THE RELATION BETWEEN SCIENCE AND THEOLOGY: THE CASE FOR COMPLEMENTARITY REVISITED

by K. Helmut Reich

Abstract. Donald MacKay has suggested that the logical concept of complementarity is needed to relate scientific and theological thinking. According to Ian Barbour, this concept should only be used within, not between, disciplines. This article therefore attempts to clarify that contrast from the standpoint of cognitive process. Thinking in terms of complementarity is explicated within a structuralist-genetic, interactive-constructivist, developmental theory of the neo- and post-Piagetian kind, and its role in religious development is indicated. Adolescents' complementary views on Creation and on the corresponding scientific accounts serve as an illustration. After further analysis of parallel and circular complementarity, it is shown under which conditions complementarity of science and theology can be better justified and may be potentially more fruitful than is apparent from Barbour's or even MacKay's considerations.

Keywords: Ian Barbour; cognition; complementarity; epistemology; intellectual development; logic; Donald MacKay; science and religion; worldviews.

"Anyone, whether Christian or not, who wants to avoid logical blunders in seeking to bring science and faith into confrontation,

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needs the concept of complementarity," postulates Donald M. MacKay (1974, 226). On the other hand, Ian Barbour stipulates, partly quoting Peter Alexander: "Models should be called complementary only if they refer to the same entity and are of the same logical type. . . . [Science and religion] do not refer to the same entity. They arise typically in different situations and serve different functions in human life" (Barbour 1976, 77–78).

Clearly, MacKay and Barbour do not refer to the same notions. MacKay writes about faith and confrontation, Barbour about religion and models. However, these are not the decisive differences between the two views.[1] As will become clear, the differences hinge on the definition of *complementarity* (parallel or circular?), on the meaning of *the same entity* (existing or tentatively constructed?), and on the import of *logical type* and *different functions*.

MacKay, however, was well aware of the danger of a blanket use of complementarity: "How can we prevent complementarity from becoming yet another fashionable escape . . . from intellectual integrity in theology?" (1974, 225). He pleaded for "balance and common sense in clarifying and using appropriately" what he believed is a legitimate logical concept (1974, 242). Barbour concedes some benefit in viewing personal and impersonal models of God as complementary—but only within the same (for instance, Hindu or Christian) tradition.

I argue that the inquiring system has to be adapted to the problem structure, and a major point is that we are not discussing an object or system that can be understood from analysis of its appearance or from a single manifestation. Rather, the "object" or "system" behaves so differently under different circumstances that different categories of explanations are required. Nevertheless, all manifestations are linked "internally." The inquiring system in question, designated "thinking in terms of complementarity" or "complementarity reasoning," has much to do with determination of that link, and this is particularly true if a paradigm change is required before the problem structure can be understood fully (e.g., the change from classical to quantum physics or from Jesus the Prophet to Jesus the Messiah (Reich 1989b). Before such a change, the ambient (scientific) culture may well consider that positing such a link is logically incompatible, paradoxical, or even absurd.

Although I accept MacKay's logical complementarity, I also argue for epistemological complementarity. I therefore attempt to clarify the contrast between MacKay's and Barbour's views from that perspective and to look at the heuristic potential of each view. Thus thinking in terms of complementarity is examined as cognitive

process. In its most developed form, that type of thinking is posited to go beyond Piagetian formal operations. As will be shown, the thinking in question falls between analogical and dialectical thinking, and involves features of both. The connection with theories of faith development and religious judgment is also explained, and the results are illustrated by interviews with adolescents about Genesis, the "Big Bang," and evolution. These views are important: on one hand, many lifetime ideas are developed in late adolescence; on the other hand, the interviews point toward the heuristic value of complementarity.

