Wholeness & Embryogenesis, Part 1 (Extending "The Hierarchical Genome and Differentiation Waves" §1.03, 1.04, 1.05)

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Wholeness in Physics

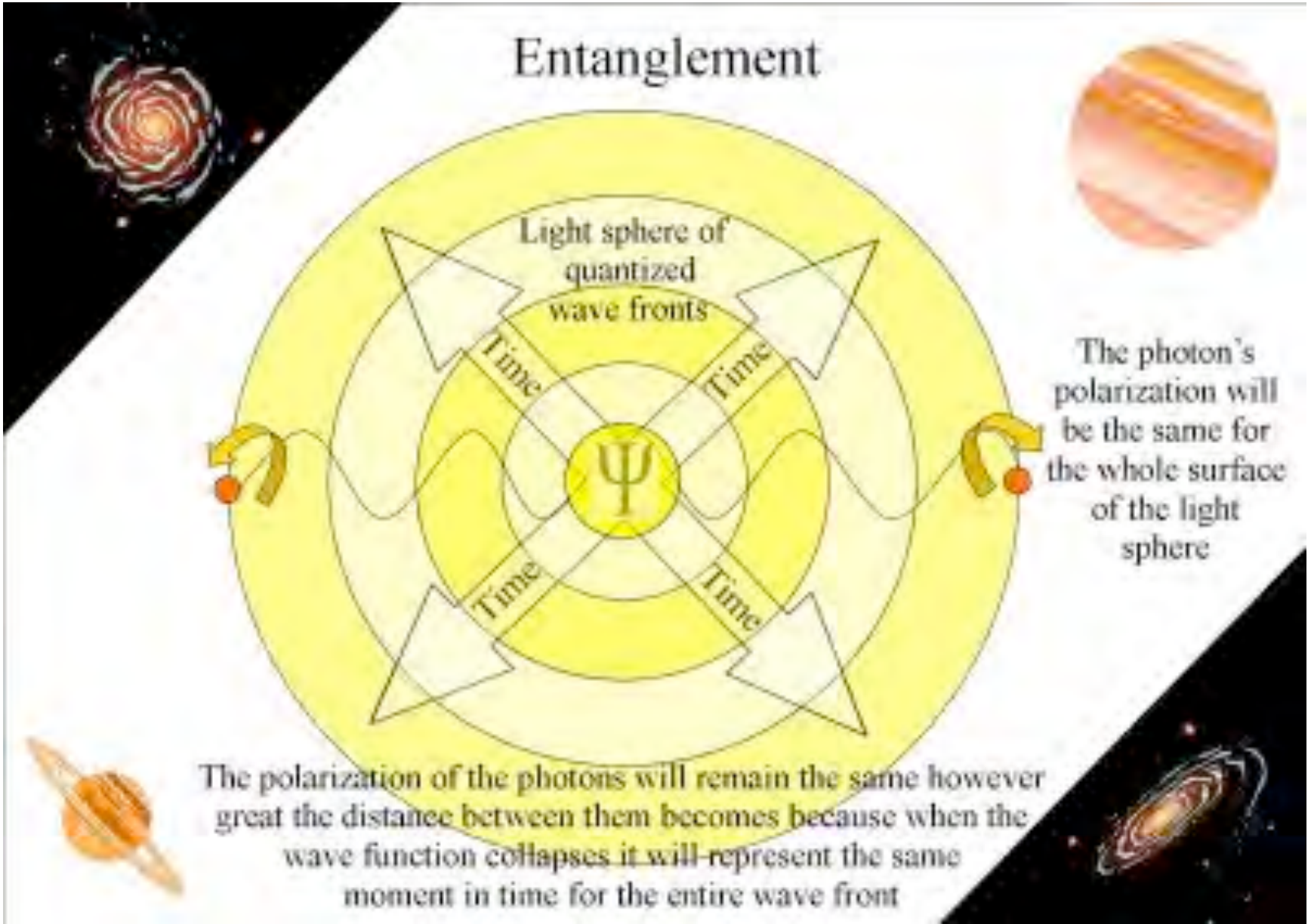
- Why should we take “wholeness” seriously?
- “Spooky action at a distance” predicted as a disproof of quantum mechanics:
- Einstein, A., B. Podolsky & N. Rosen (1935). Can quantum mechanical description of physical reality be considered complete? *Physical Review* ***47,*** 777-780***.***

