Manuel DeLanda, *Intensive Science and Virtual Philosophy* (London: Continuum, 2002)

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INTRODUCTION: Deleuze's World

I. Audiences:
  A. analytic philosophers of science and philosophically minded scientist
    1. Difficulties
      a. Confusion with postmodernism
      b. D's resources
    2. Strategy: Reconstruction of D (his world, not his words: see appendix)
      a. not an interpretation of what he wrote:
      b. D's conclusions as robust to changes in theoretical assumptions and strategies
      c. i.e., as virtual (mechanism-independent)
  B. Deleuzeans (p.6):
    1. MDL admits there is much more to D than just ontology
    2. Reconstruction as violence
      a. to D's texts
      b. to collaboration with Guattari
      c. to D's style
II. Focus on D's ontology, not his full philosophy
  A. D as realist (thus not pomo)
  B. Immanentist (thus anti-essentialist)
  C. Explains individuation through [immanent] dynamical processes
III. Forecast of book:
  A. Chapter 1: mathematical-formal ideas about virtual structure of dynamical processes
  B. Chapter 2: spatial aspects of differential morphogenesis
  C. Chapter 3: temporal aspects of differential morphogenesis
  D. Chapter 4: D's problematic epistemology:
    1. devalue axioms / truth in favor of problems / importance & relevance
      a. Not general laws (linguistically interpreted), but correctly posed problems
      b. Problems concern the distribution of singular and ordinary (important & not)
      c. Not a closed world capturable by sentences, but an open world to be explored

CHAPTER 1: The Mathematics of the Virtual: Manifolds, Vector Fields and Transformation Groups

I. Introduction to Multiplicities (9-10)
  A. Deleuze's signature concept (9)
  B. Intended as replacements for essences (9-10)
    1. Essential definitions explain
      a. Identity of species
      b. Resemblance of species members
    2. For Deleuze, morphogenetic processes
      a. Explain identity of species and resemblances
      b. Are immanent processes (use material self-organizing resources)
      c. Structure of such processes (mechanism-independence) are virtual
  C. Multiplicity: structure of space of possibility: regularities of morphogenetic processes (10)
II. Manifolds (10-16)
  A. Origins of construction of manifolds (11-12)
    1. Descartes and Fermat: two-dimensional co-ordinate space
      a. embedding of curves in co-ordinate space: assigning numbers to points
      b. allowing use of algebra to explore geometric relation
    2. Gauss: differential geometry:
      a. Calculus to find instantaneous value (for rate of change of properties of geometrical objects)
      b. Study of surface w/o reference to embedding space: "surface is space in itself"