Function and Characteristics of Thinking in Terms of Complementarity

The thinking that we will discuss describes or explains "functionally coherent units" (references) that are conceptually unified by their functional coherence but are not yet explained by any unified laws or analytical procedures. An adequate explanation is posited to result from (1) examining at least two different modes of being that occur under differing circumstances; (2) interpreting the observations by noncompatible[2] concepts; and (3) searching for the "coinherence"[3] of noncompatible aspects under all circumstances (Reich 1989b; 1990). Illustrative (but not uncontested) examples are (1) the explanatory description of light in terms of wave- and particlelike behavior (as distinct from the mathematical quantum physics formalism), (2) the definition of the Divine Word and its embodiment in Jesus of Nazareth in terms of two natures that exist "without confusion, without change, without division, without separation,"[4] and (3) the conception of human beings in terms of the complementarity of mind and body (although it is not clear which psychological model is to be linked to which physiological processes). In all cases, the subtle links between the two (or more) modes of being are a *sine qua non* condition (otherwise, the case falls outside our present discussion—we are not dealing with class logic).

MacKay (1974, 241) and Barbour (1976, 77)—among others—insist that this link, characterized by the coinherence of noncompatible aspects, should be present in every situation, and they consider this a fundamental aspect of complementarity. That view is consistent with my analysis on the philosophical level, but it is not helpful as far as the cognitive process is concerned: the coinherence may well be present, but not easily noticed. Observation shows that understanding develops from characteristics that meet the eye toward the defining features (which may be more subtle, more hidden), from

comprehension of isolated entities or concepts toward their relationship.[5] For instance, comprehension of the nature of light went from observations of its wave- and particlelike behavior to the integration of quantum formalism, and finally to Heisenberg's uncertainty relation. Similarly, comprehension of the identity of Jesus went from the concept that God and human beings are separate and different (the common understanding in his lifetime) to the insight of the Apostles that Jesus is the Christ, and only then to the Chalcedonian definition in which the link between the two natures is clarified (as quoted above). Again, precise observation of the placebo effect, a manifestation of the link between mind and body, came late in the study of the mind-body problem—and its *real* understanding does not yet seem in sight.

In the present case, it so happens that one can learn something on every step of the cognitive process. In this view, MacKay's and Barbour's insistence on *one* situation is unnecessarily restrictive: certain features of complementarity come to light precisely in different situations (which are probably also those that are more easily observed). As for Heisenberg's uncertainty relation, it is of course true that noncompatible features are implicit in any situation, yet some may be more hidden in certain circumstances. Is it not easier to study these features separately in differing situations? Similarly, Jesus Christ has been made known in two natures that exist "without division, without separation," and hence both natures must exist in any situation. However, these natures also exist "without confusion, without change." Isn't it more sensible, therefore, to start the long road toward understanding by examining situations in which one nature appears much more prominently than another?[6] Again, is the placebo effect, although it will have to be understood eventually, the most promising phenomenon for *starting* to unravel the mind-body problem? As this discussion shows, the philosophical and psychological perspectives are not necessarily the same. Although it is important to ask, with Immanuel Kant, "*What* can I know?" it is at least as important to ask, with Jean Piaget, "*How* does my mind gain knowledge and insight?"

The main characteristics of thinking in terms of complementarity should be clear from the foregoing. Supporting intuition, this type of thinking serves as a heuristic, as a useful cognitive device for gaining a deepened understanding of problems such as those outlined above. It does this (Reich 1990, in press) by:

clarifying and defining, at least tentatively, the "functionally coherent unit" (i.e., the reference that is to be described or explained);

listing all descriptions, or explanations A, B, . . . , from differing categories, even if they are considered incompatible, incommensurable, etc., by the ambient culture, possibly adding new ones, and dealing with any conflicts arising;

establishing the circumstances under which A, B, . . . , describe or explain particular aspects of the reference, and, if a genuine understanding does not come forth, reconsidering A (B, . . .) as an approximation or only as an analogy;[7]

discovering and describing any (even unexpected) links between the different descriptions or explanations, and disclosing (even unsuspected) common attributes and coinherences;[8]

assessing the extent to which the relative (proportional) explanatory contribution of each mode depends on the current "strength" of the other mode(s)—as distinct from a contribution described by a fixed relationship;

developing a complete synopsis or theory that explains all features of the reference in different circumstances and situations;

explaining any shifts in the meaning of the concepts needed to explain the reference, its modes, and the new synopsis or theory.

