Explanation & Unification

Recall (Lecture XIX)

- Phillip Kitcher sought to preserve what he considered were some of the strongest **methodological & logical** features of Hempel; namely that **scientific explanations that resort to theory** can be characterized as some form of a **deductive/ derivative activity**: "Theoretical explanation provides some support for the Hempelian idea that explanation is derivation…[n]onetheless, Hempel's account of theoretical explanation is underdeveloped, and with good reason." (428) (He articulates a defense of this **Deductive Chauvinism** in § 5).

- Recall also from your previous readings of Kitcher that he is a ***scientific realist***, of the "softer" epistemic/methodological variety: **Scientific realists need not be strict or strong metaphysical realists** (insofar as stipulating that there exists one unique ontology "**[T]**ruth" of the world that science shall 'uncover'). Scientific realists can resort to comparatively weaker epistemic and methodological issues[1]: whether (in the case of later Kitcher) arguing that theories function as 'maps' which though sharing obviously some correspondence with features of the world (i.e. "**[t]**ruth") are also inevitably and irreducibly characterized by the pragmatic en epistemic interests of the theorists/mapmakers. He argues that the **global methodological goal**[2] of science is a **search for greater understanding:**

> The search for understanding is…a fundamental goal of the [scientific] enterprise [conceived of in a global methodological manner]. The quest may take many different forms in different historical and disciplinary contexts, but it is tempting to think that there is something that underlies the various local endeavors, something that makes each of them properly be seen as striving after the same goal. (419)
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> We want to allow that **science should make progress** by **appreciating new possibilities for explanation.** (435-436)

[1] In this regard, recall the introductory lecture on realism: Nicholas Cusanis (15th cent) with his 'inscribed polygon in a circle' illustration of the minds attempts to comprehend the world, in which 'no polygon, no matter how many sides are added ever converges to the circle is an early example of this weaker epistemc notion of realism. Recall also from **Lecture XIX** : "Kitcher (like many realists…recall Boyd with his 'virtuous circle' defense of scientific realism viz. confirmation theory) is invoking the above notion of unity as an *inference to the best explanation* (IBE) for an epistemic defense of scientific realism. Similar to Boyd, in his criticisms of vanFraassen, Kitcher (as other realists) argue that the burden of proof rests upon the anti-realist's shoulders on just how to provide an account for such unifying activity in scientific explanations: to write it off as a 'pragmatic virtue' (in the case of van Fraassen) strikes realists as question-begging: *what makes this a virtue in the first place*?" (pp. 5-6)

[2] A controversial notion. Note that Laudan believed in no such thing, as he argued the methodologies of science were underwritten by their research tradition

- For Kitcher, this necessarily involves a notion that **scientific explanation is an endeavor aimed at unification**. So Hempel's scheme of *explanans* as premises and *explananda* as conclusions isn't precise enough:

> *[I]deal* explanations are derivations. Here there is agreement…with Hempel…But on the [unification] systematization account, [though] an argument is considered as a derivation…**An ideal explanation [nevertheless] does not simply list the premises but shows how the premises yield the conclusion.** (431)

- Kitcher characterizes this systematic schema in terms of a set $E(K)$ defined as "the explanatory store" over the set of the **deductively closed and consistent set of sentences** [3] K characterizing the beliefs of a scientific community endorsed at a particular time (i.e. Hempel's notion of scientific knowledge):

> $E(K)$ is to be the set of derivations that best systematizes K, and I shall suppose that the criterion for systematization is unification. ***E*(*K*), then, is the set of derivations that best unifies *K*.** (431)

- The essential point is of unification is paraphrased from Michael Friedman:

> $E(K)$ [is] the set of arguments that achieves the **best tradeoff between minimizing the number of premises used and maximimizing the number of conclusions obtained.** (431)

- In terms of the general issue of **scientific realism** (viz. the theory of scientific explanations) Kitcher sets up his position contra Wesley's Salmon's more robustly metaphysically realist one: For Salmon, ideal explanations comprise **I-E-T**'s (or Ideal Explanatory Texts) which give **a completely fundamental account of the underlying causal processes and histories of the explanandum**.[4]

> I have some uneasiness about the **mammoth causal histories** that appear to be envisaged [by Salmon & Railton] and about their status as 'ideal' answers to 'ideal' questions…[though] [m]y **main concerns about the causal approach lie elsewhere.** (n. 9, 500)