3. Riemann: N-dimensional space
B. Deleuzean multiplicity uses two traits of a manifold (12-13)
1. variable number of dimensions
2. absence of higher space
a. that gives extrinsic co-ordinates,
b. and hence a unity (as an essence provides a unity)
C. Relation of geometric properties of manifolds and properties of morphogenetic processes (13-16)
1. Dynamical systems theory:
a. Dimensions of manifold represent properties of processes or systems
b. Manifold represents state space: model of physical processes
2. Modeling process:
a. Define degrees of freedom (relevant parameters: ways system can change)
b. Map each degree of freedom onto a dimension of the manifold
c. State of system then = a point in the manifold [= "state space"]
d. Trajectory of curve of point's motion = model of behavior of system
3. Use topology to determine recurrent behavior across models and hence systems
a. Poincaré discovered singularities (= topological feature of state spaces)
(1) singularities act as attractors (with basin of attraction)
(2) represent long-term tendencies of systems
(a) points: steady state
(b) loops: oscillations
(c) [chaotic: turbulent]
b. Example of how using singularities changes view of morphogenesis
(1) minimal free energy as point attractor: soap bubble and crystal
(a) same topology [virtual structure]
(b) different [intensive] processes [mechanism-independence]
(c) different geometric properties of products
(2) singularities structure manifolds, which represent state spaces [possibilities]
III. Differences between essences and multiplicities (16-28)
A. Multiplicities: obscure / distinct, while essences are clear / distinct (16-22)
1. obscurity of multiplicities: sets of singularities must unfold = progressive differentiation
2. Egg metaphor: embryogenesis:
a. zones of biochemical concentration
b. physical polarities (bulk of nucleus / yolk)
3. Technical definition of progressive differentiation: group theory
a. Group = set of entities (w/ property of closure) and rule of combination
(1) Groups of transformations: classify geometric figures by invariants
(2) degree of symmetry = # of transformation that leave a property invariant
(a) this amounts to a classification by affect [intensive property]
(b) can now envision conversion by symmetry-breaking transition
i) phase transitions in physical systems display symmetry-breaking
ii) gas more symmetrical than solid, so gas becoming solid = symmetry-breaking
4. Progressive differentiation in state space
a. Bifurcation = symmetry-breaking that converts a [set of] singularity[ies] into another
b. Study bifurcators: manipulating control parameters determining strength of external shock
c. Critical values of control parameters = threshold of bifurcation
d. Bifurcations have recurrent sequences [as singularities have recurrent forms]
(1) examples:
(a) heating liquid actualizes the conduction / convection / turbulence sequence
(b) also in biological morphogenesis [gene products facilitate a sequence]
(2) thus virtual bifurcations are mechanism-independent; actual processes are specific
B. Multiplicities as concrete universals [attractors linked together by bifurcators] (22)
1. Not general essences
2. But divergent universality of multiplicities:
a. Different actualizations bear no resemblances
b. Multiplicities structure processes, not product
C. Multiplicities are meshed together in a continuum yielding zones of indiscernability (22-28)
1. Not strict division of essences

2. Requires movement from continuous to discontinuous spaces
   a. Space = set of points & means of binding them into neighborhoods by proximity / contiguity
      (1) Euclidean space is a metric space because points are bound together by fixed lengths
      (2) other [e.g., topological] spaces are non-metric, but closeness can be defined as “infinitesimal"
3. non-metric spaces can become metric through progressive differentiation
   a. Detour through 19th C geometry:
      (1) Hierarchy: topology - differential - projective - affine - Euclidean geometries
      (2) Abstract scenario for birth of real space
   b. compare metric / non-metric geometrical. properties to extensive / intensive physical prop.
      (1) Extensive: intrinsically divisible
      (2) Intensive: cannot be divided w/o a change in kind [phase transitions]
   c. intensive space progressively differentiates to yield extensive structures
      (1) example from quantum field theories
         (a) splitting off of gravity from undifferentiated primal force
         (b) gravity constitutes metric structure of 4-dimensional manifold spacetime

D. Recap of differences between multiplicities and essences (28)

IV. Transition: (28-29)

A. Self-criticism of presentation as metaphorical: forecast of Ch 2 as removing metaphor

B. Forecast of rest of Chapter 1

V. Detailed analysis of nature of multiplicities (29-44)

A. Technical details of D’s ontological interpretation of contents of state space (30-32)

1. Construction of state spaces
   a. Choice of manifold as model
   b. From experimental observation (from actual series of states) we create trajectories
   c. Differentiation operator applied to trajectories to generate velocity vector field
      (1) this models inherent tendencies of many trajectories [in (d) below] by means of
      (2) singularities
         (a) precise nature only known in step (d) below
         (b) but this step (c) gives existence and distribution of singularities
         (c) are asymptotic attractors of trajectories; hence they are never actualized per se
            i) asymptotic stability of trajectories relative to a basin of attraction
            a) tested by perturbing trajectories
            b) to see if they stay w/in a basin of attraction
            ii) structural stability of distribution of singularities in vector field of state space
            a) tested by perturbing vector field [by adding small vector field]
            b) to see whether resulting distribution is topologically equivalent
            c) or if a bifurcation event results in a new distribution
   d. Integration operator applied to vector field for further trajectories to create phase portrait
      (1) these trajectories model succession of actual states
2. Deleuze: ontological difference btw recurrent features (c) and trajectories (d) in state space
3. FINAL DEFINITION OF A MULTIPLICITY:
   nested set of vector fields related by symmetry-breaking bifurcations, plus distribution of attractors