One therefore sees that the reasoning under discussion is aware of various correlations: between the reference and the explanations, between the explanations and external circumstances, between the accepted meaning of words and their use in the pertinent case, between the empirical findings and the logic assumed, and possibly between the observer and the observed.

Now that we have characterized high-level complementarity reasoning, how does it develop?

Development of Complementarity Reasoning

Thinking in terms of complementarity develops in stages, ideally reaching four or even five levels (Oser and Reich 1987).[9] At level 3, achieved by a majority of our nonrepresentative subjects in adolescence, a person has acquired the basic capacity to think no longer (automatically) in terms of true-false decisions but, where appropriate, in terms of coordinating competing explanations (A, B, . . .). At level 4 (late adolescence or early adulthood, if at all), the link between A and B becomes clear and the lack of transsituational consistency is dimly perceived. Level 5 (adulthood) corresponds to the confirmed competence already described.

Relation to Other Forms of Thought

The development of complementarity reasoning parallels logical-mathematical thought, according to Piaget (Piaget 1970, 711; 1983,

110). Indeed, the Piagetian theoretical framework[10] applies, inasmuch as "equilibration" (Piaget 1970, 725; 1983, 122) seems to play a role in developing the ability to think in terms of complementarity; that is, one observes the spontaneous tendency of mental structures to perfect themselves by resolving contradictions, filling gaps in knowledge, etc., and to improve their adaptation through a more complex, higher-level organization. More specifically, Reich and Oser (1990; Reich in press) hypothesize, for each level, commonalities and differences between the two forms of thought (see table 1).

A given (sub-) stage of Piagetian operations is posited as a necessary yet insufficient condition for reaching the corresponding level of complementarity reasoning, and the first empirical findings support this hypothesis. The differences in the logics underlying the problem structures that are dealt with by the two forms of thought probably explain at least part of the differences listed. Piagetian operations assume that, despite appearances to the contrary, a statement is (1) either true or false, (2) can be rechecked (empirically) at any time, and (3) does not contain any "paradox" (i.e., does not appear to involve logical contradictions). None of these assumptions

TABLE 1

HYPOTHESIZED COMMONALITIES AND DIFFERENCES BETWEEN PIAGETIAN (SUB-) STAGES AND LEVELS 2–4 OF COMPLEMENTARITY REASONING

Piaget	Com. reas.	Both	Only Piaget	Only complementarity
Concrete operations	2	Dealing (intuitively) reversibly with 2 entities	Concrete entities that are intrinsically independent of each other	"Theories" that, if really complementary, are not independent but subtly linked
Transition	3	Global dealing with systems	System characterized by fixed relationships	Frequently no (known) systemwide or fixed relationships
Formal operations	4	Use of hypothetico-deductive method	Transsituational consistency; time only as external parameter	Dependence of explanatory weight of a given theory on circumstances/ (life)time

need be true for the problems that complementarity reasoning deals with (Reich 1989b).

Which other forms of thought interest us?

As a cognitive technique, the thinking under discussion falls between analogical and dialectical thinking (Secretan 1987);[11] that is, certain cognitive schemata in those types of thought are also used in complementarity reasoning. Bringing out commonalities and differences between A and B is also found in thinking in analogies,[12] whereas the following operations are shared with dialectical thinking—(which, nevertheless also requires additional operations: location of an element or phenomenon within the whole(s) of which it is part; description of a whole (system, form) in structural, functional, or equilibrational terms; assumption of contextual relativism; assertion of the existence of relations, the limits of separation, or the value of relatedness; description of a two-way reciprocal relationship; assertion of internal relations; and multiplication of perspectives as a concreteness-preserving approach to inclusiveness.[13]

Complementarity Reasoning and Religious Development[14]