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[3] I.e., K is **closed** under $\vdash$ or deductive consequence. That is to say, $K \subseteq \Lambda$**contains all possible statements derived from other statements in *K* via** $\vdash$. Recall previous lectures (**II, XVIII**) that $\vdash$ is a *syntactic notion of validity* characterized by a particular logic's **rules of inference:** in the case of **FOPL**, for instance, there are 14 such rules (**Lectures II, XVIII, XVIIIb**). Moreover, Λ is some *logically regimented formal language* (ideally constructed recursively by logical constants, variables, connectives, and rules of inference)**.** K is **consistent** means that it is impossible to derive (under $\vdash$) any sentence/formula φ and $\neg\varphi$ from K. Stated formally: $\forall \varphi \in \Lambda$: $\neg(K \vdash \varphi \ \& \ K \vdash \neg\varphi)$

[4] Recall example I cited from Michael Janssen's talk duing **Lecture XIX** : To explain (according to Salmon) the behavior of the appearance of a piece of chalk I am rotating in front of you eyes would require (in principle) specifying the I-E-T of the chalk + my hand system, giving the completely causal story, down to the microphysical level of the chalk+my hand's constituents: i.e., for instance, specifying the dynamical trajectories (in probabilistic terms *pace* Quantum Mechanics) of the trillions of particles comprising such a system. An I-E-T of my hand –rotating-chalk would be different from an I-E-T of my hand-rotating-pencil.

- As suggested by the above quote, it's not the *practical* issue of reducing some explanation of some explanandum into some "mammoth causal history" that bothers Kitcher as much as the epistemic and methodological *principle* of treating causality as a *primitive notion*. In this respect, he is in full accord with Hempel (who as you recall argued that all causal explanations are DN, but not conversely.) In general terms, Hempel's empirical commitments[5] predisposed him towards an epistemic view of causation: that the concept may play a useful role in explanatory relevance, but is by no means some fundamental physical (let alone a metaphysical!) property:

> Hempel's work appears to stand in a distinguished tradition of thinking about explanation and causation, according to which causal notions are to be understood either in terms of the concept of explanation or in terms of concepts that are themselves sufficient for analyzing explanation. Empiricist concerns about the evidence that is available…are frequently translated into claims about conceptual priority**…[T]he thesis that we can only gain evidence for causal judgments by identifying lawlike regularities[6] generates the claim that the concept of law is prior to that of cause.** (420)

Recall Carnap's paper here: scientific explanations should essentially include talk of laws! According to Kitcher this leaves the theorist (of explanation) with two alternatives:

> A successful analysis of explanation might be used **[a]** directly to offer an analysis of causation—most simply, by proposing that one event is causally dependent on another just in case there is an explanation of the former that includes a description of the latter. **[b]** Alternatively, it might be suggested that the primitive concepts employed in providing an analysis of explanation are just those that should figure in an adequate account of causation.

Kitcher points out that Salmon (and others) have selected **[b]** and gives this strategy a passing nod (viz. accounts of lawhood):

> It is not hard to see that the causal approach bypasses the problem of providing an analysis of scientific laws. While proponents of the approach may believe that, in general, complete causal histories will mention laws of nature…it is not

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[5] Which are in this respect in line with Bertrand Russell's (who was a primary champion *for* and inspiration *of*) the early Vienna Circle Logical Positivists and their subsequent philosophical off-spring (the logical empiricists). Russell argued in general that 'causation' is at best some folk-concept, which has no place in fundamental sciences. Russell argued specifically in his 1904 landmark paper that (presumably) causal relations reduce to *functional dependencies* in the mathematical sense. For instance, the 'folk' statement "force causes acceleration" is reduced formally to Newton's Second Law, $F_{\text{net}} = ma_{\text{c}}$, positing therefore a *functional* dependence between the dependent variable F_{net} (the vector sum of all the forces acting on a body) and the independent variable a_{c} (the acceleration experienced by the body's center of mass), where mass m acts as proportionality parameter. Such skepticism about causal claims of course goes all the way back to David Hume's critique of the presumedly necessary connection between an event's effect and its cause. For Hume, this presumed necessity was just another egregious incidence of an inductive fallacy.

[6] See note 5 above. For Russell, such regularities should be in principle expressed by way of functional dependencies and differential equations (describing the dynamic laws).

