamental science, physics?
5. Do laws of nature govern the world, or do they just describe the world?

We have looked a bit at the problem distinguishing between laws and accidental generalizations. Further, there is a problem justifying any knowledge of the laws, the problems of induction.

Here is another worry about the supposed universal nature of laws.
Consider two possible laws:

L_1: No signal travels faster than light
L_2: All raptors have a hooked beak.

Both L_1 and L_2 are universal.
Any counter-example to L_1 would lead us to give it up.
L_2, in contrast, seems to admit of exceptions.
If we found a raptor with a straight beak, or with no beak at all, we would maintain the law.
The difference between L_1 and L_2 is often described by calling L_2 a ceteris paribus (other things being equal) law.
So, L_1 is a strict generalization and L_2 is a ceteris paribus generalization.
Strictly speaking, though, we are unlikely to call any statement which admits of exceptions a law at all.
Generalizations, like L_2, are statements of special sciences.
In light of the ceribis paribus problem, we might give up the idea that there are laws, strictly speaking, in the special sciences.
The laws of physics, though, are presumably not ceteris paribus laws.
Nancy Cartwright, *How the Laws of Physics Lie*, argues that even the most fundamental statements of physics are in fact ceteris paribus claims.
Take the law of gravitational attraction:

L_3: $F=Gm_1m_2/r^2$

It says that the force between two objects is calculable from their masses and the distance between them.
But, the force between any two objects is also influenced by other forces, like electromagnetic forces.
Similarly, consider the law that whenever the temperature of a metal bar changes, the length changes as described:

L_4: $\Delta L = kL_0 \Delta T$

But, this transformation will fail to happen, say, if one is hitting the ends of the bar with a hammer.
So, even the laws of physics may be ceteris paribus.

One response to these difficulties, a non-philosophical one, is to ignore these problems.
Another possible response to the problems is to give up on the laws of nature.
Bas van Fraassen argues, in *Laws and Symmetry*, that there are no laws of nature.
According to van Fraassen, the notion of a law is a philosopher's invention.
Thus, van Fraassen is an eliminativist with regards to laws.

Philosophers of mathematics are familiar with this kind eliminativism.
The core philosophical problem in mathematics involves explaining our knowledge of mathematics without sensory access to the abstract objects to which number terms, and geometric terms, refer.
There are no numbers or ellipses in the physical world.
Traditionally, mathematical epistemology is non-empiricist.
Philosophers have long posited a non-sensory faculty for learning about mathematical objects.
Some philosophers, faced with the empirical inaccessibility of mathematical objects, deny that there are mathematical objects.
Hartry Field, for example, calls himself a fictionalist; see his *Science without Numbers*.
He says that statements like 2+3=5 are, strictly speaking, false.
Van Fraassen's eliminativism is similarly motivated.
Both Field and van Fraassen deny the truth of commonly-accepted statements (e.g. 2+3=5, F=ma) because they can not justify those beliefs by appeal to sense experience.
Other eliminativists, like Ronald Giere, are motivated by the difficulties with scientific truth.

Eliminativism is counter-intuitive.
We do seem to have a good grasp of paradigmatic statements of laws, and how they differ from accidental generalizations.
The eliminativist overreacts to the epistemic problem, and gets rid of too much.

Among non-eliminativists, there are several competing schools of thought about what laws are.
Roughly, we can distinguish:

1. Reductionism/Humean supervenience;
2. Laws as connections among universals; and
3. Autonomy.

We will look at the first view, that laws supervene on, or reduce to, ordinary (non-nomic) facts, on Tuesday.
That view, and its variations, is the most influential, and is called many names.
In addition to Humean supervenience and reductionism, it is also called the systems view, or MRL.
(MRL stands for Mill, Ramsey, and Lewis, though David Lewis is the most recent and important contributor to the view.
Lewis credits John Stuart Mill and F.P. Ramsey for the view.)
There are, of course, distinctions among the views with these labels, but we will ignore them.
According to MRL, the laws of nature are nothing more than facts about the world, put together in some way.
The world is just a collection of facts, or events, or stuff, and the laws add nothing above that.
"All there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another" (Lewis, 1986).

In opposition to the MRL/Humean supervenience view, there are two views that conclude that laws somehow go beyond the particular facts on the ground.
The universals view sees laws in the connections among properties of the objects.
The autonomy view sees laws as additional furniture in the universe.

Armstrong, who is influential, but whom we will not read, argues that laws express necessary relations among universals.
Consider, 'all whales are mammals', or 'all uranium spheres are less than one mile in diameter'.
The first law expresses a relation between the property of being a whale and the property of being a mammal.
The second law expresses a relation between the property of being a sphere of uranium and the property of being one mile in diameter.
Such properties are universals, characteristics that particular objects may share, and the laws are necessitations among them.
These necessitations are not logical relations, but physical laws.
The problem with the universals approach is that it appeals to our ability to recognize universals.
But, universals are at least properties of objects in the world, and so that view continues to be naturalistic, even if not Humean.

Carroll presents an alternative anti-reductionist, non-supervenience approach, which I call autonomy.
For Carroll, the laws are not reducible to either objects, as MRL states, or to natural properties of those objects, as Armstrong claims.
He argues that there are special nomic properties about the world that do not reduce to physical facts.
The laws are autonomous of any particular physical facts.

The MRL is the default view because it is the most parsimonious.
We are pretty sure that there is a world full of stuff out there.
If we can avoid positing laws in addition to the stuff, we can have a simpler view of the world.

So, Lewis and Maudlin will give us the MRL view.
Carroll will present the autonomy view, in contrast.
Beebee and Loewer will defend MRL, in different ways.
And, Schneider will try to deflate the Carroll objection, I think.