

V. Containment and Reciprocity in Biological Systems: A Putative Psychophysical Organising Principle

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1. Introduction

The stuff of life, the living substance that is common to all biological organisms, is the aqueous society of biochemical activity ongoing in every cell in every living body. The basic biochemical ‘reactions’ of life are largely similar with variations of a theme played out in different cells living in different environment, *e.g.* the core biochemical metabolic processes of all life likely stem from an ancient, early-earth ancestor (Smith & Morowitz, 2004). However, even more common to life than shared biochemistry are the basic structural properties of all cells and all living organisms into complexes of compartmentalised units. In this paper, I will argue there are common feelings driving the generation of these ubiquitous structures in nature and that these feelings may constitute one of several primary forms of feeling in living systems.

The panexperiential process philosophy, exemplified by Whitehead’s “Philosophy of Organism” (Whitehead, 1929), shifts the typical mechanism-driven theoretical framework to allow common principles of enacted self-organisation to come forward as driving forces behind biological organisation (*e.g.* Agar, 1936). It casts new light on what is occurring at the molecular, cellular, intra-, and inter-organismic levels to show common principles of process, or activity based on feeling, are occurring at each one (Agar, 1943; Birch, 1999). Biological organisation is similar to non-linear physical organisation where motifs are found repeated through many magnitudes of scale (West & Brown, 2005). However, biological organisation is also quite different. It is a self-generated activity of the parts that contributes to the formation of the whole—in significant quantities from trapped or collected resources—that does not happen in the

purely physical systems. These patterns are ‘living’ patterns in flesh and blood of the type that we experience and that basic organisms may experience, too. It is the *living* patterns we are closely familiar with and that we *drive* into being through our actions dependent on the presence of primitive ‘instincts’, or *feelings*, arising during specific, usually social, contexts.¹ It is these feelings that I want to bring out here, to show that one set of them can generate the most common organisations seen in biology, contained systems. This set of feelings appears to drive the activities of basic living systems and so they appear to be fundamental and ubiquitous.

2. Feeling Feeling Feeling

Process thought emphasises feeling as being the primary ‘stuff’ of process and therefore the primary ‘stuff’ of the universe [PR 172]. Feelings contribute to the prehensions and to the guidance of the actual occasion to satisfaction (PR 19 [29]; Delafield-Butt, 2008). This “lure for feeling is the germ of mind” (PR 85 [131]). Actually, feeling is all there really is. Leue (2005) sums it up best, describing each actual occasion as “feeling feeling feeling.” In other words, an ‘organism’ is a feeling feeling another feeling (subject, transitive verb, object).

If ‘feeling feeling feeling’ is at the heart of the material processes of life, then this suggests a new framework for biological processes based on the evolution and manifold expression of this basic processual system. But what are these feelings and how are they common among the different scalar layers of biological organisation? The process ‘feeling feeling feeling’ must share common principles reflected throughout biological organisation and that have evolved to give different expressions of the same fundamental process, just as different anatomical or genetic arrangements have evolved to serve specific purposes in specific contexts yet have developed from a common root to serve the basic life processes of the organism. What are these feelings and how do they express themselves in nature?

3. Universal Forms of Feeling

If feelings operate not only in human relations, but are ubiquitously present in all relations between ‘organisms’, as the primary stuff of actual occasions, then some of the same feelings that structure and shape our human relations may also be present in the structuring and shaping of

biological systems generally. These feelings common to nature and to man must be fundamental feelings in our human experience of them, and not just species-specific ones (see, *e.g.* Birch, 1995). I think, and will present here, that one set of these feelings are the feelings that underpin the quality of form of relating between two intimate individuals. To describe these feelings phenomenologically is very difficult because of their fundamental nature. Such a study of these experiences may be a useful approach for the future. Here however, I want to identify one set of them and look at what we can know of them through their rational study in two disciplines that recognise the importance of feeling in living, ecological developmental psychology and psychoanalytic theory.