We now turn to complementarity reasoning in selfhood and faith development, as described by James Fowler (1987, 53-77),[15] and also in the development of religious judgment/consciousness, as described by Fritz Oser (e.g., 1985; 1988; in press; Oser and Gmünder [1984] 1988). Fowler (1987, 71) refers to the last but one of his developmental stages (see table 2) as "conjunctive faith and the inter-individual self" because that stage is posited as characterized by "a rejoining or a union of that which previously has been separated." (The name is taken from Nicolas of Cusa's *coincidentia oppositorum*.) Although Fowler does not use the term *complementarity* in this context, it is clear from the wording (on page 72) that he refers to the type of thinking under discussion: "One begins to make peace with the tension arising from the fact that truth must be approached from a number of different directions and angles of vision. As part of honoring truth, faith must maintain the tension between these multiple perspectives, and refuse to collapse them in one direction or another." Note that, according to Fowler, this stage is typically not reached before the mid-thirties. (See Reich 1990 about obstacles to thinking in terms of complementarity.)[16]

The theory of Oser and Gmünder ([1984] 1988) is more restricted; it posits that "with age-related growth the relationship

between a person and an Ultimate Being (to which the person actually refers) becomes (1) more autonomous, more differentiated, and more universal, and (2) more connected, more integrated and more ideographic" (Oser 1988, 48; for his "stage" descriptions on pp. 52–53, see table 3).[17] Complementarity reasoning here,

TABLE 2

STAGES IN SELFHOOD AND FAITH, ACCORDING TO JAMES FOWLER (STAGE 6 IS OMITTED BECAUSE IT IS NOT YET EMPIRICALLY FOUNDED)

Stage	Designation	Characteristics (condensed by K. H. R.)
0	Primal faith and the incorporate self	Dualism of self-other, self-object, self-environment; gradual differentiation between these domains and the self
1	Intuitive-projective faith and the impulsive self	Emotional and perceptual ordering of experience; symbols or representations of deity may mix anthropomorphic and nonanthropomorphic imagery; potential for forming deep and long-lasting emotional and imaginal orientations in faith
2	Mythic-literal faith and the imperial self	Orientation to narrative and story as principal means of constructing, conserving, and sharing meanings; God rewards people when they do right, and punishes people when they do wrong. Selfhood is embedded in its needs, wishes, and interests, and they shape a person's interpretation of experience and of other persons
3	Synthetic-conventional faith and the interpersonal self	I see you seeing me, and I see the me I think you see; the individual begins to be aware of, and attends to, his or her interiority; values, commitments, and beliefs are seen as central to identity and worth; God knows who we are and what we are becoming, and as Divine Other, he sustains and fulfills our selfhood
4	Individuative faith and the institutional self	Third-person perspective; critical examination of one's heritage and beliefs, symbols, and values, which involves gains and losses
5	Conjunctive faith and the interindividual self	We stutter when we speak of the Divine; the reality our symbols and metaphors seek to express spills over them in excess and dissipates behind them in a simultaneous disclosure and concealment of the holy; readiness for serious mutual dialogue with traditions other than one's own

TABLE 3
STAGES OF RELIGIOUS CONSCIOUSNESS, ACCORDING TO FRITZ OSER AND PAUL GMÜNDER (STAGE 0 IS OMITTED BECAUSE IT IS NOT RELEVANT HERE)

Stage	Designation	Description (translation by K. H. R.)
1	*Deus ex machina*	There is an Ultimate Being who protects you or sends you something hurtful, dispenses health or illness, joy or despair. The Ultimate Being influences you (and all other living beings) directly. The Ultimate Being's will must always be done; otherwise the relationship is broken
2	*Do ut des* ("Give so that you receive")	The Ultimate Being can be influenced by prayers, offerings, obedience to religious rules, etc. If one cares about the Ultimate Being and passes the tests He [or She] sends, He will act like a trusting and loving father [or mother]. An individual can influence the Ultimate Being or can fail to do so, depending on his or her needs and free will
3	Deism	The individual assumes full responsibility for his or her life, and for the world. Although freedom, meaning, and hope are linked to decision, the Ultimate Being is apart. He [or she] has his [or her] own field of action, we have ours. The Ultimate Being's wholeness encompasses a freedom, hope, and meaning that are different from the human variety. Transcendence is external to the individual, but represents basic order in the world and life
4	Correlation	When an indirect, mediated relationship with the Ultimate Being has come into existence, the individual continues to assume responsibility; but he or she wonders about the conditions for bearing such responsibility. They see their commitment as a way to overcome a lack of meaning and hope, as well as absurdity. Transcendence is now partly inside (immanence), as the Ultimate Being becomes the condition for the possibility of human freedom, independence, etc., according to the divine plan

