

The Quantum Potential
and
The Epigenetic
Landscape

Stephen Wood

Quantum potential

- The quantum potential depends on the whole experimental arrangement and acts on every part.
- The effect of the quantum potential does not depend on the strength of the quantum field, but only on its form.
- Information of the whole arrangement is potentially active everywhere but only actually active where the particle is.

Differentiation

- Every cell in the adult body has the same DNA, but different types of cells have different patterns of activity.
- Only those stretches of DNA relevant to the cell's role are translated into proteins.
- Only part of the genetic information of the whole is active in any cell.

Active genetic information

- ‘it is only the form of the DNA molecule that counts, while the energy is supplied by the rest of the cell (and indeed ultimately by the environment as a whole).
- ‘Moreover, at any moment, only a part of the DNA molecule is being ‘read’ and giving rise to activity. The rest is potentially active according to the total situation in which the cell find itself’ (Bohm and Hiley, 1993: 36).

Regeneration

- Differentiated cells are able to regenerate whole individuals
 - ◆ Plants: can grow a whole new plant from:
 - ◆ Cuttings – from a root, shoot or, more unusually, a leaf
 - ◆ Vegetative structures – such as corms or tubers
 - ◆ Animals such as *Hydra* and *Planaria* can be cut in half and regenerate into two individuals

Living wholeness

- Regeneration shows the wholeness of the organism and defies mechanistic explanation.
- ‘Given that Abraham Trembley’s investigations of regeneration in Hydra (published in his *Mémoires* in 1744) launched the era of experimental biology, it is ironic that the problem of regeneration still awaits a satisfying mechanistic explanation’ (Newmark and Alvarado, 2002).

Living wholeness

- ‘no matter how many times we divide the fuchsia plant [to take a cutting] it remains whole ... when we divide the plant, it is always the original plant but never the same specimen’ (Bortoft, 1982: 48).
- ‘The potato is not grown commercially from seed, but from *sets*, which are just potatoes, and so all the potatoes of one variety in the world are *one plant*. They are one individual that has just been divided and divided’ (Seymour, 1977: 116).

Totipotent cells

- Totipotency is the ability of a single cell to divide and produce all the differentiated cells of an organism. This ability is found in:
 - ◆ The cells of the meristematic tissue of a plant cutting or tuber
 - ◆ A human embryo
- In totipotential cells, the whole of the genetic information is potentially active.
- They are responsible for the quality of living wholeness.

Pluripotent cells

- Totipotential cells specialise into the *pluripotent* cells, which can develop into any of the three major tissue types:
 - ◆ Endoderm – lining of the gut
 - ◆ Mesoderm – muscle, bone and blood
 - ◆ Ectoderm – nerves and skin

Multipotent cells

- Pluripotent cells undergo further specialisation into *multipotent* cells
- They are committed to give rise to a limited range of cell types, which serve a common function.
- Blood stem cells give rise to red cells, white cells and platelets, each of which are considered to be *terminally differentiated*.

Differentiation

- Differentiated cells usually lose the ability to give rise to new individuals:
 - ◆ Information is active in the cell's function, but the rest is inactive.
- Along a pathway of differentiation, the information that is potentially active becomes less and the cell takes on a more definite form.

Contraction

- Nicholas of Cusa – the wholeness and perfection of God, which embraces all contradiction and all opposites, is *contracted* in his creatures.
- ‘God, in eternity, understood one thing in one way and another thing in another way. Herefrom arose plurality, which in God is oneness’ (*On Learned Ignorance*, 2: 108).

Contraction

- Differentiation is the contraction of the wholeness originally present in the totipotent embryo, by stages pluripotent, multipotent and terminally differentiated.
- Wholeness is not the only feature of interest among living things. We also need to understand how that wholeness contracts so as to be lost, actually and potentially.