Both of these disciplines have examined the psychobiological nature of the mother-infant relationship. It is here where psychoemotional experiences interact so very closely with vital physiological process, providing us with informative material to consider how *felt experience* and the vital *biological processes* of living interact. In the interactions of the infant with adult others, our analytical adult minds can begin to see, and thus begin to appreciate, how feelings drive us to engagements with others and to steer our course of actions through them, thus shaping our behaviour and giving structure to our lives.

4. Reciprocity and Containment in Human Relations

In an engagement between two intimate humans, feelings form their binding togetherness. These feelings are generated by, and generate ‘containment’ and ‘reciprocity’. They are based on contingencies of feeling between the two to form a fit that brings them together into a dyadic whole. Importantly, if this relation is capable of containment, then it is capable of enduring hardship and extremes of feeling. Containments and reciprocities are expressed in activity in the interaction, and so they manifest in a physical, bodily reality, but it is the containment and reciprocity of feeling that is the substance of the engagement and the driver of the activity (Stern, 2004).

Containment and reciprocity lie at the two ends of a continuum of relating (Douglas, 2007). Reciprocal engagements form a shared patterning in the interaction, usually with a rhythmic balance of give and receive where one expresses then receives the expression of the other, reciprocates in expression, and so on (Stern, 1971; Trevarthen, 1977; Trevarthen, 1998). When the dynamic of the sharing becomes stretched when one individual is

suffering in intense feelings, especially those that are not manageable by the individual alone, then in a reciprocal engagement, the other acts to 'contain' the intensity of those feelings (Bion, 1959; Bion, 1962). The relation moves toward the container-contained end of the continuum.

Understanding this process of relating between containment and reciprocity forms a major foundation for modern psychoanalytic theory. It is a specific mechanism by which the concerned sympathy of one person is able to comfort, protect, and help the other to accept, live through, and survive a crisis. Feelings can become too much for one person to manage and must be contained by another for normal life to continue. Bion (1959, 1962) introduced the idea from his psychoanalytic work with patients, but drew on his observations of mother-infant interactions. Formalising the idea, he named the harmful extremes of feeling, 'beta elements', and the role of the other in containing these elements, the 'alpha function', to transform these into 'alpha elements', or manageable feelings. A container-contained relation is formed through the projection of beta elements and their transformation into alpha elements by a love and a drive to stabilise, or make well an otherwise reciprocal and intimate relationship.

The process is important. It forms the foundations of a developing human mind. It is the mechanism by which the sympathy of an intimate other is able to comfort and protect another during a crisis, however great or small. When feelings become too much for one person, they can be contained by another. In this form of relating, the container is one who is able to accept and to accommodate the stresses and traumas experienced by the other, and the contained is the one with psychological extremes that cannot be 'held' by oneself, but must be somehow expelled. In a container-contained relationship, the expulsion of the extreme is then taken up and processed in a novel way unfamiliar to the expeller. This processing of the extremity is all important, because it shows the other how to cope with this apparently uncopable situation. In this way, the expeller brings back into himself the same energy originally expelled, but transformed into an acceptable new form through a previously unknown mechanism. We have all experienced container-contained relationships and we all still live in them even in our so-called 'independence' as adults. This form of relating is particularly noticeable in intimate relationships where the contained and containing element is especially deep, but these relations also exist more superficially in our everyday engagements, too, and form looser dynamics of professional companionship and friendship.

The idea of containment in psychoanalytic theory is one of its most prominent contemporary ideas, because it lends itself as a pragmatic tool when understanding the patient-analyst relationship. The system is

superficially similar to feed-back regulation, but the energies transmitted are feeling qualities and the one who feeds back does so by psychologically processing the energies of the other in order to give them back in an acceptable form. The patient-analyst relationship acts as a 'container-contained' relationship and its unique form enables the patient to revisit his or her early structures of containment formed during the first parent-infant and parent-child relations. These early relations are of importance for one's healthy or unhealthy psychological development.