B. Modal status of multiplicities: virtual and actual vs possible and real (33-39)

1. Modal status of possibilities: Quine jokes about difficulty of individuating possibilities
   a. Many approaches to modal logic concentrate on language:
      (1) on counterfactual sentences
      (2) linguistically specified possible worlds
   b. Ronald Giere uses state space approach to possible worlds
      (1) each trajectory = one possible historical sequence
         (a) defined by laws
         (b) and by initial conditions
      (2) we have many trajectories / possible histories: what are the statuses of the unchosen?
         (a) “actualism”: all trajectories are fictions, mere properties of a math model as tool
         (b) Giere: this misses global regularities of field, which influences how counterfactual behavior
         (c) Deleuze is not an “actualist,” but he would have differed from Giere:
            i) regularities of trajectories are consequence of singularities shaping vector field
            ii) and thus misses the ontological difference [and source of order]
   c. Focus on linear equations (typical in classical physics due to math limitations) obscures:

(1) ontological difference of singularity and trajectory
(2) bcs vector fields are so simple
(a) one fixed point for linear dynamic systems
(b) no attractors, only trajectories for quasi-isolated conservative systems
d. in more typical cases (nonlinear systems) w/ multiple attractors vector field can't be ignored
(1) the state space is partitioned into cells (basins of attraction)
(2) attractors may be of different types
2. Modal status of virtual [singularities]: (why create a new modal status for singularities?)
a. Objection: could restrict singularities to realm of possible
(1) option: by considering basin of attraction as merely a subset of points of state space
(2) response: existence & distribution of singularities are given in vector field, before phase portrait
(a) they thus define overall flow tendencies of vectors
(b) even point attractors are asymptotic: never actualized (systems fluctuate around point)
b. Objection: could use traditional notion of necessity for modal status of singularities
(1) option: classical physics
(a) general laws relate successive points in necessary way
(b) initial conditions specify which trajectories are necessarily generated
(2) response: but singularities change the action of general laws and initial conditions
(a) many initial conditions (w/in a basin of attraction) produce same goal for trajectory
(b) end state trajectories determined by attractor, not by general laws (historical linkage of states)
c. Objection: these arguments only necessitate considering other factors, not a new modal status for attractors
(1) option: are not end states in these cases necessary?
(2) response:
(a) again, we have excessively simple model in mind: single point attractor
(b) multiple attractor spaces break the link between necessity and determinism
i) the actual basin of attraction the system inhabits at any one time is contingent
ii) the specific distribution of attractors may change given a bifurcation
3. NB: Deleuze does not use the above arguments, although they are consistent with his ontology
[in other words, DeLanda as created a divergent actualization {a differentiation}of Deleuze]
C. Guides to speculation in D: constraints of avoiding essentialism (39-44)
1. Possible worlds postulating fully formed individuals imply commitment to essentialism
a. Particular essences: transworld identities
b. General essences: transworld counterparts
2. Deleuze:
a. Two constraints:
(1) Avoid essentialism: morphogenesis by pre-existing forms
(a) insisting on genetic account of individuals
(b) Critique of the possible as mere addition of reality:
i) assumes predefined form retaining identity despite non-existence
ii) and resembling forms adopted when realized
(2) Avoid typological thinking: classification by resemblance of properties of products
(a) avoid classification by resemblance and identity of products
(b) these are to be treated as mere results of physical processes
i) bio-speciation processes: sorting by selection and consolidation by isolation
a) uniform selection (sorting): resemblances among species members
b) strong isolation (consolidation): identity of species
ii) chemical / physical processes: gold example: intermediate structures
(c) avoid [subjective] classification by analogy and opposition
i) must give account of objective possibility of such judgments
ii) [by revealing virtual structures of production processes]
VI. Conclusion / forecast (44):
A. Constraints: avoiding essentialism and typology
B. Resources:
1. Traces of virtual left in intensive processes it "animates"
2. Role of philosopher:
a. Follow these tracks / clues
b. Develop reservoir of conceptual resources to complete project sketched in this project
(1) defining multiplicities