Einstein & Quantum Entanglement

- "Einstein later referred to this as *spukhafte Fernwirkungen* (spooky actions at a distance)"
- Buhrman, H., R. Cleve & W. Van Dam (2001). Quantum entanglement and communication complexity. *SIAM J. Comput.* ***30(6),*** 1829-1841***.***
- **But there is now plenty of evidence that quantum entanglement is a reality**

Explanation by Symmetry

http://quantumartandpoetry.blogspot.com/2009/06/quantum-entanglement-and-new-quantum.html



David Bohm

- Bohm, D. (1980). *Wholeness and the Implicate Order. London, Routledge & Kegan Paul.*
- Bohm, D. (1986). The implicate order : a new approach to the nature of reality. In: *Beyond Mechanism: The Universe in Recent Physics and Catholic Thought. Eds.: D.L. Schindler. Lanham, University Press of America: 13-37.*
- Bohm, D. & B.J. Hiley (1993). *The Undivided Universe: An Ontological Interpretation of Quantum Theory. London, Routledge.*

David Joseph Bohm (1917-1992)

- http://en.wikipedia.org/wiki/David_Bohm

David Bohm's Entourage

- Briggs, J.P. & F.D. Peat (1986). *Looking Glass Universe: The Emerging Science of Wholeness, Simon & Schuster.*
- Peat, F.D. (1987). *Synchronicity: The Bridge Between Matter and Mind. Toronto, Bantam Books.*
- Briggs, J.P. & F.D. Peat (1990). *Turbulent Mirror: An Illustrated Guide to Chaos Theory and the Science of Wholeness, Harper & Row.*

David Bohm Sanctified

- Hiley, B.J. & F.D. Peat, Eds. (1991). *Quantum Implications: Essays in Honour of David Bohm. London, Routledge.*
- Peat, F.D. (2000). *The Blackwinged Night: Creativity in Nature and Mind. Cambridge, Massachusetts, Perseus Publishing.*
- Briggs, J.P. & F.D. Peat (2000). *Seven Life Lessons of Chaos: Spiritual Wisdom from the Science of Change, Harper Perennial.*

Ties to Karl Pribram

"In collaboration with Stanford neuroscientist Karl Pribram, Bohm helped establish the foundation for Pribram's theory that the brain operates in a manner similar to a hologram, in accordance with quantum mathematical principles and the characteristics of wave patterns"

- http://en.wikipedia.org/wiki/David_Bohm

More Wholeness Physics: Robert Laughlin

- Laughlin, R.B. (2005). *A Different Universe: Reinventing Physics from the Bottom Down. New York, Basic Books.*

Robert Laughlin, 1998 Nobel Prize for the fractional quantum Hall effect

- "We live… at the end of Reductionism, a time in which the false ideology of human mastery of all things through microscopics is being swept away by events and reason. This is not to say that microscopic law is wrong or has no purpose, but only that it is rendered irrelevant in many circumstances by… the higher organizational laws of the world."

Wholeness in Embryogenesis

- It is with this recent soul searching in physics, not yet resolved, that I want to reconsider the history and present state of embryology