5. Dynamic Forms of Reciprocity and Engagement

In an engagement with another, there is a patterned exchange of activity, all of which is communicative. Repeated cycles of reciprocated actions form the hallmark of a communicative engagement and set the foundation for language (Malloch & Trevarthen, 2008). In early mother-infant communication, these cycles of reciprocated activity form the bond of attachment. They generate strong affective feelings as well as a dyadic state of co-consciousness (Tronick, 2005). They take place in multiple modalities, including the voice, touch, and gesture, to express and to communicate internal feelings in reciprocal relation with those of the other. The engagement of the two organisms is an engagement of two feelings forming a common, coherent whole. In infant development, sympathetic sharing in the resulting dyadic state of consciousness is required for the healthy development of both parties, infant and mother. In a developing psychopathology, the reciprocity fails leading to distress, anxiety, and eventual developmental trauma (Reddy, 2008).

It is the sharing, the 'togetherness', that brings satisfaction and health (Trevarthen, 1977). These rhythmic infant-adult episodes of mutual engagements of feelings occur through time in narrative patterns that open, then build, and climax before closing (Malloch, 1999). Importantly, the communication and narrative sequence is regulated by, and regulates autonomic physiological processes essential to vital health (Trevarthen, Aitken, Nagy, Delafield-Butt, & Vandekerckhove, 2006). There occurs a mutual regulation of visceral physiology, as well as a mutual regulation of feeling. The feeling and the physiology are entwined, so to speak, between two organisms in intimate engagement.

The coming together of two is represented by the term *amphoteronomics*, coined to signify the reciprocal phenomenon of 'ruling together', and is closely related to, though distinguished from the traditional *autonomic* processes of self-regulation (Trevarthen et al., 2006). Mutual co-regulation

of affect and physiology appears central to a human sympathy of motives that generates the prospective function of the whole ‘self as agent’ who, with specialised sensory capacities, picks up information as perceptual ‘affordances’ (Gibson, 1977) to guide, check and correct movements of the body and its parts so they will as one integrated system, attain their intended goals effectively and efficiently (Brazelton, 1974).

In sum, reciprocity can be generalised from mother-infant research to be defined as “the sophisticated interactions between [two organisms] when both are involved in the initiation, regulation, and termination of the interaction. Reciprocity applies to the interactions in all relationships” (Douglas, 2007). In contrast, loneliness is, in a psychological reality, one of the most powerful ways that we can know death. The fear of death is rather an expression of the fear of loneliness, a fear of the lack of reciprocal relating and thus a dearth of living satisfaction.

6. Reciprocity as a Route to Satisfaction

Whitehead’s notion that the actual occasion aims to achieve ‘satisfaction’ (Whitehead 1929) is an intriguing, but unclear idea. What is ‘satisfying’, exactly? I have been puzzled by whether in a spiritual sense it is simply satisfying ‘to be’, ‘to exist’, and that that is enough. Or if, in fact, there is something more tangible about a satisfaction. Whitehead’s metaphysical scholarship defines a satisfaction as an increase in ‘contrasts’, or in ‘intensities of feeling’. If we consider again the process of relating and bring these ideas to mind, we see in the infant-adult dyad the sharing of feeling can amplify the feelings, bringing great joy.

Joy is the product of a mutual regulation of social exchange by both partners. Smiling back and forth is the prototypical example; it usually begins at a relatively low level of intensity. Each partner then progressively escalates—kicking the other into higher orbit, so to speak. The exchange occurs in overlapping waves, where the mother’s smile elicits the infant’s, reanimating her next smile at an even higher level, and so on. These overlapping waves build in intensity, until, most often, simultaneous mutual hilarity breaks out. (Stern, 1990)

Importantly, Stern brings us through the behavioural expressions of affect to look at affect communicating with affect, feeling feeling feeling, rather than behaviour sensing behaviour.

Reciprocal relations generate a shared consciousness that has at its core a feeling of satisfaction. These feelings can be known through our own human

dynamic of reciprocally relating and the phenomenology of this process of relating may be known through sensitive introspection. Their fundamental character and their essential importance in generating healthy psychoemotional foundations in humans suggests the feelings found in this reciprocal processural form, and the structure of that processural form, are strong candidates for universals applicable to all so-called 'organisms'.