(2) describe formation of virtual continuum [theory of virtual space]
(3) specify relation of multiplicities to actual history [theory of virtual time]
(4) describe relation of virtuality and laws of physics
c. Completing project will result in a leaner ontology: eliminating laws of physics and essences

CHAPTER 2: The Actualization of the Virtual in Space

I. Extensity: Production of the extensive from intensive processes (46-58)
A. Bio-speciation: populations and rates of change replacing fixed types and ideal norms (46-51)
1. Actual: Species as individuals rather than kinds [flat ontology]: (46-47)
a. Part-whole [causal] relations w/ members, not exemplification
b. Differences in scale, not ontological status
2. Intensive: Need to specify intensive speciation process (47-50)
a. Population thinking vs typology:
(1) population and heterogeneity:
(2) homogeneity must be explained
b. Rates of change [norm of reaction] vs ideal norms or degrees of perfection
(1) flexible relation of genotype / phenotype
(2) to allow for relations of rates of change [environmental change / gene change]
c. Intermediate structures: demes as concrete reproductive communities
3. Virtual: Relation of intensive processes to virtual multiplicities (50-51)
B. Organisms: structures & qualities produced in embryogenesis (51-58)
1. Spatial structuration: cellular migration, folding, invagination (52-54)
a. Adhesion processes [1st articulation: substance and form of content]: molecular
(1) sheets
(2) migratory groups
b. Structural formation [2nd articulation: form and substance of expression]: molar

NB: anexact yet rigorous thought necessary for nonmetric/intensive processes

2. Qualitative differentiation of neutral cells into muscle, bone, blood, nerve, etc. (54-56)
a. Kauffman's model for induction:
(1) network of gene activation: intensive property of connectivity
(2) Replaces parts of simple symmetry-breaking cascade model
3. Assembly of organisms with capacity to evolve (56-58)
a. Mechanics: rigid assembly
b. Biology: open space for search for new forms
(1) topological connectivity:
(2) diffusion through fluid medium
(3) lock and key assembly
4. Recap (58)
II. Intensity: Nature of intensities and their concealment in "objective illusion" (59-68)
A. Nature of intensities (59-64)
1. Recap:
a. Indivisible w/o change of nature
b. Non-additive, but averaging
2. Diversity [properties of given products] vs difference [productive intensive differences]
a. Stable states
b. Critical transitions
3. Biological intensities: gradients measured by rates of change drive changes
a. Molecular movements [of populations of units]
b. Energy movements through population
4. Production of affects: capacities for affecting or being affected:
a. Open combinatorial spaces [affect space]
b. Kauffman proposes study of recurrent assembly patterns (e.g. autocatalytic loops)
c. Affects and assemblages
d. Gibson and affordances

