



Reduction



The Legacy of Logical Positivism

- Positivism: positive knowledge: knowledge grounded on perception
- Logic: the tool for building up from these foundations
- Hypotheses, laws, and theories: general statements that go beyond individual cases
 - General claims
 - Explain individual phenomena

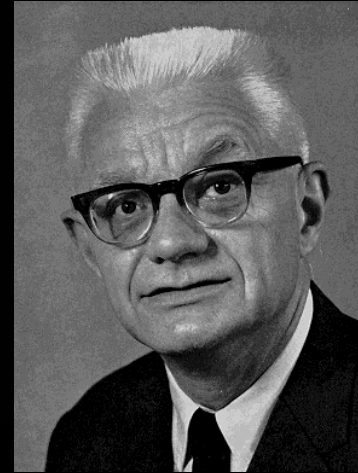
Vienna Circle: Neurath, Gödel, Schlick, Carnap, et alia






The D-N Model of Explanation

- Logic links the generalizations to the particulars that are to be explained
- Hempel and Oppenheim (1948): Explain a phenomenon by showing that a description of it followed logically
 - Law(s)
 - Initial conditions
 - ∴ Phenomenon to be explained
- Deductive-nomological (D-N) model of explanation





Major Concern of the Positivists: Unity of Science

- How to relate the findings of the different sciences so as to make for a unified account of the world?
- Think of phenomena, and the disciplines that study them, as layered in levels

Social sciences—Societies

Behavioral sciences—Individuals

Physiology—Organs and organ systems

Molecular and Cell Biology—
Cells or organelles

Biochemistry—Macromolecules

Physical chemistry—Molecules

Physics—Atoms



Theory Reduction

- Putnam and Oppenheim: extended the D-N model to explain the relation between theories:

Theory at lower level (statistical thermodynamics)

Bridge laws

Boundary conditions

∴ Theory at higher level (phenomenological thermodynamics)


- Critical requirements:
 - Theories at both levels
 - Bridge laws relating the vocabularies





Reductionism applied to theory succession

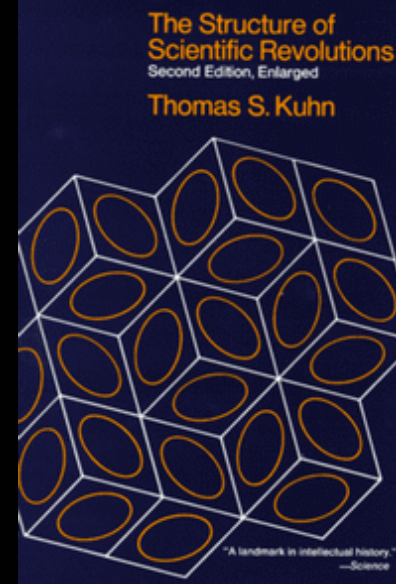
Reduce an old scientific theory to its replacement
(Newton to Einstein)

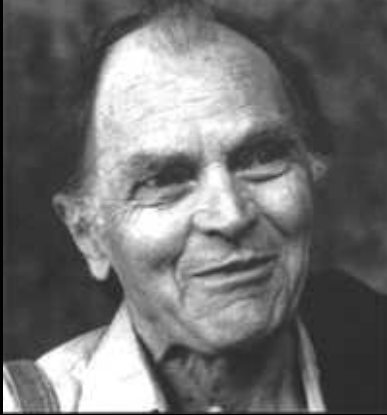
1. Enables old theory to be corrected
 2. Provides deeper insight and more effective control over phenomena in the old theory's domain
 3. Provides us with a simpler account (as multiple old theories are all reduced to the same new theory)
 4. New theory inherits all the evidence of the old theory
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The specter of incommensurability

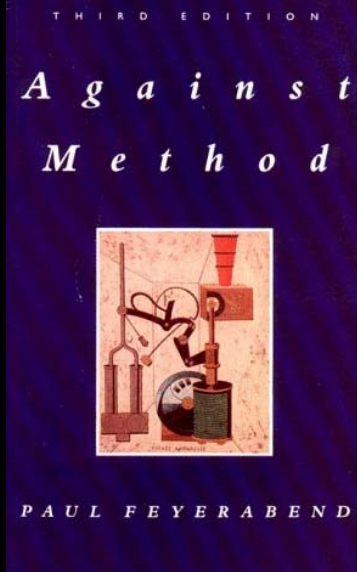
- An examination of the history of science suggests something different
 - Revolutions between incompatible theories
 - Revolutions arise when old theories are failing and are *replaced* by new theories
- Contrast between normal and revolutionary science