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TABLE 3 (*Continued*)

Stage	Designation	Description (translation by K. H. R.)
5	Communication	The Ultimate Being (God) appears in each human commitment, yet at the same time transcends it. The Ultimate Being becomes apparent in history and revelation, so that transcendence and immanence interact. This total integration renders possible universal solidarity with all human beings. The Realm of God becomes a symbol for a peaceful and fully committed human potential, which creates meaning not in options, detached from the world, but in truly social perspectives

according to Oser (1985, 181), is similar to its role in faith development. At stage 3, a person interprets relevant situations as involving only his or her actions and responsibilities; a divine realm is felt to be distant, and can be accepted or rejected. At stage 4, in contrast, "part of human existence is understood in terms of human potential, and a second part is understood in terms of the Ultimate [Being]", taken as the condition for the possibility of human freedom . . . and action" (Oser 1985, 181). Thus complementarity reasoning here assists in the coordination of ego needs and the divine plan.

By now it is clear that thinking in terms of complementarity can permit one to gain insight into the workings of certain "functionally coherent units." Its absence, in fact, can lead to cognitive dissonance —for instance, regarding issues that are dealt with by both science and religion. The following examples show this possibility, but also that, under favorable circumstances, it need not arise.

Complementarity of Divine Creation, the "Big Bang," and Evolution As Viewed by Adolescents

Why are the views of adolescents of relevance in this context? On one hand, adolescents have supposedly acquired Piagetian formal operations—among other things, that is, the capacity to think for themselves, using abstract thought, hypothesis building, and logical argumentation. On the other hand, adolescents are searching for their position in the adult world and, in the process, examining the often-conflicting statements that have been presented to them (see, e.g., Richard 1985). In the words of Katja (15 years and 6 months; henceforth written *15, 6*): "Well, and then I started little by little

to clarify my own ideas about the Church and God, and I perhaps no longer merely accepted everything. And then one's worldview changes, of course." In fact, a disproportionately large fraction of an individual's important lifetime ideas seems to be formed during the teenage years.

Problem 9 of our study (Oser and Reich 1987) concerns the origin of the universe and the beginning of life in various forms. For a scientist, the "Big Bang" and evolution provide adequate explanations (A). For a cleric, these are welcome, but only partial, explanations. For him (or her), God's plan was required at the outset, and God is still present today—for example, when one perceives the beauty of natural events or has to make a difficult moral decision (B). A subject's interview begins with the question: "Who is right, A or B?" The answer is then followed up to bring out the reasoning.

A 13-year-old, a 15-year-old, and three 16-year-olds (Carole, Richard, and Ursula) sided with the scientist (A): "He can *prove* his point, the minister cannot." Yet others saw this differently. First, the level 3 responses (including those slightly below or above), Aloys (12, 6) said: "God works perhaps through good luck, that at a given moment just the right thing happens, like, just the stuff arrives which was needed." Peter (16, 2): "The 'Big Bang' is all right, but insufficient as an explanation. That takes something more, like a higher spirit who originated the 'Big Bang'." Katja (15, 6): "The first matter cannot have appeared from nowhere. . . . A higher power—which must certainly exist—has presumably come in and somehow contrived that this matter came into being. . . . After that point, things evolved on their own . . . perhaps according to the possibilities planned by the higher power." Emil (15, 7): "In the beginning God has made these particles, and then this cloud, this gaseous aggregate formed . . . and then God let events take their natural course. . . . How life became possible on Earth, that already indicates something superior acting backstage." Françoise (18, 4): "The scientists are also right, but they cannot say why the world exists. . . . God wanted it to exist. . . . But one has to understand this symbolically, this portrayal of Adam and Eve . . . I simply would combine it with the theory of evolution."