        5. Expanded sense of intensity: capacity to form heterogenous assemblages:
            a. Relating difference to difference
            b. Endowing process with capacity of divergent evolution
    B. Concealment of intensive under the extensive (64-68)
        1. Limits of classical thermodynamics: (64-65)
            a. Focus on final equilibrium state
            b. But this is only subjective amplification of an objective illusion
        2. How then to allow virtual to manifest itself? (65-68)
            a. Study far-from-equilibrium systems
                (1) maintain intensive differences
                (2) nonlinear, multi-attractor systems
            b. Pay attention to the coexisting nonactualized [i.e., virtual] attractors
            c. Beware temptation to study them in low-intensity states [= linearization of system]
        3. Philosophy thus as counter-actualization [e.g., study of the 'virtual limb' of tetrapods] (68)
III. Virtuality: Attaining the virtual [demetaphorization of state space model] and exploring affects (68-77)
    A. Introduction (68-71)
        1. Metaphoric sketch of symmetry-breaking of a topological space (69)
        2. Target for a theory of the virtual: (69-70)
            a. Meshed continuum of heterogenous spaces
            b. Continuum = "space of spaces" [= plane of consistency =synthesis of heterogeneity as such]
    B. 'Philosophical transformation' of math concepts of vector fields into philosophical concept of multiplicity (71-74)
        1. Virtualizing the differential (71)
            a. Function as mathematical individuation process (take input and output a trajectory)
            b. Deleuze removes relation of input (independent) and output (dependent)
                (1) to reach pure reciprocal determination
                (2) i.e., not delta x / y but delta x / delta y
        2. Virtualizing singularities (71-72):
            a. Attractors as limit states [implies individuality]
            b. Deleuze: vector field: only existence and distribution of singularities are given
                (1) singularities and bifurcators as ideal events
        3. Virtualizing affects as capacities for interaction (72)
            a. extension of singularity into an infinite series of ideal events [condensation of singularities]
                (1) metaphor: phase transition of actual material [e.g., water]
                    (a) critical points (0, 100 degrees)
                    (b) followed by series of ordinary (ideal) events
            b. defining these series w/o metrics (as infinite ordinal series)
                (1) infinite ordinal series behaves as topological space, as continuum
                (2) out of which emerges by symmetry-breaking the cardinal (metric) numbers
    C. 'Philosophical transformation' of information theory into concept of the plane of consistency (74-77)
        1. Convergent and divergent relations among series [pure capacity to be affected] (74-75)
            a. Impassivity: multiplicities depend on empirical fact of actual causal relations
            b. Incorporeality: multiplicities as incorporeal effects of actual corporeal causes
        2. Quasi-causality [pure virtual capacity to affect] (75-77)
            a. Invariance w/ respect to transformations is a key component of multiplicities
            b. Quasi-cause is the operator of such transformations
                (1) create resonances among infinite series
                (2) change in probability of one series relative to such change in another
                    (a) = information transmission
                    (b) =signal/sign system
                (3) 'Philosophically transformed' to change in distribution of singular and ordinary
IV. Objection: why postulate a quasi-causal operator? (77-81)
    A. Emergent computation: evidence for spontaneous information transmission operations
        1. Behavior of materials near phase transitions
        2. Hypothesis of evolutionary pressure to keep early organisms poised at edge of phase transition
    B. Whatever merits of D's solution, he has correctly posed the problem
        1. Detailed description of intensive morphogenesis
        2. Description of concrete mechanisms of immanence [how virtual is produced from actual]