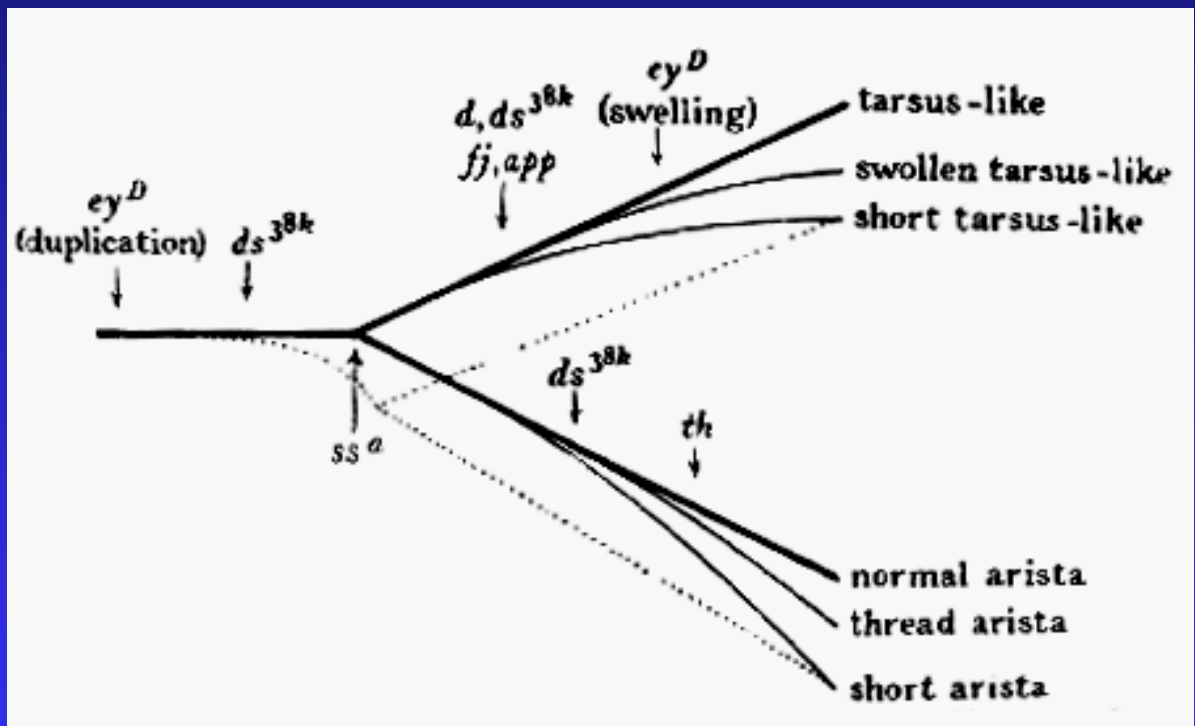
Bifurcation

- The example of barrier penetration: the quantum potential lowers the height of the barrier, allowing particles to pass through. Depends on the position of the particle in the wave packet.
- ‘There is a critical trajectory, which divides the trajectories that go through from those that do not. This evidently resembles a bifurcation point of a kind typical of the non-linear equations describing unstable systems’ (Bohm and Hiley, 1993: 75).

Bifurcation

- Waddington was the first to construct bifurcation diagrams, long before their emergence in the sciences of chaos and complexity.
- ‘In embryonic development we are confronted with alternative modes of development, the choice between which is taken in reference to an external stimulus, or to an internal one ... In considering the effects of genes, we find alternatives, the choice between which may be taken in response to diffusible substances’ (Waddington, 1956).

Bifurcation



Bifurcation diagram showing the fate of an imaginal disc from the antennae of *Drosophila*

Channels

- Returning to the example of barrier penetration, we can say that the particle enters one of two distinct *channels* – reflected or transmitted.
- Information in the channel that the particle enters is actually active, whereas in the empty channel, information is actually inactive.
- Information in the empty channel retains the potential to act on the particle, since the channels can be made to overlap again.

Channels

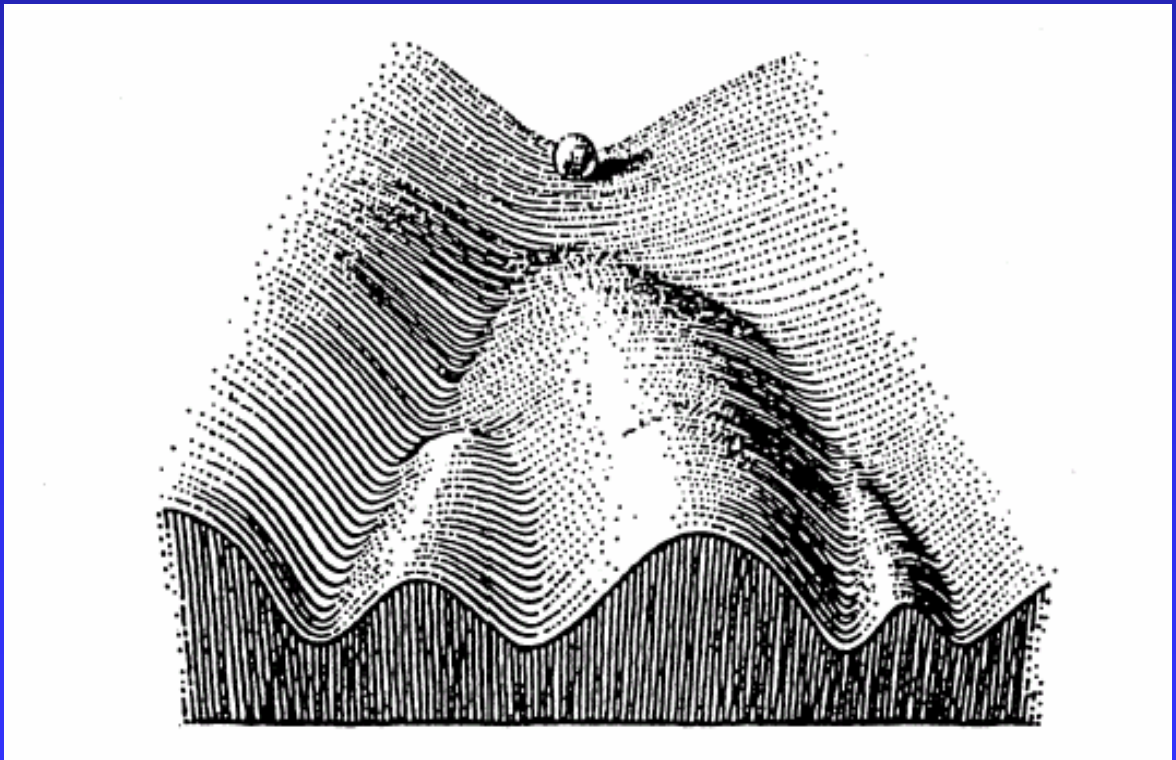
- Consider a pluripotent cell that gives rise to ectodermal tissue. At this stage, the information for both skin and nerve cells is still potentially active.
- Yet there is a bifurcation along the pathway, where the cell will enter either the nerve channel or the skin channel.
- If the cell follows the skin channel, the nerve information has become inactive, where the skin information is active. If it follows the nerve channel, the reverse is true.

Channels

- Many plant cells remain totipotent.
- The empty channels that they have left behind during their differentiation still have an influence on their behaviour.
- The actually inactive information may be reactivated to allow an entire plant to be regenerated from a single cell.

Epigenetic landscape

- Waddington's image of bifurcations among channels (chreodes).



Points of contact

- Wholeness, where whole determines part
- Information that is potentially or actually active or inactive
- Bifurcation points, where information is activated and inactivated
- Channels, which express the different fates of particles or cells