Making Wholeness Palatable

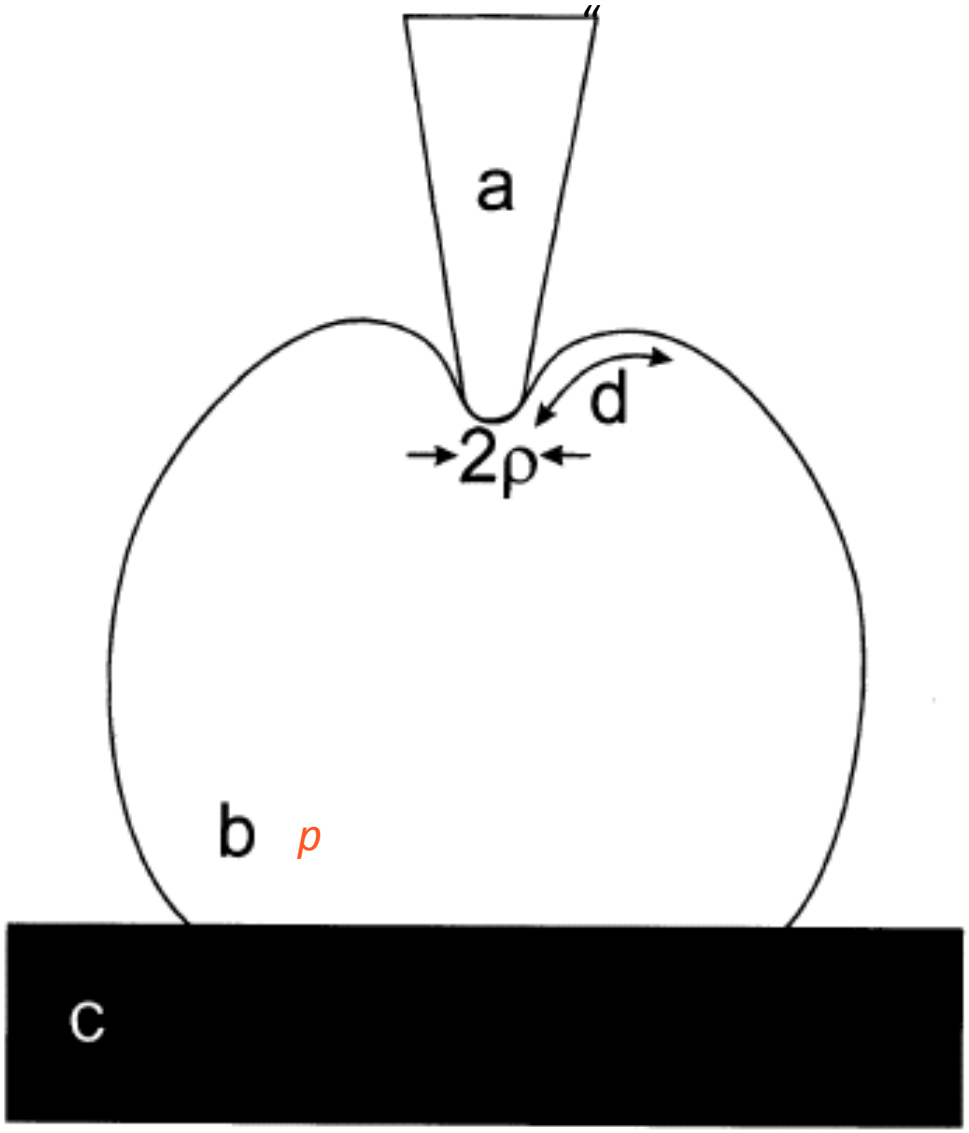


Fig. 1 Schematic view of deformation of a spherical bacterial envelope by the AFM cantilever. (a) The cantilever; (b) the bacterial envelope, (c) the substrate. We also show the contact domain (diameter 2ρ), and the cut-off distance *d*.

Boulbitch, A. (2000). Deformation of the envelope of a spherical Gram-negative bacterium during the atomic force measurements. *J. Electron Microscopy* **49**(3), 459-462.

Mathematical Wholeness

The free energy *F* is an integral over the whole surface of the surface tension σ, stretching in area *A*, and the applied force **f**, less an integral over the whole volume of the turgor pressure *p*:

$$F = \oiint \left[\sigma + \frac{\lambda}{2} \left(\frac{\delta A}{A} \right)^2 - (\mathbf{f} \cdot \mathbf{n}) \psi \right] dA - p \iiint dV.$$

Direct Application to Embryos

- $p = 7$ atm in amphibians
- p. 90 in Beloussov, L.V. (1998). *The Dynamic Architecture of a Developing Organism An Interdisciplinary Approach to the Development of Organisms*, Dordrecht Kluwer Academic Publishers.

Hans Driesch (1867-1941)

- Driesch was a clear thinker. One of his major contributions was to set our agenda, which is still in place, awaiting completion. How is it that cells in an embryo end up:
- As the *right kinds*
- In the *right place*
- At the *right time*
- To which we now add:
- In the *right numbers*?

http://home.tiscalinet.ch/biografien/biografien/driesch.htm

*Sea Urchin's fertilized egg dividing and growing into a blastocyst, time lapse: http://amazingbeauty.org/Nature/ABbiology02-baby.html.
Also see: http://worms.zoology.wisc.edu/urchins/SUmainmenu.html.

