*Recall (***Lecture XXIII**):

- In broadly metaphysical terms, philosophical theories of law or **nomology** distinguish themselves between **necessitarian** and **regularity theories.** Necessitarians argue that what underwrites nomology is its **universal** or therefore **necessary** character, whereas **regularity theorists** argue that there is nothing above and beyond **nomology** than *actual* regularities or patterns found in nature.[1] Both positions are fraught with their own distinctive difficulties (touching, for instance, on more general issues like *realism* versus *anti-realism*).

- Nancy Cartwright ("Do the Laws of Physics State the Facts?") represents a rather skeptical extreme of **regularity theory**, indeed one that seems to turn the table among most preconceptions concerning the status of laws in biology versus the laws of physics: *according to Cartwright, laws in biology state the facts (or at least are far more representative of relating real occurrences with others) while the laws of physics (especially the most 'fundamental') don't!* "Not only do the laws of physics have exceptions, unlike biological laws, they are not even true[2] for the most part, or [even] approximately true." (**CC1998,** 866)

- To gain an insight what *prima facie* may appear bizarre on the part of Cartwright's claims, it's necessary to note that her generally anti-realist position concerning laws depicts a 'trade-off' between *representational power* (i.e. the 'facticity' [p. 865] of some law *L*, regarding whether or not *L* accurately depicts facts of reality) versus *explanatory power*:

[1] A. J. Ayer (**CC1998**) makes oblique reference to the distinction in his discussion touching on issues of theology (808-809). Historically, **necessitarians** would fix their claims on lawhood as having some kind of a ***transcendent*** (i.e. going above and beyond what is ***actually*** the case) basis (whether divine or otherwise…non-theologically based notions for instance would include mathematical Platonism) whereas **regularity theorists** would ague the opposite (in an ***immanent*** notion). David Hume of course was a regularity theorist, who argued for instance *that there is no notion of empirical necessity* (the only kind of necessity is *deductive*) connecting, for instance, cause with effect (or vice versa). Causality, in other words, like *all natural law*, are derived from *actual regularities and patterns found in nature.* There is nothing more to the story, for Hume, else one could engage in armchair *a priori* reasoning and 'discover' contingent principles of nature. Ayer is likewise a regularity theorist, of a more sophisticated epistemic and logical variety. C.S Peirce was also a regularity theorist, who argued that physical laws, like organisms, can evolve in time. Dretske (not assigned in your readings) is on the other hand a necessitarian (drawing much inspiration from metaphysical and logical theories of *essentialism* developed by Saul Kripke and Hilary Putnam.)

[2] "True" in the sense of presupposing a **correspondence theory of truth** (recall **Lecture II**); A statement φ is true if and only if φ corresponds with or represents some objective state of affairs. (The statement "the cat is on the mat" is true provided the statement represents some objective state of affairs in the world, in the case, some particular fact concerning some particular cat and its spatial location with respect to some particular mat.)

[O]ur explanatory laws don't tell us what they [i.e. theoretical entities] do. It is in fact part of their explanatory role not to tell…**I am worried about truth and explanation, and how one excludes the other.** (867)

The failure of facticity does not have so much to do with the nature of physics, **but rather with the nature of explanation.** We think that nature is governed by a small number of simple, fundamental laws. [On the other hand] [t]he world is full of complex and varied phenomena, **but these are not fundamental.** They arise from the interplay of simpler processes obeying the basic laws of nature. (868-869)

[A] law must describe one effect (the effect which actually happens); but to be explanatory, it must describe another. **There is a trade-off here between truth and explanatory power.** (869)

- Her 'facticity' versus 'explanatory power' distinction could be (to a certain extent) likened to Hempel's **Requirement of Maximum Specificity** (or RMS--recall **Lecture XVIIIb)**. Contrary to Hempel's RMS, however, Cartwright takes a dour view concerning the worth of an explanation the more it's rendered specific in the 'facticity' sense. As she states above in the second passage**: "The world is full of complex and varied phenomena, but these are not fundamental."** **Metaphysically** she presupposes that the specific *appearances* of the world, i.e. the *facts* (concerning actual objects and actual systems) that present themselves aren't 'fundamental', i.e. are in some way 'derivative,' to the extent that **epistemically** the more an 'explanation' becomes precisely specific (insofar as representing such 'complex' facts) it loses its *general* character of an explanation to the extent that it becomes a *specific description*.