Paul Feyerabend

- Emphasized the radicalness of theory change and its irrationality
- "Given any rule, however 'fundamental' or 'necessary' for science, there are always circumstances when it is advisable not only to ignore the rule, but to adopt its opposite." – Paul Feyerabend
- "The best education consists in immunizing people against systematic attempts at education." – Paul Feyerabend



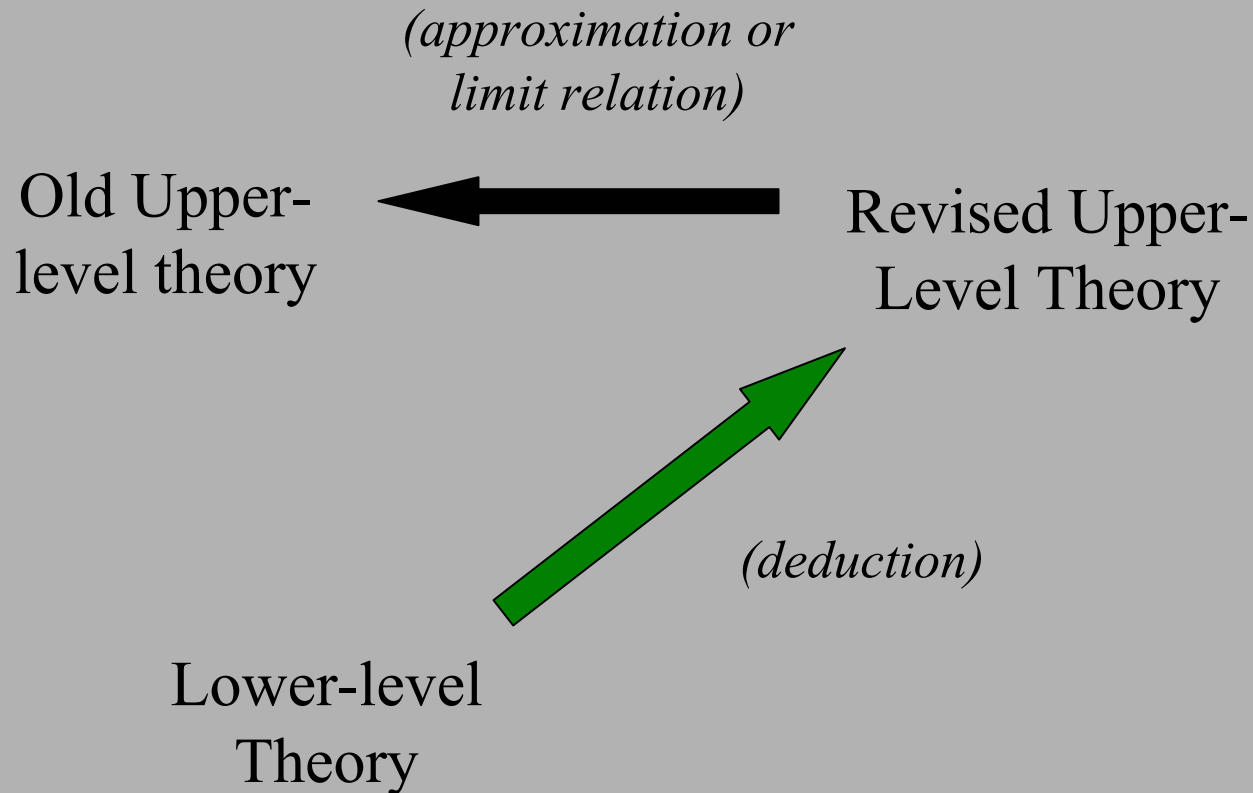


Incommensurable Theories

- Newtonian mechanics and special relativity:
 - Newtonian mass is absolute
 - Einsteinian mass is relative
 - Newtonian velocity measured from absolute rest
 - Einsteinian with respect to a reference frame (only the speed of light is fixed in all reference frames)
 - These differences are not patched over by translation manuals—they reveal different ontologies
 - But one can show how Newtonian equations approximate Einsteinian ones under special conditions
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Schaffner's integrated model of reduction