CHAPTER 3: The Actualization of the Virtual in Time

I. Introduction: Arrow of time: classical and relativistic physics vs. thermodynamics (82-84)
  A. Reversibility of processes w/o change of fundamental properties:
    1. invariance of laws
    2. Time here is only a container for events; stable world as ideal of physics: being w/o becoming
  B. Deleuze aims for world of becomings: beings as result of irreversible processes
II. Extensive time: (85-91)
  A. Nature of extensive time: (85-86)
    1. Simple model: nested set of sequences of cycles of different extensions
    2. In reality, many overlaps between cycles w/in any one individual
  B. Process or metrization of time: spontaneous broken symmetry (86-91)
    1. Hopf bifurcation: converts steady state attractor into a periodic one
      a. Steady state displays invariance re: time displacements
      b. But a periodic process is invariant only re: multiples of the period
    2. Iberall: characteristic period of nonlinear oscillators ? nested set of levels = unfolding of time
    3. Deleuze: passive synthesis: contraction of past and future into lived present
      a. Chronos: presence at one time scale is contraction of past/future at inferior time scale
      b. Such lived presents are not psychological
        (1) solution to time-travel twins via attention to objective time scale of bio-oscillators
        (2) relation of objective time scales to capacities to affect and be affected [“affordances”]
          (a) characteristic time scales as relaxation time of basin of attraction
          (b) affects then are defined via relation of relaxation time to interaction time
  III. Intensive time (91-102)
  A. Nature of intensive time: (91-95)
    1. Definition: sequences of oscillations
      a. w/ critical points [singularities]
      b. that can mesh w/ parallel sequences [affects]
    2. Examples from Winfree’s research:
      a. Birth and death of oscillators: distribution of singular and ordinary moments
        (1) Critical stimulus at singular moment can destroy or create oscillators
        (2) But this is only a trigger: the effect depends on intensive structure of the oscillator
      b. Synchronization/entrainment [forming hetero-assemblages]: meshed parallel structures
  B. Complexification of neat symmetry-breaking model for metrization: novelty in evolution as interplay of singularities [critical thresholds] and affects [hetero-assemblages] (95-102)
    1. Relative acceleration of parallel embryogenetic processes: heterochrony (95-98)
      a. Rate-dependent (chemical reaction and diffusions)
      b. Rate-independent (genetic information): gene action controls above rates via enzymes
    2. Ecosystems as parallel-processing networks: changing rates of fitness relations (98-100)
      a. Population density of species: parallel hetero time scales
        (1) divided at critical thresholds / phase transitions
        (2) characteristic relaxation times: resilience to shocks
          (a) degree of connectivity [length of food chain]
          (b) geo-factors: availability of minerals
      b. Network of biomass flow
      c. Evolutionary rates of coupled species [accelerations and decelerations at critical points]
    3. Symbiogenetic evolutionary acceleration [affects / hetero-assemblages par excellence] (100-02)
      a. Many levels of scale of symbiotic co-evolution
      b. D’s alternate formulation of intensity as “speeds of becoming and capacities to become”
        (1) changes in relative speeds of parallel embryogenetic processes
        (2) capacities to become as co-evolutionary lines of flight
IV. Virtual spacetime: the work of the quasi-causal operator (102-113)
  A. Construction of virtual continuum [pre-actualization] (103-110)
    1. Recap of spatial construction of continuum [“condensation of singularities”] (103-104)
      a. Prolonging singularities into series of ordinary ideal events
      b. Establishing relations of convergence and divergence between series
        (1) Information theory model: "sign/signal system"
          (a) coupled changes in probability distributions of series: emerging at edge of phase transition

        (b)   parallel-processing models of embryological and eco-processes at critical points of connectivity
      (2)   Deleuze: virtual series cannot presuppose individuation, so we depart from info model:
        (a)   changed distribution of singular & ordinary w/o numerical probability
        (b)   dense ordinal series
        (c)   production of mobile and ever-changing ["nomadic"] distributions
  2. Temporal construction of virtual (Aion): work of quasi-causal operator (105-109)
    a. Progressive unfolding of multiplicities through series of symmetry-breaking events
      (1)   all such events fully coexist with one another
      (2)   and are produced simultaneously: doesn't violate relativity strictures on simultaneity
        (a)   because virtual space is ordinal
        (b)   because virtual time is supposed to replace fundamental laws
          i) eternal
          ii)   simultaneously valid
    b. Clarification of such a nonmetric time: temporality of pure becomings w/o being
      (1)   a parallelism w/o directionality [0 degrees as virtual event = neither melting or freezing]
      (2)   pure becoming as "always forthcoming and already past"
      (3)   unfolding of time itself: an ordinal time
        (a)   sidesteps the present
        (b)   by an unfolding into past and future
    c. Quasi-causal weaving of multiplicities into hetero-continuum must be instantaneous
    d. Comparison of actual and virtual time
      (1)   processes in actual time: limited duration, but potentially infinite [sequence of cycles]
      (2)   virtual time: nonmetric:
        (a)   unlimited in unfolding into past / future, but finite like instant
        (b)   time composed of singularities: maximum and minimum
          i) events of unlimited duration (of unfolding of multiplicities)
          ii)   events of zero duration (operation of quasi-cause)

NB: DeLanda admits the imprecision and speculation of this account, attributing it to lack of scientific work on nonmetric time as opposed to a century of work on nonmetric spaces and symmetry breaking