7. Biochemistry, Cells, Organisms and the Actual Occasion

An understanding of biological systems driven by feeling requires the notion that even the most fundamental particles, or entities, of the natural world, the molecules that make up our cells, have within them small powers of self-willed action (Basile, 2008). It is on the back of Whitehead that, for example, the feelings that generate the containments we experience and act out as developing and adult humans are not merely human ones, but biologically universal feelings.

An 'organism' is what Whitehead calls an 'actual occasion' or an 'actual entity'. For the purposes of pragmatism, we can consider at the most basic level that an atom or a molecule is an organism with some possibility to enact its wilful action to achieve satisfaction; any entity is one that acts with a degree of unity. A macromolecular complex, for example, is an organism in an intracellular societal context, or a tightly bound collection of molecules in a cellular organelle may be an organism, or a cell may be an organism. Working up still further, cell systems are organisms and whole complexes of cells acting with unity are organisms. From the level of the cell upward, no biologist would disagree that this is the case; we only come into more controversial realms when we consider subcellular and molecular systems as 'organisms'. The power of Whitehead's philosophy removes these traditional barriers of thought and allows for conceptions of cellular and intra-cellular processes of felt experience by the entities that make them up, what we typically call molecules, proteins, *etc.*

Further, the containing relationship does something peculiar. It creates a sense of an interior where there was none previously. Between two individuals there is no physical interior, but within both an effective reciprocating relation and a containing container-contained relation, a felt sense of 'interior' develops, or co-consciousness. This can manifest itself in the physical domain, but in a manner that is not entirely obvious at first. The containing relationship prevents certain actions and affords certain others through the change in internal feelings of each party, and also

sometimes through direct or indirect physical intervention. The reciprocal relating creates a new world of possibility.

8. Reciprocity and Containment in Biological Systems

In biological systems, reciprocal relations between parts are ubiquitous. For example, reciprocal relations between biochemicals form the basis of metabolic cycles (Smith & Morowitz, 2004), signalling complexes (Muller, Obeyesekere, Mills, & Ram, 2008), genetic regulation (Nelson & Bissell, 2006), neuro-hormonal systems (Nelson & Bissell, 2006), developmental systems (Oyama, Griffiths, & Gray, 2003), physiology (Bernard, 1865) *etc.* There is no biological system that is not engaged in a reciprocated exchange with another, nor is there one that is not made up of reciprocal relations between its parts. Reciprocated exchange forms the basis of so-called equilibriums (Kirkwood & Oppenheim, 1961) between chemical systems and so-called homeostasis (Cannon, 1929; Cannon, 1932) in 'living' systems, such as protozoans or metazoans.

From the very process of conception through to the mature physiological functions of an adult, the organism is built on reciprocal inter-relations between specialised and complementary parts. Additionally, its self-driven activity in its social and object environment remains embedded in reciprocal relations with others, in this case made by the totality of the organisms acting in its world (Reed, 1996). Physical containment of these processes is also ubiquitous. Biological organisation is based on compartmentalised specialisms, each compartment contains a set of biological activity (*e.g.* biochemical activity, specialised cell function) that would otherwise not be able to endure without the protection of the containment. The difference between biological compartmentalisation and psychological inter-personal containment is obvious, the former is composed of biological material while the latter is composed of volitional action driven by feelings of sympathetic attunement, or love. However, the difference is not as clear-cut as it first seems and I believe that in these differences and similarities lie some clues to the nature of feelings in biological organisations.