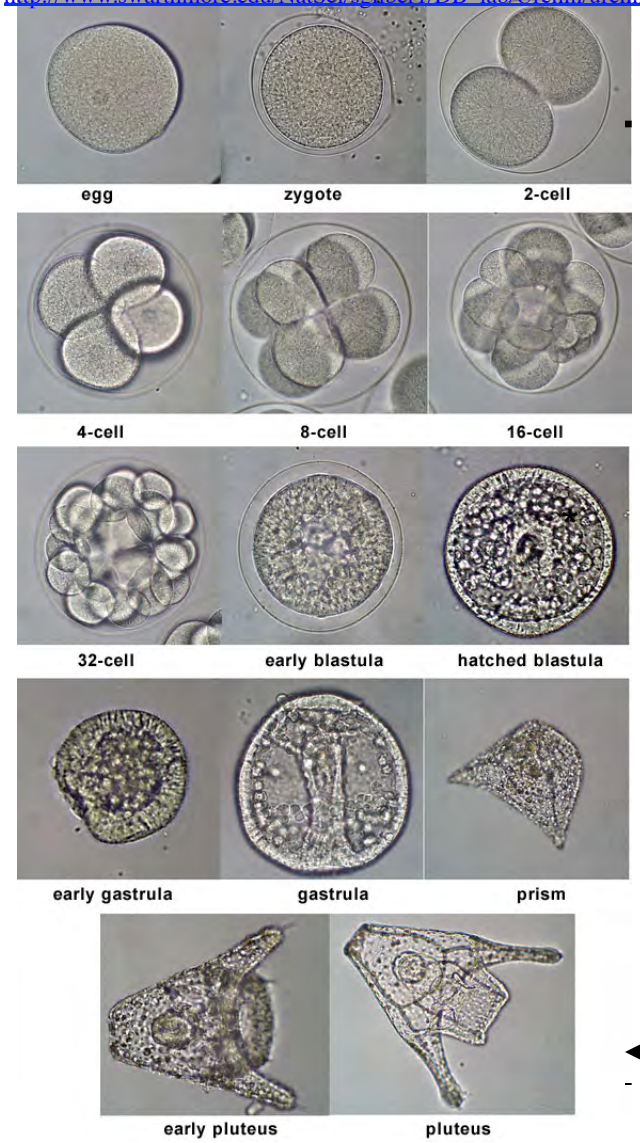
The Right Stuff

The Million $ Hans Driesch Prize is Awarded by MacDonald's Hamburger Restaurants!

The (Rail)Road to Vitalism

Sea Urchin staging series, taking one week

http://www.swarthmore.edu/NatSci/sgilbert/DB_lab/Urchin/urchin_stage.html



B&O Steam Locomotive

from Sue Breakiron Wert

http://www.fay-west.com/connellsville/historic/picture2/steam_locomotive.shtml

- Shake apart

x2

Baby, months later: Adult sea urchin:

http://ebiomedia.com/prod/BOechinoderms.html.

http://www.mbayaq.org/efc/living_species/default.asp?hOri=1&inhab=201

The (Rail)Road to Vitalism

- No machine known to him would function as two identical machines if chopped in half.
- But the two cells turned into two whole pluteus embryos (albeit of half the volume each). Therefore embryos aren't machines.
- Driesch turned to vitalism, the idea that there is something special about life that sets it apart from physics and chemistry, an "entelechy" that operates inside each cell, altering its physics and chemistry.
- He was the last professed vitalist.
- But his observation is still unexplained.

Key Driesch Paper

- Driesch, H.A.E. (1892). The potency of the first two cleavage cells in echinoderm development. Experimental production of partial and double formation. In Willier, B.H. & J.M. Oppenheimer, *Foundations of Experimental Embryology*, New York Hafner, p. 39-50.

Driesch's Vitalism

- Driesch, H.A.E. (1908, 1929). The Science and Philosophy of the Organism. London, Black.
- Driesch, H.A.E. (1914). The History and Theory of Vitalism. London, Macmillan and Co.
- Driesch, H.A.E. (1933). Psychical Research: The Science of the Super-normal. London, G. Bell & Sons.