  3. Objection: why not settle for essentialism to account for attractors and bifurcators? (109-110)
    a. Deleuze: virtual entities as constraints complementing actual causes in self-organizing / intensive processes
    b. But let's not allow unfamiliarity with his terminology to obscure the worth of his project
B. Extraction of multiplicities from actual intensive processes [counter-actualization] (110-113)
  1. "Slicing through" an actual system [eliminating actuality] to reach topological invariants
    a. Distribution of singularities [attractors and bifurcators]
    b. Full dimensionality of state space
  2. Plane of consistency as space of variable dimensionality meshing together hetero-multiplicities
    a. Absence of supplementary [N + 1] embedding space
    b. Operation of quasi-cause at N - 1 dimensions:
  3. Definition of multiplicities by outside, by line of flight [showing how they connect w/ others]
V. Recap / transition (113-116)
A. Recap
  1. Counter-actualization: extraction of virtual multiplicities from intensive processes
    a. Action: instantaneous sampling of all actual events at all different time scales
    b. Effect [line of flight]:
      (1)   Acceleration of escape from actuality
      (2)   High intensity nonlinear systems: already moving to virtual by effects of non-actualized attractors
  2. Pre-actualization: immediate unfolding and assemblage of multiplicities into hetero-continuum
    a. Actions:
      (1)   Extension of singularities into series
      (2)   Creation of convergent and divergent relations
    b. Effects of the "dark precursor"
      (1)   Give multiplicities a certain autonomy from intensive processes
      (2)   Endow multiplicities as impassive and sterile effects w/ morphogenetic power
B. Caveat:

1. Whatever merits of D’s actual solutions, he has correctly posed the virtual problem
2. D’s constructivist method matches the two tasks of the quasi-causal operator
   a. Extraction of events [counter-actualization]
   b. Unfolding plane of consistency [pre-actualization]
3. D’s epistemology
   a. Philosopher must catch up to the objective movement of the quasi-cause
      (1) extraction of a virtual event = defining of what is problematic in the actual event
         (a) discernment of relevance / importance
         (b) grasping objective distribution of singular and ordinary
      (2) giving consistency = showing problems do not disappear behind solutions

CHAPTER 4: Virtuality and the Laws of Physics

I. Introduction: the disunity of science (117-118)
II. Physics: axiomatics vs problematics: against linearity of causes & models(118-149)
   A. Countering axiomatics / deductive-nomological model of explanation: (118-128)
      1. Rescuing causes from laws stating constant regularities (120-122)
      2. Rescuing models from linguistic renderings of laws (122-128)
         a. Giere
         b. Cartwright: population thinking applied to models
            (1) some establish causal relations between events [interface w/ actual]
            (2) others quasi-causal relations between singularities [interface w/ virtual]
   B. Problematics: fundamental laws as posing problems: distribution of singular/ordinary (128-134)
      1. Extra-propositional and sub-representative nature of problems (128)
      2. Garfinkel and contrast spaces (129-133)
      3. Posing problems so that relations of causes and quasi-causes are revealed (133-34)
   C. Recap: (134-35)
   III. Isomorphism of ontological and epistemological problems (136-149)
   A. Intensity: Causes in experimental physics (136-145)
      1. Epistemological extensity: deducing entities from laws: subordination of lab to logic (136-41)
         a. Hylomorphism [passive matter] via focus on linear causality

NB: social constructivism as hylomorphic

            (1) additive causality [vs emergence]: components presupposed by additivity
               (a) uniqueness
               (b) necessity
               (c) uni-directionality
               (d) proportionality
            (2) all these in turn presuppose externality of cause [and hence passivity of matter]
         b. Intensive and problematic matter through nonlinear causality [artisanal sensitivity]
            (1) self-organization [bodies]
            (2) self-assembly [affects]
      2. Epistemological intensity: connecting operations to materiality (141-145)
         a. lab as heterogenous assemblage allowing for expertise acquisition
            (1) study of properties: individuation of phenomena [survive theory changes]
            (2) study of capacities: how they affect and are affected by other entities
         b. Deleuze: lab assemblages as epistemological counterparts of ontological intensities
            (1) extraction of virtual problems requires embodiment in intensive assemblages
               (a) [transcendental {i.e., virtual} empiricism]
               (b) meshing of singularities and affects of experimenter and machines, models and lab processes necessary for learning and accumulation of embodied expertise
            (2) as well as accumulation of actual data (mere knowledge vs learning)
      3. Summary two ways of subordinating problems to solutions in causal realm (144-145):
         a. Elimination of nonlinear causal capacities of material systems to find easy solutions
            (1) by homogenization
            (2) by study under low-intensity equilibrium situations