If there is even an iota of *joie de vivre* present in the interactions of molecules, then there will be cause to preserve this feeling. The first molecular arrangements that generated the origins of life are cyclic, or reciprocal. These make up the modern prokaryote thermo- and mycoplasmas constructed of three coupled cycles of biochemical activity

forming sustainable relations through their reciprocal inter-relating. “The existence and co-operation of these three subsystems is the prior condition for the presence of life” (Gániti, 1971). One feeds into the other and the other feeds back to the first, and so on *ad infinitum*. *Ad infinitum*, that is, until some other molecular entity or energy extreme comes crashing in and disrupts the system, destabilising and ruining it. In order to preserve the fragility of the molecular arrangement, protection must be established. One protection is the first ‘compartmentalisation’, one of Gániti’s prokaryotic subsystems, the first membrane to surround the cyclical molecular system to preserve and protect it. However, in a panexperiential world-view, no entity is inert and passive. The molecular system that makes up the membrane must itself be contributing to a set of relations that provides a sense of satisfaction.

This is important, and possible through two means. Either the immediate set of relations provides a sense of satisfaction by placing two entities in a stable relation, or the entities generate a sense of satisfaction by contributing to a greater whole, the entire complex of entities that make up the stable set, the primitive cell. I think it is likely to be both, that there is an intense satisfaction in the immediate set of relations and another quality of satisfaction in the generation of a greater whole. This question is really one of what contributes to any one actual occasion and how the degrees of physical (coordinate) separation or functional (genetic) intimacy correspond to degrees of prehensive intensity in any one occasion. In other words, a question best addressed at length elsewhere.

The most primitive containment, the phospholipid bilayer membrane, is ubiquitous in cellular life. In fact, it characterises cellular life. The membrane is composed of two layers that are identical and surround the cell, giving the cell its boundary, its ‘skin’, and the regulatory apparatus allowing life-sustaining material in and keeping life-threatening material out (Nagle & Tristram-Nagle, 2000; Tristram-Nagle & Nagle, 2004). The molecular unit of the lipid bilayer membrane is the lipid. The membrane is composed of hundreds of millions of individual lipids, each one nearly similar to the next. The membrane becomes arranged because of the electrostatic properties of the lipids. Each lipid has an electrically charged head and two parallel electrically neutral tails. The medium of living biochemical organisation is water—our bodies are greater than sixty percent water. Water is electrically charged. Thus, the lipids arrange themselves so that their charged heads interact with the water and their tails then try to move as far away from the water as far as possible. A bilayer is one solution.

Each lipid within the phospholipid bilayer membrane works to physically contain the entire inside of the cell through its interactions with its neighbouring lipids and water solutions. By its position in the membrane structure, it immanently produces that structure through the satisfaction of its own immediate relations, and thereby engages in and contributes to the process of 'physical' containment. In satisfying those immediate relations, therefore, it contributes its vital part in preserving and therefore satisfying the greater whole. How does it satisfy its own, immediate relations? It does so through a dynamic chemical process of balancing electrostatic charges. It must 'work' with its neighbour to find a stable balance of relations, and in this case doing so creates an organisation we call the lipid bilayer membrane, made from the resulting arrangement of electrostatic properties along its tail and head.

On the basis of the foregoing discussion, how can we now account for reciprocity and containment in the individual molecular interactions? The same manifestation of containment and reciprocity that we witness in the infant-parent dyad and whose feelings we can come to know through analytic retro- and intro-spection of our own experience may be present in the interactions between two phospholipids in a cellular bilayer membrane. The same patterns of relating are apparent. The dynamic of electromagnetic charge interaction is one of reciprocal inter-relations that take place via 'discretised' quanta of activity (Feynmann, 1985; Oppenheimer, 1931), analogous to those quanta of activity that make up any one gesture in a narrative of gestures in a parent-infant engagement. That is, I propose each lipid molecule is able to direct the placement and interaction of its electric charge in such a way that it resembles the direction and placement of limbs, voice, and body in our active engagement in interaction. That is to say that in molecular engagements, the most comparable apparatus to our effectors (hands, feet, voice *etc.*) are the outer electron shells (these are the most distal atomic components and the ones that interact most directly with others) and so it may be with these apparatus that an atomic organism may enact its iota of 'will'. The phospholipids form stable relations between each other by balancing their charges to produce satisfactory hydrophobicity and hydrophilicity of its regions with that of its environment, the charges and neutralities of its neighbours.

