Section 4—Downward causation for molecules

Is there downwards causation from chemistry to physics? Hendry wants to address this in terms of the question: are there configurational Hamiltonians, or are they all resultant?

- In other words, are there any complex models in quantum chemistry which are not reducible, even in principle, to more basic theories that apply in full generality?

To empirically support CP, we need to do more than establish that there is a descriptively adequate physical model for every system—that doesn't rule out emergent chemical downwards causation:

> 'The lesson of Broad's emergentism is that the mere existence of a force function for every system, satisfying no further constraints on its construction, fails to rule out downward causation, for the force function for some complex systems might be "configurational."' (p.163)

We need to establish that there is a descriptively adequate resultant Hamiltonian in each case. Here is the method Hendry suggests (p.164):

i. Specify a list of fundamental physical interactions (gravitational, electromagnetic, strong-and weak-nuclear).
ii. Enumerate the microparticles present in the relevant system and list their charges, masses, and values of any other relevant quantities.
iii. Using only the approved "fundamental" forces in (i), list the interactions occurring between the microparticles enumerated in (ii).
iv. Using the results of steps (i)–(iii), write down the kinetic and potential energy operators and add them.

But (says Hendry) QM doesn't look like that. Example of CO_2 molecule; seems we treat the parts of the molecule as oscillators/rotators with degrees of freedom fixed by the molecular structure of which they are parts:

> 'The emergentist will see this as a case of downward causation: we did not recover the CO_2 structure from the "resultant" Hamiltonian, given the charges and masses of the various electrons and nuclei; rather we viewed the motions of those electrons and nuclei as constrained by the molecule of which they are part.' (p.165)

Possible reply: we ignore (i)-(iv) for practical reasons; exact treatment available *in principle*.

- Against this "proxy defence", Hendry offers some familiar remarks on the Born-Oppenheimer approximation being inconsistent with QM, but add that:

- In fixing the nuclei, we specify bond lengths and import structure, which removes the symmetries of the exact solutions. [See symmetry problem, below]

Point: burden of proof is with the reductive physicalist. Not clear that there is any evidence of the availability of a resultant Hamiltonian for every system.

Section 5—the methodological argument

Here Hendry dismisses some arguments that reductionism (i.e. denial of downwards causation) is somehow built into methodology of fundamental physics.

- Reply seems to be: so what? Doesn't follow that it is (i) justified, or (ii) true

But reflect on Quine's principle, as described by Hendry:

> Quine has it that if the physicist suspected there was any event that did not consist in a redistribution of the elementary states allowed for by his physical theory, he would seek a way of supplementing his theory. (pp.167-8)

If we find configurational forces, don't we always have the option of complicating our fundamental ontology so that they are attributable to physical entities?

- c.f. Sydney Shoemaker's 'micro-latent powers' ('Kim on Emergence')

Chapter 10—Modelling Downward Causation in Chemistry

Purpose of chapter: to argue against (i) and (ii) of the following orthodoxy:

i. any physicalism worth the name ought to be incompatible with the existence of causation 'downward' from the entities, properties and laws studied by higher sciences to their microphysical constituents
ii. successful quantum-mechanical explanations of chemical bonding render unlikely the existence of downward causation from the chemical to the physical
iii. the very idea of downward causation is murky, with some formulations being trivial and less interesting than emergentists think, while stronger formulations are implausible or even incoherent.

Strategy: propose a *counternomic* conception of downwards causation, according to which—on current physical theory—there is reason to take molecular structure as emergent.

Section 2—reduction, emergence and causation

A lot of this repeats the foundational material from chapters 8 and 9, and doesn't add much.

Key points:

- many varieties of ontological dependence (supervenience v. weak condition), not all license the reducibility of the dependent entities to those upon which they depend
- **Alexander's dictum**—chemical properties are irreducible iff they confer novel causal powers (exhibit downwards causal influence) in relation to basic physical properties
- **Counternomic conception** of downward causation: 'to say that some system exhibits downward causation is to make a counternomic claim about it: that its behaviour would be different were it determined by the more basic laws governing the stuff of which it is made' (pp.178-9)

Section 3—quantum chemistry: the symmetry problem

Hendry considers three lines of defence for reductionists: (i) proxy defence (already discussed several times in connection with Born-Oppenheimer approximation); (ii) bet on future exact treatments within QM that supersede current ones; (iii) provide a general argument for ontological reduction (e.g. completeness of physics, as discussed earlier). Amounts to inductive argument that future physics will be able to reduce chemistry.