b. Subordinating causal lab interventions to formal cognitive products of lab assemblage

B. Virtuality: Quasi-causes in theoretical physics (145-149)

1. Deleuze's epistemological approach to state space: emphasis on singularities as problematic

a. State space trajectories are not causes: only actual events are causes

b. But state space analysis does provide info about quasi-causal [structures of processes]

(1) differential relations ? vector field capturing tendencies as distribution of singularities

(2) these singularities define conditions of the problem

(3) while solutions [trajectories] are individuation processes guided by tendencies

2. Comparison re: solutions vs problems

a. Analytic philosophers: focus on solution / trajectories [focus on linearity]

(1) Measuring properties of a system and plotting numerical values as a curve

(2) This curve should be geometrically similar to a state space trajectory

b. Deleuze: focus on problem / singularities

(1) Disregards this resemblance between metric objects

(2) To focus on topological isomorphism of singularities in model and system

(a) model and physical system are co-actualizations of same virtual multiplicity

(b) explains the genesis of the resemblance of the products

3. Comparison re: generality vs universality

a. Analytic:

(1) laws are general: rule governing evolution of series of states

(2) trajectories are particular: application of that rule for a particular initial condition

b. Deleuze:

(1) distribution of singularities determines which changes in initial conditions are relevant [where the boundaries of basins of attraction fall]

(2) not generality, but universality of virtual multiplicities: model and system are both actualizations

IV. Mathematics: solvability vs problematics (149-54)

A. Algebra and group theory [Galois] (149-152)

1. Particular [numerical values] vs general solutions [another formula]

2. Galois and group theory: inversion of subordination of problem to solution

a. rather than general solvability providing criterion of a well-formed problem

b. form of problem became explanation of general solvability

3. Importance of this inversion

a. Extracting the "virtual" [counter-actualization]

(1) by revealing invariants [which transformations of solutions have no effect on validity]

(2) groups express the objectivity of problems:

(a) what we don't know about the solutions

(b) = distribution of singular and ordinary

b. Unfolding of groups [pre-actualization]

(1) progressive differentiation of specification of problem

(2) as a by product, individual solutions emerge

B. Differential equations [Poincaré] (152-54)

1. Differential equations also have particular and general solutions [produced by integration]

2. 18th C [differential] physics tended to neglect models w/ insoluble equations

a. This use of solvability as criterion for choice of physics problems

b. Produced clockwork view of reality due to predilection for linear equations

(1) linear equations exhibit superpositionality: sum of valid solutions is also valid

(2) superposition biased process of accumulating models in theory of classical mechanics

3. Poincaré reversed the emphasis on solvability by studying problematics of "three body problem"

a. He examined existence and distribution of singularities organizing space of all solutions

b. = He examined the "problem space" itself: qualitative info on tendencies of all solutions

V. Summary: a theory of virtuality (154-56)

A. Barriers to attaining the virtual: assumption of a closed, unproblematic world

1. Solvability in mathematics

2. Axiomatics in classical physics

3. Linearity

a. Causes [in experimental physics]: additivity

b. Models [in theoretical physics]: superposition

B. Attaining the virtual lets us live an open, problematic world

1. Nonlinearity
   a. Causes: complex affects
   b. Models: multiple attractors
2. Historicity
   a. Actual: causal processes of individuation
   b. Virtual: quasi-causal processes of extraction and unfolding of ideal events