This arrangement maintains itself in calm, benign conditions through this type of reciprocal electrostatic dynamic, forming a stable balance and so an enduring relation. It is when a perturbation to this relation occurs that the relation is pushed from being in reciprocated balance to being under threat, or pushed to an extreme. Accommodation of the disturbance must be made. As one phospholipid moves out of position with the other, both experience

higher energy feelings that have an inherent ‘pull’ to which they respond by resuming their former position. The dynamic both in spatial and in energetic terms creates a relational ‘well’ of stability, what dynamic equilibrium theory calls a low energy basin. It is the inherent ability of one individual lipid to appropriate the increased (c.f. traumatic) energy of its companion lipid, to ‘process’ this additional energy, and to give it back to the other in a new, beneficial form that closely parallels the larger form of human psychological containment.

In the lipids’ case, the containing lipid is less defined as an individual acting alone to contain as we might see a mother doing, and as is more observable as a component in a large sheet of dynamic relations. In this view, when the impact of high energy is felt by one part of the system, one lipid say, this experience is distributed over a sheet of hundreds of thousands of lipids. While this is observable, it occludes the fact that the distributions of energies comes back to the individual relations of, say, the impacted lipid and its neighbour. It is the arrangement of the lipids altogether that gives one the ability to be able to contain the up-swells of another. This core process-relational notion of ‘individual-in-community’ is an important fact not to be missed. For humans as well, it is our social distribution of containments and the distributions of energies that enables the one to contain the other. Isolated, each is bound to perish.

9. Concluding Remarks

If we are to believe that we can apply experience down to the individual ‘experiences’ of molecules (Cobb, 1984; Griffin, 1988) and that experience holds some universal qualities present in every layer of biological organisation, then we have to consider how our human experience is driven by fundamental feeling and how these might be applicable. It has been shown that a process account of biochemical activity is achievable and may be necessary to explain the temporal course of reaction dynamics (Early, 1981; Stein, 2006). One set of feelings are the sympathies in the reciprocal, attuned relation with an intimate other. Psychoanalytic work has shown that the feelings present in this form of relating are fundamental to our psychological makeup and that these feelings are primary. They are thus a good bet for ascribing to them universal importance in every ‘organismic’ relation. From a biological view, molecules form the primary ‘building blocks’ of our constitution. Thus, what is present in us may be present in them. Our experience may be applicable to them. This reasoning forms the basis of exploring the possibility that common feelings present in and

driving reciprocity and containment in human relations are also present in and are driving 'reciprocal' and 'containing' relations between the most basic entities, the molecules.

I have given here only one infinitesimally small example of a reciprocal and containing relation between two seemingly insignificant lipids in a bilayer membrane of an anonymous cell that could be any cell in any organism in any part of the world. If we begin to examine this same structure of relating and driving engagement to form enduring relations through reciprocal and containing actions, then we begin to see this feature everywhere in nature. The biological systems positively explode with commonality. This can mean two things: either our definition is insufficiently precise to be useful, or the process is so very fundamental that it is ubiquitous in living systems. It may be that both are true: Increased resolution of the definition with precise examples by empirical observation and characterisation of this phenomenon will reveal in greater clarity the psychophysics of reciprocating and containing relations. Importantly, our definition of 'organism' must be improved, and our understanding of organisms as actual entities in biochemical systems must be enhanced (*e.g.* see Stein, this volume). This will give us greater understanding of what constitutes an 'organism' and what possibilities those, especially biochemical organisms have to enact themselves into satisfaction. If we can begin to identify these fundamentals, we will be better positioned to further examine not only reciprocity and containment in basic biological systems, but also the role such a putative set of feelings may play in creating enduring biological processive-order.