Churchlands' Reduction- Replacement Continuum




Reduction


Revision

Replacement


- Kepler to Newton
- Heat to mean molecular energy


- Newton to Einstein

- Phlogiston to oxygen
 - Ptolemy to Copernicus
 - Humors to modern medicine
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Mendelian and Molecular Genetics

- Can Mendelian genetics be reduced to molecular genetics?
 - Intuition: this does not seem to be a case of revolution—Mendelian genetics not replaced by molecular genetics
 - Molecular genetics gives a fuller account of what Mendelian genetics describes
 - Some features of Mendel's story revised
 - Dominance not strict
 - Polygenic traits
 - Independent assortment fails when genes on the same chromosomes but this does not require replacement
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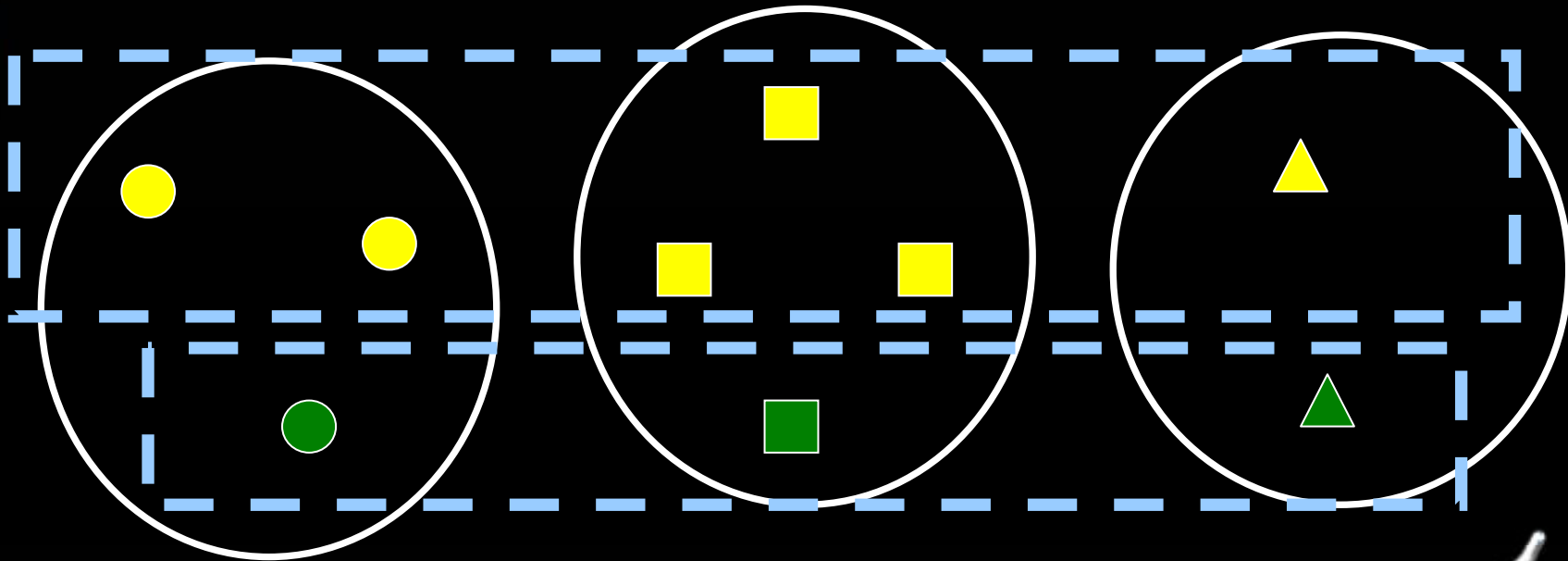


Challenge: Derive a Revised Mendelian account from Molecular Genetics

- Segregation easy: factors on separate chromosomes that themselves segregate in meiosis
 - Revision to independent assortment easy: linkage groups on chromosomes
 - Dominance: seems like the thing to explain molecularly
 - how does one allele get expressed but not the other?
 - Need to map notions like allele, gene, expression, etc. on to terms of molecular genetics
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The challenge for bridge laws


- The categories of two theories may cross-categorize the phenomena



Even worse, what if the only thing that the items that fit the higher-level category share is that they fit the higher-level category?