Symmetry problem

I think Hendry wants the symmetry problem to undermine all three responses, but unfortunately I'm not sure what it is. It seems to be summarised by Hendry as follows:

> Now arbitrary solutions to exact Coulombic Schrödinger equations should be spherically symmetrical, but polyatomic molecules cannot be spherically symmetrical, for their lower symmetries are important in explaining their behaviour. Consider for example the hydrogen chloride molecule, which has an asymmetrical charge distribution which explains its acidic behaviour and its boiling point. In the Born-Oppenheimer approximation, the spherical symmetry that is expected of exact solutions to the full Schrödinger equation is simply replaced by a less symmetrical structure that is compatible with the asymmetrical charge distribution. Molecular structures cannot be recovered from the Coulomb Schrödinger equations, but not because of any mathematical intractability. The problem is that they are not there to begin with. (p.181)

The issue seems to be that without assuming molecular structure (i.e. departing from spherical symmetry of the exact solutions), we can't account for the asymmetric charge distributions of polyatomic molecules. I am not sure how to assess the truth of this claim.

- I know it is easier to solve the equations when we assume spherical symmetry, but Hendry must be referring to a principled difficulty here, not mere intractability

- I think the problem here is that because nuclei in Born-Oppenheimer structures are fixed, those structures are more like molecules than assemblages of quantum particles, which have greater symmetry. And these asymmetries are crucial, chemically.

The conclusion of the argument, in any case, is that we need to import structure into quantum chemistry to account for the observed phenomena. But then chemical structure is an "unexplained explainer", and not something that looks reducible to fundamental physics.

- Option (ii). According to Hendry, it is "unpromising", because the symmetry problem, which is not at all clear, stems from foundational quantum mechanics. OK.

- Option (iii). Bet on some future QM replacement being able to reduce molecular structure to fundamental "physics". Papineau-style argument for CP relative to chemistry—future physical theory won't include molecular structure.

Option (iii) is tenable only if something in current QM lends support to the view that molecular structure has no causal power over and above its "physical" parts.

Symmetry problem and CP

Hendry argues at length that the symmetry problem suggests that molecular structures do in fact have novel causal powers and so are irreducible.

- If this is correct, then current physics in fact suggests that future physics won't be able to reduce chemical structure to anything more (mereologically) fundamental

Hendry gives two arguments. The first in on p.183: (direct argument)

i. 'if the acidic behaviour of the hydrogen chloride molecule is conferred by its asymmetry, and the asymmetry is not conferred by the molecule's physical basis according to physical laws, then surely there is a *prima facie* argument that ontological reduction fails.'

'On any conservative amendment to quantum mechanics, the explanation of why molecules exhibit the lower symmetries they do would appear to be holistic, explaining the molecule's broken symmetry on the basis of its being a subsystem of a supersystem (molecule plus environment). This supersystem has the power to break the symmetry of the states of *its* subsystems without acquiring that power from its subsystems in any obvious way. That looks like downwards causation.'

Second argument (indirect argument)

Related to the first: structures we import into QM by means of "approximation" to the exact solutions do causal-explanatory work that we can't account for in terms of basic physics.

- But this removes any inductive support we might have from e.g. the fact that there is a finite stock of non-configurational fundamental forces, for CP

So, the commitment to CP is not justified on general inductive grounds either. [Compare this with the case for reducibility about the mind from progress in neuroscience.]

'If emergentism were true, and configurational Hamiltonians really did govern the behaviour of molecules, then the disunified structure of quantum mechanical models explaining molecular structure and bonding, including the unexplained symmetry-breaking through the imposition of determinate molecular structure by hand, is just what one would expect.' (p.186)

Section 4—Understanding emergentism

Purpose of section: to rebut some arguments against downwards causation.

- Kim's argument that downwards causation is either unremarkable (because ubiquitous), or incoherent (violates 'causal power actuality principle'). Hendry argues that on the counternomic conception of emergence, Kim's cases are all ones in which there is no genuine downwards causation.

- Possible tension between Alexander's dictum (causal criterion of novelty for properties) and counternomic conception of emergence. Does AD require CTP?