10. References

- Agar, W. E. (1936). "A Contribution to the Theory of the Living Organism." *The Quarterly Review of Biology*, 11, 16-34.
- Agar, W. E. (1943). *A Contribution to the Theory of the Living Organism*. Melbourne & London: Melbourne & Oxford University Press.
- Basile, P. (2008). "Panpsychism." In M. Weber & W. Desmond (Eds.), *Handbook of Whiteheadian Process Thought, Vol. 1*. Frankfurt: ontos verlag.
- Bernard, C. (1865). *Introduction à la médecine expérimentale*. Paris: Bordas.
- Bion, W. R. (1959). "Attacks on Linking". *International Journal of Psychoanalysis*, 40.
- Bion, W. R. (1962). "A Theory of Thinking." *International Journal of Psychoanalysis*, 43.

- Birch, C. (1999). *Biology and the Riddle of Life*. Sydney: University of New South Wales Press.
- Birch, C. (1995). *Feelings*. University of New South Wales Press.
- Brazelton, T. B. (1974). "The Origins of Reciprocity: The early mother-infant interaction." In M. Lewis & L. Rosenblum (Eds.), *The Effects of the Infant on its Caregiver*. London: Wiley.
- Cannon, W. B. (1929). "Organization for physiological homeostasis." *Physiological Reviews*, 9, 399-431.
- Cannon, W. B. (1932). *The wisdom of the body*. New York: W. W. Norton & Co.
- Cobb, J. B., Jr. (1984). "Overcoming Reductionism." In J. B. Cobb, Jr. & F. I. Gamwell (Eds.), *Existence and Actuality—Conversations with Charles Hartshorne* (pp. 149-166). Chicago: University of Chicago Press.
- Delafield-Butt, J. T. (2008). "Process and Action: Whitehead's Ontological Units and Perceptuomotor Control Units." In K. Spyridon (Ed.), *Process and Life*. Frankfurt: ontos verlag.
- Douglas, H. (2007). *Containment and Reciprocity: Integrating Psychoanalytic Theory and Child Development Research for Work with Children*. London & New York: Routledge.
- Early, J.E. (1981). "Self-Organization and Agency: In Chemistry and Process Philosophy." *Process Studies* 11: 242-58
- Feynmann, R. (1985). *QED: The strange theory of light and matter*. Princeton, NJ: Princeton University Press.
- Gániti, T. (1971). *The Principles of Life*. Oxford: Oxford University Press.
- Gibson, J. J. (1977). "The Theory of Affordances." In R. Shaw & J. Bransford (Eds.), *Perceiving, Acting, and Knowing*. Hillsdale, NJ: Erlbaum.
- Griffin, D. R. (1988). "Of Minds and Molecules: Postmodern medicine in a psychosomatic universe." In D. R. Griffin (Ed.), *The Reenchantment of Science*. Albany, NY: State University of New York Press.
- Kirkwood, J. G. & Oppenheim, I. (1961). *Chemical Thermodynamics*. New York: McGraw-Hill.
- Leue, W. H. (2005). *Metaphysical foundations for a theory of value in the philosophy of Alfred North Whitehead*. Ashfield, MA: Down-to-Earth Books.
- Malloch, S. (1999). "Mothers and infants and communicative musicality." *Musicae Scientiae, 1999 Special Issue*, 29-57.
- Malloch, S. & Trevarthen, C. (Eds.). (2008). *Communicative Musicality*. Oxford: Oxford University Press.
- Muller, M., Obeyesekere, M., Mills, G. B., & Ram, R. T. (2008). "Network topology determines dynamics of the mammalian MAPK1,2 signaling network: bifan

