Philosophy of Science // Fall 2016

Handout 19

Reduction rejected: Kitcher

Background. Suppose we think of scientific theories as axiomatic theories that have empirical content. We first identify the purely formal calculus. This calculus will be characterised by logical terms, non-logical terms, and rules of inference. Among non-logical terms we may find: 'molecule', 'atom', 'electric charge'. They will not be explicitly defined by the theory. Instead, their relational properties will be specified. These terms will be *implicitly* defined.

Calculi, for them to have empirical content, should be equipped with rules of correspondence. Their role is in connecting calculus terms with observation. That is: non-logical terms contained in the calculus will be empirically *interpreted* by these rules.

Thus theories are 'partially interpreted' formal calculi. There is a (relatively) clean separation between theoretical apparatus and observation data. And since theories are axiomatised formal systems, it is to be expected that, if any interesting relation exists between two distinct theories, it will be some form of logical entailment.

Now, new theories typically extend the range of application of earlier theories. That is, old theories are special cases of the new theories.

Example 1. Newtonian mechanics holds for low relative velocities. It was a mistake to apply it to high velocities.

$$\begin{aligned} x' &= \frac{x-ut}{\sqrt{1-\frac{u^2}{c^2}}} & \qquad x' &= x-ut \\ y' &= y & y' &= y \\ z' &= z & z' &= z \\ t' &= \frac{t-\frac{ux}{c^2}}{\sqrt{1-\frac{u^2}{c^2}}} & t' &= t, \end{aligned} \tag{19-1}$$

A less general theory will hold in special cases that, however, can be ubiquitous. So we represent this claim thus:

$$\text{If } (T \,\&\, d), \text{ then } T', \tag{19-2}$$

where T is a more general theory, T' is a less general one, and d is a statement describing the special case. If (19-2) holds, then we say that T' is reducible to T.

The two genetics. Classical genetics specifies the laws of heredity without any recourse to the facts at a molecular level. Obviously so, since it was developed in the 19th century before the field of molecular biology even existed. Molecular genetics determines laws of heredity based on the understanding of the internal workings of genes, their molecular dynamics. How are the two genetics related?

One might think that classical genetics has been reduced to molecular genetics. Yet showing that has proved to be elusive. Perhaps then we have a failure of reduction.

Reduction reconsidered. The claim of reduction can be split into three parts:

(R1) The laws of classical genetics can be derived from the laws/principles of molecular genetics.
(R2) The vocabulary of classical genetics can be linked to the vocabulary of molecular genetics by bridge principles.
(R3) The laws of classical genetics can be explained by the fact of derivation from the principles of molecular biology (explanation by unification!).

Let us look at these claims in turn. What is the problem with (R1)? Here, simply put, there are no laws of genetics to speak of. Examining the practice of classical geneticists, one finds many statements and descriptions of fact, but no generalisations about gene transmission across different organisms.

Yet don't we have Mendel's laws? Kitcher addresses the Second law that describes the transmission of genes during a cross, namely the production of haploid gametes by diploid organisms.

The law states that genes (at different loci of a chromosome) are transmitted independently. Here the problem is that the law allows exceptions. The genes located close on the same chromosome are transmitted together.

Perhaps the law can be amended. That would not be unusual, as there are many examples of laws in science, including physics, where laws hold only approximately. This would not do either, because regular processes in the cell (cytological processes) can affect the gene transmission as well.

Furthermore, Kitcher argues, this does not even touch the heart of the problem. The Second law was shown to be irrelevant to the later research in cytology. In effect it was made outdated by cytological research (indeed, the earliest attempts to ground Mendel's law in cytology go back to the beginning of the 20th century).

What about (R2)? We need bridge principles that would allow us to perform reductive derivations. We are looking, that is, for an entailment for some such form:

$$\forall x(x \text{ is a gene } \leftrightarrow \mathcal{M}x), \tag{*}$$

where $\mathcal{M}x$ is a sentence of molecular biology. Since genes are segments of DNA, the job of $\mathcal{M}x$ would be to tell us that which segments of DNA count as genes.

Here the first problem is, crudely, that genes are too diverse for us to be able to come up with such generalisation. But perhaps we could try brute force, taking into account that there is only a finite number of genes and organisms. This will not do, because laws must have the character of necessity: they must tell us would would have happened if, say, the initial conditions were different. This necessity cannot be extracted from the enumeration of actual instances.

What of (R3)? We can skip the biological (or rather, cytological) details and get to the philosophical point. It is this: more detail does not engender a better explanation. We have a relatively simple cytological story that provides an explanation in terms of meiosis (a certain kind of cell division). We *might* have a lengthy derivation of its claims from molecular biology, but that would not improve our explanation. It would instead damage it.

One might respond that a too detailed explanation is bad for the minds of limited capacity, and that more powerful minds might find it enlightening. But, Kitcher argues, the claim does not depend on any assumption about our mental capacity. In order for a detailed explanation to explain it should interpret meiosis as a natural kind. Only then it would be able to subsume it under general laws. But this cannot be done, since meiosis is a heterogeneous process, as far as its molecular characteristics are concerned.

Question 2. Consider Newton's law of gravitation:

$$F = \frac{Gm_am_b}{d^2}.$$

Not satisfied with this crude formula, suppose I want a deeper explanation. Could we claim that there will be an analogous failure if I try to derive it from the laws of quantum physics? from the laws of general relativity?

Two practices. Classical genetics developed as a study of a problem of pedigree. This is a problem of transmission of phenotypes from one generation to the next. By the field of classical genetics we understand not a body of theories united by logical connection, but a conglomerate of explanatory practices. Central to the practice of classical genetics was the theory of gene transmission.

Molecular biology illuminated the process of gene transmission with the notions of replication, mutation, and with the descriptions of the structure of particular genes. Yet this does not mean that all generalised descriptions of genes have to be derived from molecular biology. Nor does it mean that classical genetics can framed as a conjunction of general laws.