- This specific 'facticity' (=description) versus general 'explanation' notion is a theme we've explored previously, concerning Kitcher's 'unification' versus Salmon's 'detailed casual account.[3]' (recall **Lectures XIX, XX**) In this respect, regarding the notion explanation, Cartwright pushes the **methodological** notion that **explanation *is* reduction.** She states this explicitly, as a matter of fact:

  [W]e explain complex phenomena by **reducing them to their simpler components.** This is not the only kind of explanation we give, but it is an important and central kind. (869)

- **Note 1**: Laying her above qualification aside (as stated in the second sentence: "…not the only kind of explanation we give") nevertheless her antirealism concerning explanation relies heavily on this presupposed methodological reductionism. Recall however (**Lecture XX**) that this is by no means a given or obviously agreed upon assumption! Margaret Morrison, for instance, as we have seen, is a methodological pluralist and does not believe that to explain is to reduce

[3] In Kitcher's and Salmon's terms, yhe 'explanatory store' $E(K)$ for Kitcher maximally unified over the set K of knowledge-claims, by minimizing the number of *ad-hoc* statements in K. While for Salmon the 'ideal explanatory text' (I-E-T) gave an ideally complete account of all the fundamental causal processes (down to the level of the microphysical) of a particular phenomenon.

to simpler components, simply because explanation presupposes unification, and as she claims, *there is no obvious connection between unification (as a theoretical activity) and actual unity in nature*. Ask yourself: Would Cartwright's skepticism here concerning '[facticity] truth and explanatory power' wither once this methodological reductionism is removed?

- Aside from her chief assumption of explanatory reductionism, however, her anti-realism comes equipped (in complementary) fashion with some metaphysical presuppositions. She draws a distinction between ***causal powers*** versus ***actual production***.[4] She employs this distinction to dispel the obvious objection to her claim that the *ceteris paribus* ("all things being equal") modifiers implied in fundamental laws like for instance the gravitation (Newton), electrostatic (Coulomb), magnetodynamic (Lorentz), etc. force laws don't restrict the truth to just such cases when a particle happens to be subject to just *one* of those forces, but that the truth of such laws hold in the more complex cases simply because the *total* force is simply the *vector sum.*

  For example, as is usually conceived of textbook physics, as articulated by J.S, Mill in his notion of the *composition of causes*[5] suppose a (slightly charged) particle (of charge q) is in 'free-fall', i.e. falling through a non-zero electric and magnetic field ($\vec{E}$ & $\vec{B}$, respectively) through a medium which isn't a vacuum (like air, with local density ρ). **In other words, imagine a realistic situation**. Then the natural response is that the actual force the particle feels is simply the *vector sum* of component forces. Expressed mathematically, we'd say a particle (of mass m) has a center of mass accelerating according to Newton's second law[6]:

$$\vec{F} = m\vec{a}$$

  where: $\vec{F} = \vec{F}_G + \vec{F}_C + \vec{F}_B + \vec{F}_V + \ldots$ is such a vector sum of component forces, describing respectively gravitational (weight) force, electrostatic force, magnetodynamic, friction (viscuous) force, etc. (Such component forces in turn are of course describable by laws stated in algebraic formulae: $\vec{F}_G = G\frac{M_E m}{r^2}\hat{r}, \vec{F}_C = q\vec{E}, \vec{F}_B = q\left(\vec{v}\times\vec{B}\right), \vec{F}_V = \rho v^2\hat{r}, \ldots$ respectively describing Newton's laws of universal gravitation, Coulomb's law of electrostatic

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[4] In some of her later writings (*How the Laws of Physics Lie* [1983] and *The Dappled World* [1999]) she expands on this distinction, paying homage to Aristotle's modal and metaphysical distinctions of *potentiality* versus *actuality*. In both general and specific ways, Cartwright's claims (as she herself mentions) share much in spirit with Aristotle's.

[5] That the causal behavior of the *whole* (Newtonian) mechanical system is simply the sum of its individual causal parts.