- motif regulation of C-Raf and B-Raf isoforms by FGFR and MC1R." *FASEB*, 22, 1393-1403.
- Nagle, J. F. & Tristram-Nagle, S. (2000). "Structure of lipid bilayers." *Biochim. Biophys. Acta*, 1469, 159-195.
- Nelson, C. M. & Bissell, M. J. (2006). "Of extracellular matrix, scaffolds, and signaling: tissue architecture regulates development, homeostasis, and cancer." *Annual Review of Cell and Developmental Biology*, 22, 287-309.
- Oppenheimer, J. R. (1931). "Note on Light Quanta and the Electromagnetic Field." *Physical Review*, 38, 725-746.
- Oyama, S., Griffiths, P. E., & Gray, R. D. (Eds.). (2003). *Cycles of Contingency: Developmental Systems and Evolution*. Cambridge, MA: MIT Press.
- Reddy, V. (2008). *How Infants Know Minds*. Cambridge, MA: Harvard University Press.
- Reed, E. S. (1996). *Encountering the World: Toward an ecological Psychology*. Oxford: Oxford University Press.
- Smith, E. & Morowitz, H. J. (2004). "Universality in intermediary metabolism." *Proc. Natl. Acad. Sci. USA*, 101, 13168-13173.
- Stein, R. L. (2006). "A process theory of enzyme catalytic power—The interplay of science and metaphysics." *Foundations of Chemistry*, 8, 3-29.
- Stern, D. (1971). "A micro-analysis of mother-infant interaction: Behaviors regulating social contact between a mother and her three-and-a-half-month-old twins." *Journal of the American Academy of Child Psychiatry*, 10, 507-517.
- Stern, D. (1990). "Joy and Satisfaction in Infancy." In R. Glick & S. Bone (Eds.), *Pleasure Beyond the Pleasure Principle* (pp. 16). New Haven, CT: Yale University Press.
- Stern, D. (2004). *The Present Moment in Psychotherapy and Everyday Life*. New York: W. W. Norton & Co.
- Trevarthen, C. (1977). "Descriptive Analysis of Infant Communication Behavior." In H. R. Schaffer (Ed.), *Studies in Mother-Infant Interaction: The Loch Lomond Symposium* (pp. 227-270). London: Academic Press.
- Trevarthen, C. (1998). "The concept and foundations of intersubjectivity." In S. Braten (Ed.), *Intersubjective Communication and Emotion in Early Ontogeny* (pp. 15-46). Cambridge: Cambridge University Press.
- Trevarthen, C., Aitken, K., Nagy, E., Delafield-Butt, J. T., & Vandekerckhove, M. (2006). "Collaborative Regulations of Vitality in Early Childhood: Stress in Intimate Relationships and Postnatal Psychopathology." In D. Cicchetti & D. J. Cohen (Eds.), *Developmental Psychopathology* (pp. 65-126). New York: John Wiley & Sons.

- Tristram-Nagle, S. & Nagle, J. F. (2004). "Lipid bilayers: thermodynamics, structure, fluctuations, and interactions." *Chemistry and Physics of Lipids*, 127, 3-14.
- Tronick, E. (2005). "Why is connection with other so critical? The formation of dyadic states of consciousness and the expansion of individuals' states of consciousness: Coherence governed selections and the co-creation of meaning out of messy meaning making." In J. Nadel & D. Muir (Eds.), *Emotional Development* (pp. 293-316). Oxford: Oxford University Press.
- West, G. E. & Brown, J. H. (2005). "The origins of allometric scaling laws in biology from genomes to ecosystems: towards a quantitative unifying theory of biological structure and organisation." *J. Exp. Biol*, 208, 1575-1592.
- Whitehead, A. N. (1929). *Process and Reality*. New York: Macmillan.

Notes

¹ “The force that through the green fuse drives the flower
Drives my green age; that blasts the roots of trees
Is my destroyer.

And I am dumb to tell the crooked rose
My youth is bent by the same wintry fever.

The force that drives the water through the rocks
Drives my red blood; that dries the mouthing streams
Turns mine to wax.

And I am dumb to mouth unto my veins
How at the mountain spring the same mouth sucks.

The hand that whirls the water in the pool
Stirs the quicksand; that ropes the blowing wind
Hauls my shroud sail.

And I am dumb to tell the hanging man
How of my clay is made the hangman's lime.
The lips of time leech to the fountain head;
Love drips and gathers, but the fallen blood
Shall calm her sores.

And I am dumb to tell a weather's wind
How time has ticked a heaven round the stars.

And I am dumb to tell the lover's tomb
How at my sheet goes the same crooked worm.”

—Dylan Thomas, *ca.* 1934