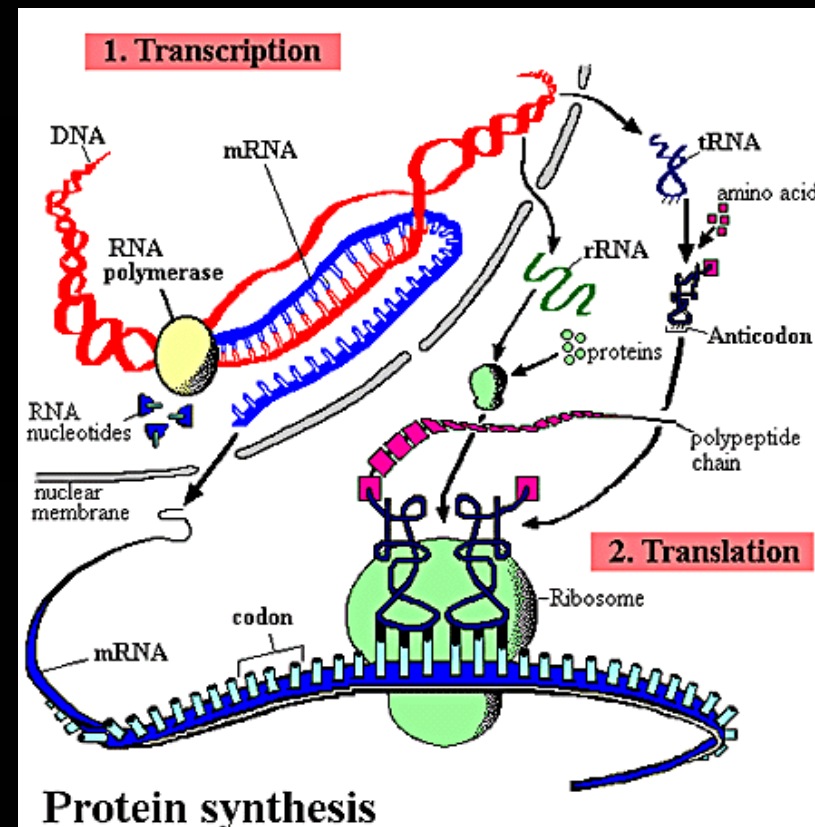


Mendel's factors

- Units of
 - Inheritance—passed on
 - Variation—mutation
 - Coding for traits
 - Differing amounts of DNA play these roles
 - Inheritance involves copying strands of DNA
 - Mutation involves single nucleotides
 - Coding for traits requires long strings of nucleotides
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Molecules and traits

- Is a length of DNA itself to be equated with a Mendelian trait?
 - Or it plus the whole machinery involved in expression





Too stringent a view of reduction?

- “What geneticist could take seriously any explication of ‘reduction’ which leads to the conclusion that molecular genetics does *not* amount to successful reduction of classical genetics” (Gunther Stent)
 - Is there an account of reduction that is not tied to logical deduction between theories?
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Darden and Maull's Interfield Theories




- Identify relationships between phenomena studied in different fields
 - Identifying the physical location of a process
 - Provide physical characterization of functional entity
 - Locate the cause or effect of a phenomena
- Example: chromosomal theory of Mendelian heredity
 - Led to new problem-solving research—explain patterns of joint heritability of traits in terms of linkage on chromosomes
- No need to derive one theory from the other
- **Develop a theory that spans fields**, not a relationship between two complete theories