> incumbent upon them to provide an analysis of the concept of law, at least not for the purposes of giving an account of scientific explanation. (422)

Moreover, recall Stephen Mahanes' comment in **Lecture XIX** concerning the barometer worry viz. correlation/causation:

> In Salmon (1970), the Hempelian requirement of high-probability was replaced with a requirement of statistical relevance. (n.11, 501)

In the same breath, however, Kitcher considers this problematic, insofar as a notion of causation is still smuggled in:

> Salmon and others…have explicitly introduced the notion of causation into the account of statistical explanation. (ibid.)

- Kitcher's *naturalistic* metaphilosophical positon regarding the methdological and logical continuity of mathematics with science[7] bolsters his case that asymmetry problems in explanation arise in the field of mathematics as well, where "causal considerations are quite beside the point." (425) His examples include the Bolzano-Weierstrass Theorem[8] providing the *exaplanans* for the Intermediate Value Theorem[9], the non-unique ways to characterize the axioms of a group[10], etc.

- Aside from the above subtleties concerning causation and lawhood, the obvious point for Kitcher has to with *singular* statements that I-E-Ts seem to be bound to (recall my rotating the chalk example, discussed in note 4 above). "[S]ingular explanation[s] need[] to be amended to allow that exaplanations need not, and sometimes should not, deliver information about the causal history of a particular occurrence." (427) Here he foreshadows his notion of $E(K)$:

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[7] An obviously controversial stance! Many (like John Burgess) might argue that philosophy of science should incorporate many of the results and procedures in the work done in the foundations of mathematics, while balking, however, at the stronger assumption advocated by Kitcher that such domains of study (mathematics and science) differ only in terms of degree, but not fundamentally in kind.

[8] I.e., that every infinite subset A of R^p contains a cluster point x (which is a point x such that there exists a point $x' \in$ nbd(x), where $x' \neq x$ for *every* neighborhood (nbd) of x, and nbd(x) $\subseteq A$). For instance: {0 , 1} are cluster points for the open interval (0 , 1).

[9] Given a differentiable function f on [a , b] there exists a point c in (a , b) such that f '(c) (i.e. the instantaneous rate of change of f at c) is equal to: $^{(f(b)-f(a))}/_{(b-a)}$, i.e. the *average rate of change* of f at [a , b].

[10] A Group G is a certain kind of abstract algebraic structure, that is a set S endowed with closed binary operation * (i.e. for every a, b in S there exists a c in S such that $c = a*b$.) "Natural" axiomatic characterizations of G usually run as follows: For all a,b,c in S: a) $a*(b*c) = (a*b)*c$ (Associativity), b) There uniquely exists some e in S such that for all x in S: $x*e = e*x = x$. (Identity), c) For every x there exists an x' such that $x*x' = e = x'*x$ (Inverse). As Kitcher mentions, other (non-natural) axiomaizations derive 'division' (i.e., for all x and y in S, there exists a z in S such that $z = x*y'$) from left (or right hand) identity (which in turn is derived to be equal). "[I]f we drop the restriction to *finite* groups (i.e., S can have infinitely many elements) we can show that any group satisfying the standard axioms has the division property, but [not conversely]." Hence an example of explanatory asymmetry, should one view the axiomatizations as *explanans* and the concept of group, division property as explananda.

[S]ingular why-questions are **often concerned to relate the phenomenon…to other similar phenomena, rather than to fathom the causal details of a particular situation**…The plausibility of the causal approach derives chiefly from its handling of singular propositions, [though] as we turn our attention to the explanation of general propositions, the talk of causation comes to seem forced or even inapplicable. (427-428)

- Top-down/Bottom-up theoretical explanations: "Fundamental mechanisms" (explanans) => particular causal behavior (explananda) vs 'stitching together' results from individual causal situations/sitiutaitons/events (430)

  Example (top down): Shotgun retracted upon being fired (the explanandum) *because of* Newton's Third Law (every impressed force on system 1 -> 2 experiences an impressed force from 2 -> 1 of equal magnitude and opposite direction) (the explanans.)

  Example (bottom up): Deriving (in this case usually a statistically based inference) some behavioristic principle involving physiological reactions based on observed incidences (operant conditioning, lie detector tests, etc.)