Others went even further, probing into the relationship and linking the whole to human life and thought (level 4 responses). Reto (17, 3): "A and B belong to different dimensions . . . God exists in a dimension that we cannot understand. However, God can perhaps influence people's minds. . . . I do not know the reasons, I am not God." Bernhard (16, 5): "I now rather visualize that [living] things have evolved of their own, that not everything has been created by

God, . . . I now tend to believe that God supports this [evolution] but does not implement it. . . . In the beginning God created the laws of nature, and then things evolved according to these laws." Renate (20, 4): "The possibility of evolution was contained in God's 'kickoff' at the world's origin . . . but God probably did not interfere with evolution itself . . . in which perhaps, so far, not all of the potential has come to fruition." For René (17, 8), scientific and religious statements were complementary; both are helpful and needed: the scientific statements to find one's way around this world, the religious ones to live a truly human life. Victor (19, 10): "For me there exist several models which help us to find out about the world's origin. If somebody speaks about a physics theory, in my view that does not *per se* contradict a religious worldview. Both are models of a beginning. [Such a model] does not represent the beginning itself, but the beginning as mirrored in human thinking. Adam and Eve in the Bible are a possible model of human origin, calling for interpretation. They are meant to be not really a scientific statement, but rather to underline the role of humanity."

What do we learn from this? We witness various ways of coordinating the competing explanations of the scientist and the minister, in some cases at a high level. Aloys still gropes for such a coordination; Peter recognizes that the explanation must begin with the earliest moment, and this is achieved, he believes, by connecting partial statements by the scientist and the minister. For Katja, God may have provided possibilities concerning the sequelae. Emil sees likely confirmation for such a hypothesis in the emergence of life. Françoise, in addition, emphasizes the symbolic language of the biblical account and suggests it be supplemented in terms of today's scientific knowledge. Thus all these adolescents emphasize the need for, and the possibility of, bringing explanations from both realms together—without, however, being sure (as yet) of the link's continuation in time.

For Reto, this link exists at least in people's mind; Bernhard sees the link in God's creation of the laws of nature; Renate expresses a similar idea; and René, who looks at the matter from the point of view of human action, generalizes. Victor, finally, goes further into the meaning of Adam and Eve than Françoise, and raises issues of epistemology and the philosophy of science. At this point we note (*pace* Barbour) that these adolescents quite naturally conjoin science and religion.

What makes us confident that these complementary statements result essentially from the adolescents' own thinking? This is clear not only from other unconventional answers to interviews but was

often explicitly stated. Katja put it this way: "When we learned at school how the world evolved from the 'Big Bang,' I thought things over and came to the conclusion that most probably a higher power started it all." Whether these "critical" adolescents (Carole, et al.) will later think the same way as Aloys and Victor, as well as some resulting educational *desiderata,* has been discussed elsewhere (Fetz and Reich 1989; Reich 1989a).

Parallel Complementarity

The type of complementarity admitted by Barbour has been called *parallel complementarity* by Carl Friedrich v. Weizsäcker (1955, 522): A and B (the noncompatible concepts, hypotheses, models, etc.) are of the same logical type, have previously been employed in the same discipline, and are used in the same paradigm community (Barbour 1976, 77, 84). The great advantage of these restrictions is, of course, that the danger of misunderstandings—so pervasive in initial interdisciplinary discussions—is lessened. One stands with at least one foot on known, uncontested territory, which is all the more reassuring as, in all likelihood, difficult times are ahead before one, at last, can set the second foot on the new construction that results from thinking in terms of complementarity.

Barbour gives two good examples for parallel complementarity: (1) The already-mentioned complementarity of a personal and an impersonal model of Deity (1976, 84) and (2) Tillich's individuation of human beings and God (the I-Thou encounter) and the human being's participation in the divine (the *unio mystica*) (1976, 86). An explanation in terms of one model limits explanation in terms of the other (parallel) model. Clearly, a person cannot simultaneously both kneel before God and adore him in his or her individual way *and* feel in complete and total union with God including the loss of a sense of personal identity. Nevertheless, both experiences belong to a comprehensive relationship with God. One would only wish that these examples had been worked out further to illustrate his methodological approach. Robert John Russell lists further examples of that class of complementarity: Karl Barth's analysis of the perfections of God, Dietrich Bonhoeffer's insistence on the interwoven roles of belief and obedience in Christian discipleship, and the Christian doctrines of nature and grace, justification and sanctification, etc (1988, 360).