Sterelny and Griffiths: Mendelian Genes not Defined Molecularly

- “Mendelian kinds *may have no distinctive molecular property in common*. Therefore the bridge principles are not lawlike. They do not connect a natural kind identified by hybridization and observation with a natural kind independently identified by molecular biology.”
 - Properties read onto molecular genetics for Mendelian genetics: “What properties do the molecular structures that count as alleles all share? *They have some effect on the phenotype*, perhaps through their epistatic effect on the expression of alleles at other loci, *and they occupy chromosomal locations that cause them to assort and recombine so that those phenotypic effects are expressed in Mendelian ratios.*”
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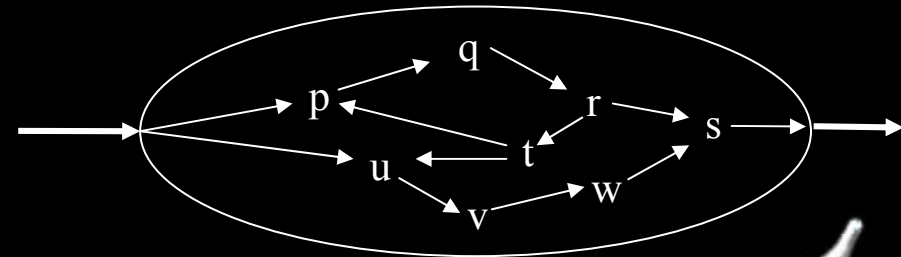
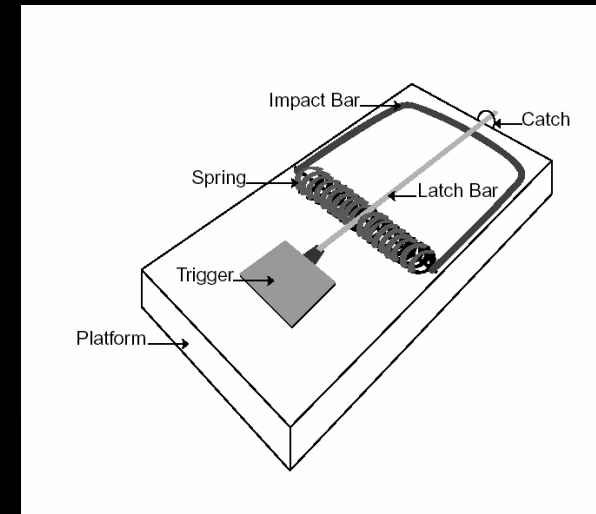


Sterelny and Griffiths - 2

- “The molecular ensembles that correspond to the Mendelian kinds do not emerge from molecular biology, but are constructed by grouping together diverse molecular events that look the same when viewed using the experimental techniques of classical genetics. *The reduction relationship this generates is not one in which the new theory explains the old, but one in which the new and old theories represent complementary and mutually illuminating ways of viewing the same physical processes*” (p. 138).
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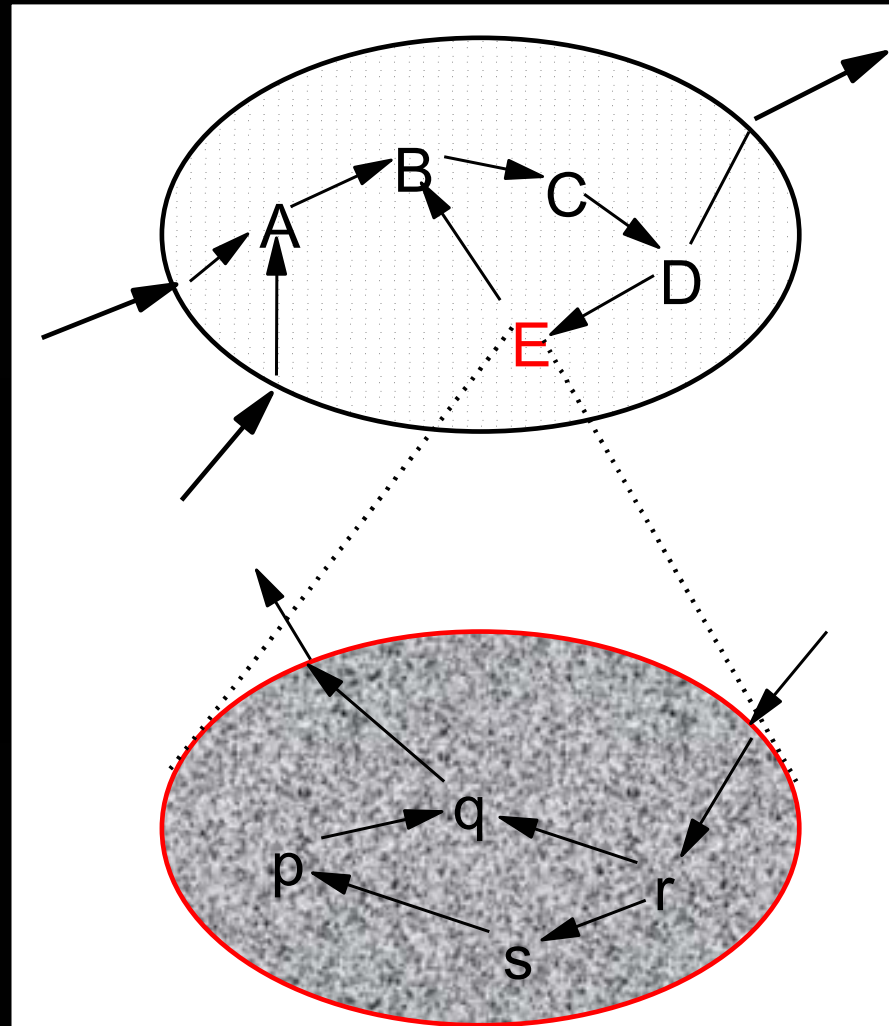
Mechanisms and reduction