[6] The arrow superscript denotes a *vector*. A vector is a (geometrical) object that possesses two properties: *magnitude* and *direction.* For example, *weight* is a vector, since when one states: "I weigh 150 lbs," magnitude and direction is presupposed. The magnitude of course is what the bathroom scale reads (in this case, 150 lbs). The *direction* however is downward, measured with respect to perpendicular to the local surface on the earth.

attraction, Lorentz's law of magnetodynamic interaction, Rayleigh's law of viscosity, etc.[7]

To all this Cartwright responds:

> The vector addition story is, I admit, a nice one. **But it is just a metaphor**. *We* add forces (or numbers that represent forces) when we do calculations. **Nature doesn't 'add' forces. For the 'component' forces** [i.e., $\vec{F}_G, \vec{F}_C, \vec{F}_B, ...$in the example above] **are not there, in any but a metaphorical sense, to be added; and the laws which say they are must also be given a metaphorical reading.** (869, emphasis added)

Cartwright, in other words, is an *antirealist* when it comes to component forces. They are convenient mathematical devices existing in a 'metaphorical sense.' So in the above realistic scenario, the particle *feels* some *actual* force $\vec{F}$, that's for sure, but to say that this force 'is the sum' of components described by the above law is akin to saying that motion in the NE (northeasterly) direction 'is the sum' of motion in the N and E direction[8]:

> [However] [w]hen a body has moved along a path due northeast, **it has traveled neither due north nor due east…The lesson is even clearer if the example is changed a little: a body is pulled equally in opposite direction. It doesn't budge an inch, but on Mill's it has been caused to move…to the left and…to the right.** (870)

Is this anti-realism a fair characterization of Mill's composition view (which expresses, as mentioned above, the ordinary 'textbook physics' conception)? Basically Cartwright makes much hay out of this aforementioned potential actual distinction: *component forces represent causal powers* (i.e. what potentially the case.) "[T]he laws we use talk not about what bodies [actually] do, but about what powers [potentials] they possess." (871)? At best, such laws (like in the case of force laws like gravitation, Coulomb, etc. in the example discussed above) *support counterfactuals*[9]: *If* no other forces act on the body (i.e., Coulomb, Lorentz, Viscuous, etc) *then* the force acting on the body is subject to Newton's law of gravitation. However, since this scenario is basically non-existent (real bodies possess some local distribution of charge, the earth possesses an atmosphere, as well as a magnetic field) the law (in this case Newton's universal gravitation) does not represent the truth:

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[7] Where M_E stands for the mass of the earth, G is the universal gravity constant, r is the distance of the particle away from the Earth's center, v is the speed of the particle, etc.

[8] The common intuition here, as expressed for example in Mill's *direct composition law.*

[9] Recall **Lecture XXIII**, supporting counterfactuals is considered a necessary condition separating generalizations of fact (like 'all students in this class are male') versus nomic generalizations. The latter should support counterfactuals (i.e. if the fact were different than they are) whereas the former don't. For example, in the case of everyone being male in a co-ed university class, we recognize that this statement doesn't hold in a counterfactual situation (if a woman happened to enroll).

The laws of physics…to the extent that they are true, don't explain much. We could know all the true laws of nature, and still not know how to explain composite cases[10]. (876)

To put it another way, the world of 'complex facts' involves for all intents and purposes composite cases.

- In terms of Kitcher versus Salmon, (unification versus causal story) Cartwright seems to advocate both, in terms of her conception of explanation, in her examples involving the carbon atom (871-875). Her she argues that the 5 level *cannot be accounted for any composite force addition* (contrary to the case discussed above involving free-fall). The last stage (c) involving the fine structuring due to electron spin is *not* accounted for by any force laws, but by general group-theoretic considerations involving symmetry and dynamics. These general symmetry considerations function analogously to Kitcher's unifying devices, while the individual component forces can be thought of as individual causal contributing agents (a' la Salmon). Hence:

  In the space of spin-orbit coupling…quantum mechanics provide general theorems about symmetry groups, [etc., i.e., Kitcher's unifying devices]…from which we can derive, covering-law style[11] the energy level of carbon…**On the other hand, to do so only misses the detailed causal story [i.e., Salmon] of *how* the splitting of spectral lines by the removal of symmetry manages to get worked out in each particular case.** (875)

- **Note 2**: Cartwright's insightfully anti-realistic position concerning component forces viz. actual versus potential causal production may nevertheless leave one with a general sense of unease. You're not alone, if you do feel that way. Like many influential present-day philosophers of science, she has her fair share of critics. Where do you think she may be engaging in question-begging, if you object to her assessments? Consider again the presupposed reductionism, (**Note 1** above), her notion of truth-as strict description, and her demand laws describe *actual dynamics* as opposed to kinematic principles. What would Cartwright say concerning kinematic constraints like no signal can travel faster than the speed of light in a vacuum? Can't laws be expressed as general constraints? Must these be classified as fictions?

[10] I.e. cases, like the one listed above concerning the body in free-fall, which is subjected to a variety of forces.
[11] Recall **Lecture XVIII**, the D-N schema.