Remembering that others admit of a wider applicability, one may ask whether Barbour's stipulations are unnecessarily restrictive. As for the example of the Deity model, he proposes that "we should not refer to the Hindu Brahman and the Christian God as *complementary*

models (if some analogy with quantum physics is thereby implied)" (Barbour 1976, 84, emphasis in the original). First a comment with respect to the parenthesis: "There is not the remotest justification for urging theologians to use it [the term *complementarity*] with physical rather than logical overtones when they happen to need it" (MacKay 1974, 240). Nevertheless, one might add that the progress made with an understanding of logic in connection with quantum physics can also be beneficial in other domains. As for Barbour's main point: if it is too early to construct models, that fact should not be a hindrance, *per se,* to *think* about the issues in terms of complementarity, as outlined above.

More debatable limitations of Barbour's approach become clear in his third example, Christology, in which there are two separate issues. (1) Barbour approves the complementarity of various images or models that express the significance of Christ's death ("penal substitute," "sacrificial victim," "liberator," "moral example" [Barbour 1976, 154–55]). One can easily see that this approval prevents exclusive emphasis on any of the various aspects; but if they are really in a complementary relationship, more work needs to be done than just to juxtapose them: they need to be dealt with as we said earlier. (2) Following his own stipulations, Barbour admits the Messiah and Logos models of William Austin as complementary, but not the Chalcedonian two-nature model(s) because these two natures are not on the same logical level (Barbour 1976, 152). No one disputes that the complementarity of the Messiah model, (emphasized in the theology of Antioch, and of the Logos model), closer to the views of the Alexandrian school, is one way to characterize the Chalcedonian definition. But is this approach the most effective didactically? Both the Messiah and the Logos models combine divinity and humanity, though in differing ways. Therefore, is the basic issue not simply relegated to a discussion of each model? The Fathers were not at all reluctant to spell out or expose the paradox of the two natures (see, e.g., Kaiser 1976; Reich 1990). In fact, does one in daily life not always establish relations between different logical levels—for instance, when a literary critic discusses the relation between a writer's plot and how the characters themselves see their future? Which brings us to the second type of complementarity.

Circular Complementarity

According to Weizsäcker (1956, 524), Niels Bohr never defined complementarity but illustrated its meaning by such examples as: ". . .

da das Wesen unseres Bewußtseins ein Komplementaritätsverhältnis zwischen der Analyse jeden Begriffs und dessen unmittelbarer Anwendung bedingt'' (. . . as the nature of our awareness entails a complementary relationship between the analysis of every concept and its immediate use). Bohr's view seems to have been that the meaning of this type of complementarity can only be clarified in a lengthy circular process of reflection: Why does one need this process? Why can one not understand each complementary aspect independently of the other(s)? Which corrections of the initial *a priori* presuppositions follow from the insights gained in this circular process?[18] So much to explain the term given by Weizsäcker (1956, 526).

As another example, let us recall MacKay's discussion (1974, 236) of Joseph and his brothers (Genesis 50:19–20). After their father's death, the brothers fear that Joseph will take revenge on them for having sold him as a slave—a very understandable apprehension, humanly speaking. What did Joseph actually say? ''Fear not: for am I in the place of God? But as for you, ye thought evil against me; but God meant it unto good, to bring to pass, as it is this day, to save many people alive.'' Here the ''functional unit'' is Joseph's life tapestry and its significance, and the noncompatible ''theories'' are (1) a natural account thereof and (2) a religious explanation that involves God's plan. As long as religion is admitted into the discussion, such an approach seems a paradigmatic example of circular complementarity: the two explanations illuminate, rather than limit, each other. Philip Hefner (1988, 270–78), for example, develops the theme of *Homo sapiens* as God's created cocreator. Although complementarity is never explicitly mentioned, Hefner's discussion fits into the present context and amplifies several points. Fowler (1987, 46 and passim) writes about humanity's partnership with God's ongoing creation, and further enriches this theme.