Herbert Spencer Jennings on Vitalism A

- “The doctrine perhaps most commonly signified by vitalism is that there is a deep-lying distinction of some sort between what occurs in the living, and what occurs in the non-living; with a correlative deep-lying distinction between the sciences that deal with the two; so that science must on this account be divided into two kinds,vitalistic and non-vitalistic”.
- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Herbert Spencer Jennings on Vitalism B

- “Vitalism is sometimes used to signify merely the doctrine that mechanistic formulation is not adequate for giving an account of nature. In place of it there must then be put some other formulation, and this is at times called vitalistic…. it merely holds that science is necessarily non-mechanistic. It would be equally valid if there were no living things as objects of study.“
- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Herbert Spencer Jennings on Driesch's Entelechy

- "The doctrine that a non-perceptual vital agent (as consciousness, purpose, entelechy) actively intervenes in the processes of organisms is at once the archetype and culmination of vitalistic doctrine; the one fully worked out exemplar of this type is the system of Driesch…. an active or dynamic vitalism, in which the vitalistic agent alters the physical processes occurring."
- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Herbert Spencer Jennings on Driesch's Entelechy

- "what entelechy does, according to Driesch, is… holding back the action that would occur - and later to release that which was held back… This is the *only* thing that entelechy can do."

- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Herbert Spencer Jennings on Driesch's Entelechy

- "If one of the two cells of an egg contained all the conditions required for producing both the anterior and the posterior part of the body, such an agent could hold back one set of processes and permit the other, thus deciding which part of the body should be produced. Or if the egg contained all conditions necessary for producing both a starfish and a sea urchin, such an agent could in this way decide which animal should be produced."

- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Herbert Spencer Jennings on Driesch's Entelechy

- "Thus there is no offense to the principle of the conservation of energy; this is the reason why the action of entelechy is to be conceived in this precise way. Driesch takes up the case of a moving element having a mass m, and shows just how the process would work; the kinetic energy "is transformed into an equivalent amount of 'potential' energy located at the place of *m* and kept there till it is set free, that is, transformed into kinetic energy" again."
- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Herbert Spencer Jennings quoting a letter from Driesch

- "It *may* be that the eggs of fishes, echinoids and birds are the same in all *essentials* of the physico-chemical constitution. There happens something very different in the different cases on account of the different 'entelechies.'"
- Jennings, H.S. (1913). Doctrines held as vitalism. *American* Naturalist **47**(559), 385-417.

Modern Perspective

- Entelechy = Maxwell's Demon, and Driesch did not take into account the Second Law of Thermodynamics
- Entelechy = DNA, and Driesch perhaps wasn't up on Mendelian genetics
- Entelechy = Intelligent Design, in the sense of Michael Behe, with specific chemical interventions occurring

My Perspective

- There is no reason to assume that the entelechy is not a physical entity
- In an abstract sense it could be equated with the quest of modern biosemiotics for how to think about information and meaning in terms of codons and other "symbolic" molecules and higher level codes
- This involves understanding the whole/part interaction during embryogenesis

My Perspective

- However, the language of Driesch includes the notion that the entelechy “wants” to do things.
- This smacks of conscious intervention.
- The evasiveness in saying by whom or what is also characteristic of modern Intelligent Design advocates.

But Driesch sounds very modern

- “But entelechy *is* able, so far as we know from the facts concerned in restitution and adaptation, to *suspend* for as long a period as it wants any one of all the reactions which are possible with such compounds as are present, and which would happen without entelechy. And entelechy may *regulate* this suspending of reactions now in one direction and now in another, suspending and permitting possible becoming whenever required for its purposes“ (Driesch, 1908).

Today's Biologists as Vitalists

- Common phrase is lecturing: Molecule A "wants" to do…
- We have not solved how cells become different from one another, the "regulation" referred to by Driesch, or how the "machine" of life works
- Minimal education of biologists in physics

Confession of Albert Szent-Györgyi

- "Every biologist has at some time asked 'What is life?' and none has ever given a satisfactory answer.... Though I do not know what life is, I have no doubt as to whether my dog is alive or dead.... Life appears to be a revolt against the rules of Nature.... Life is a paradox. It is easy to understand why man has always divided his world into 'animate' and 'inanimate,' *anima* meaning a soul.... When we have broken down living systems to molecules and analyzed their behavior we may kid ourselves into believing that we know what life is, forgetting that molecules have no life at all.“

Confession of Albert Szent-Györgyi

- "My own scientific career was a descent from higher to lower dimension, led by the desire to understand life. I went from animals to cells, from cells to bacteria, from bacteria to molecules, from molecules to electrons. The story had its irony, for molecules and electrons have no life at all. On my way life ran out between my fingers. The present book is the result of my effort to find my way back again, climbing up the same ladder I so laboriously descended".
- Szent-Györgyi, A. (1972). *The Living State, With Observations on Cancer. New York, Academic Press.*