- Models of mechanisms don't have to be represented as theories in traditional form
 - Accounts of how the *operations* of *components* of a mechanism are *coordinated* to perform the *activity* of the mechanism



Mechanisms and reduction

- Parts of mechanisms are themselves mechanisms
- Can be decomposed into the operations of their parts and the organization imposed on them
- Allows for relating levels without deriving laws



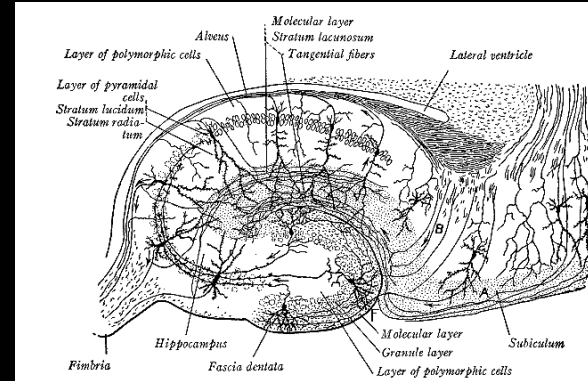
DNA and UCSD Classes

- Some strands of DNA have been in close proximity to each other twice a week for the past five weeks
- Why?
 - The relevant causal interactions are not at the DNA level
 - For whatever reasons, I taught this class and you took it
 - When we all come to class, so does our DNA
 - It doesn't have any choice
 - It comes along for the ride



Working parts and higher-level constraints

- When you came to class, so did another part of you—your hippocampus
- According to our best theories today, the hippocampus plays a critical role in encoding memory of events
 - When you learn new information, cells in your hippocampus are altered
 - Over time, your hippocampus produces changes in cortex which constitute long-term memories of what you've learned






“Either-or” Treatment of Reduction

“Reductionism is the process of *reducing complex things to their smallest parts rather than looking at them as a whole*. . . . In biology, reductionism fosters the belief that our behavior can be explained by studying the molecules and atoms that make up our DNA, rather than examining the whole animal in its environment.”

“Biologists today tend to believe that work at the molecular level will yield a more profound understanding of nature than the study of entire organisms. The work of naturalists tends to be dismissed as fuzzy science. . . . While there is no doubt that we have much to gain from molecular biology, the reductionists often lose sight of the forest in their zeal to examine the molecules in the twigs.” (Institute for the Study of Academic Racism”





A more moderate reductionism

- Reductionism does not require explaining everything at the lower (lowest) level
 - There is always a task to do at a lower level—explain how a component of a system is able to perform its operation *under the conditions in which it performs them*
 - But there are also tasks for the higher level(s)
 - Identify how the component interacts with others
 - Show how higher level activities affect the component
 - Show how the conditions arise under which the component behaves
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