- Though Kitcher admits his logical/set theoretic characterization of explanatory unification viz. $E(K)$ is somewhat "ham-fisted[11]" (n 18, 501) he sticks by this logical methodology, in order to minimally deviate from what he considers is the best that Hempel's approach has to offer. $E(K)$ is generating set based on general argument patterns $G_A = \langle A_S , S_I \subseteq \wp(F_I) , C_A \rangle$, where:

  A_S : An **schematic argument** consisting of a sequence of schematic sentences.
  S_I : A set of a set **of filling instructions** (substituting non-logical terms with logical constants to characterize a schematic sentence in logically regimented Λ.
  C_A : Classification of the argument (what describes the inferential characteristics in A_S.

  [A]ny set of arguments derives some other members of K [is] a *systematization* of K. ***E(K)* will be the best systematization of *K*…[t]he intuitive idea behind unification is the generation of as many conclusions as possible using as few patterns.** (434)

  What is distinctive about the unification view is that **it proposes to ground causal claims in claims about explanatory dependency rather than vice versa.** (436)

[11] I.e., as we have seen in Nersessian and Giere, the cognitive philosophy of science research tradition is based on schemata employing notions like innate models and mental representations. Hence it's no surprise they have a story to tell concerning scientific explanation, using cognitive models and transformational schema which have bear only a superficial connection with FOPL and set theory. See Horty's paraconsistent default logics, John Holland, et. al (1986) network of conditional rules. *Induction:Processes of Inference, Learning, and Discovery.* Cambridge: MIT Press.

- **Kitcher's epistemic realism of unification/understanding restated:**

  I claim that to **know a theory involves the internalization of the argument patterns associated with it**…in consequence, an adequate philosophical reconstruction of a scientific theory requires us to **identify a set of argument patterns as one component of the theory**. (438)

  (His characterization of Kuhn's notion of knowledge of a theory involves *know-how*, not just *know-what* [its sentences are, in whatever formal language it happens to be characterized in.])

Margaret Morrison (2000)

- **(Asymmetry/Pluralist Thesis) (Pluralist claim) Unifying scientific knowledge is a complex and heterogeneous activity. *Contra* Kitcher there seems to be no overarching way to characterize this activity. (Asymmetry claim) Most generally: *explanation seems to follow from unification*, scientists in other words, "unify first, explain later."**

  > Where significant change will occur is in our understanding of fundamental aspects of nature…**The case for unity and convergence across the history of physics is a difficult one to make…**it simply can't be made in anything but a trivial way. (55)

- However, mathematical structure are crucial to the unifying process (106), though a unified theory does *not* entail theoretical reduction. (107) Kitcher's 'deductive chauvinism', on the other hand, would hold that theoretical reduction *is* a form of explanation.

  The act of systemizing the knowledge gained through experience enables us to discover certain logical relations that hold between particular laws of nature. This in turn enables us to unify those laws under more general principles of reasons. (13)

- **Unity (Kepler)**: Physical reality ⇔ mathematical simplicity.

  > [U]nity and simplicity were related to each other via a kind of interconnectedness…[n]ot only did phenomena have to be describable using mathematically simple relations, but the interconnectedness among these descriptions had to be manifest at the empirical level…[o]nce those two were combined, Kepler could *justify* not only the elliptical orbit of Mars but also …its motion in accordance with the area law. (9)

- **Unity (Kantian)**: An ideal, regulative principle, an 'asymptotic guideline' never realized in practice. Scientific practice however presupposes such unity in the world, however, the systematic unity of the manifold of knowledge of understanding, as prescribed by reason, is a **logical** principle. (13-14) Unity as an idealization and assumption is therefore **necessary** for scientific inquiry. (16)

- **Unity (Whewell-Peirce):** Abductive inference: Whether or not convergence constitutes an explanation depends on whether or not there is a well-established theoretical framework which can account for how and why the phenomena are unified. (20)

> The more general the hypothesis the more instances it can account for, thereby 'unifying'…[however] the more general the concept or law…the less like it will 'explain' how and why particular phenomena behave as they do." (19-20)

- Her general methodological point: Philosophy ceases to be a metascience dictating standards of rationality and instead becomes a practical discipline whose normative forces arises out of cooperation with other disciplines:

I want to argue that in true cases of unification we have a mechanism or parameter represented in the theory that fulfills the role of a necessary condition required for seeing the connection among the phenomena…**the division between unification and explanation is not uncommon in unified theories, but on the basis of the unifying process we have no principled reason to expect it to be otherwise. (32-33)**

[A]lthough unified theories themselves may share structural similarities, no hard and fast conclusions can be drawn from that about nature itself. (34)