A more difficult question is the complementarity of science and religion *per se*. What is the reference object? If it is a matter of apologetic theology (see, e.g., Hefner 1988, 265), the functional unit (albeit not very clear-cut) could be the interpretation of human existence. But what is the interpretation of the more complex case of the Creator and the creation? As long as metaphorical language is used, the real difficulties of examining the links between science and religion are not yet apparent: God as novelist and the universe as a novel (MacKay 1974, 237) and God as composer and the universe as a fugue (Peacocke 1986, 97) are evocative, aesthetically pleasing, logically acceptable images—but how can we discuss concrete issues? Burhoe (1973, 440) is aware of the difficulties, and Barbour (1976,

155–65) spells out some of them in detail. However, maybe this need not be a reason *not* to attempt this work—for instance, along the lines indicated by Ralph Wendell Burhoe (1989), Holmes Rolston, III (1987), or John Polkinghorne (1989, 18–44), using the methodology stated above. In this connection the complementarity, as against a combination, of a spatiotemporal event description and its causal explanation may be particularly important (Russell 1989).[19]

Burhoe advocates conjoining the scientific approach to valid knowledge and the wisdom of highly evolved religion for determining future action: "Light from the sciences may provide some corrections or repairs to the traditional systems [of human belief] and at the same time provide some basic support or reinforcement for their fundamental wisdom" (Burhoe 1973, 413). The basic points are that (1) humanity depends on a sovereign power who transcends the power of human beings, and (2) the death of the body is not the end of all human values and purposes (Burhoe 1973, 417). These are the views of traditional religions, but according to Burhoe they can also be shown as supported by modern science.

Rolston wonders (and examines) whether a person who accepts the insight of science can maintain his or her faith. His conclusion, from his examination of the issues and methodology, is that "one must live on the cutting edge of spirituality to make sense of what lies behind and around, for only at this focus can we form within [us] the gestalt that decodes the drama" (1987, 337). Stannard (1989) expounds a similar view, involving the three explanatory frameworks (the mental, physical, and spiritual) and their interrelations. Regarding these frameworks, Stannard emphasizes the primary of our interactions with the world, as opposed to any inferences about the world in itself.

CONCLUSION

Let me begin with a triple credo (to which I subscribe): (1) "In its ability to give a theoretical status to our experience of limit and transcendence, theology is in a sense 'needed' by science. In its ability to give a theoretical status to our determinate understanding of specifiable data, science is in a sense 'needed' by theology.[20] Since this is the case, we can say that the worlds of religious and scientific meanings mediate each other" (Gerhart and Russell 1984, 176). (2) "An individual's religion is the audacious bid he [or she] makes to bind himself [or herself] to creation and to the Creator. It is his [or her] ultimate attempt to enlarge and to complete his [or her] personality by finding the supreme context in which a human being

rightly belongs" (Allport 1950, 142; 1960, 161). (3) God shows humankind a way "so that human beings can—with their peculiar combination of self-transcendence, self-consciousness, freedom to choose the good and their biological limitations—yet fulfill their potentialities and attain harmony with their creator and so *pari passu* with the created natural world" (Peacocke 1986, 130).

How can we progress toward these objectives? Complementarity, of course, is not the only conceivable relation between science and religion.[21] So what, therefore, speaks in its behalf?

First, I think I have shown that Barbour's reservations seem overcautious, particularly if MacKay's warnings are heeded. Not only can different logical levels be examined in this context, but hierarchical levels as well (see, e.g., MacKay 1974, 229–32). *Pace* MacKay, I would also argue that different situations may usefully be examined in addition to the posited situation. In my view, furthermore, the work can reasonably be started even if the functionally coherent unit has not yet been fully established—as long as there is a good probability of its existence.

Second, thinking in terms of complementarity is a natural development, given an opportunity. As were Richard, Carole, Ursula, and others, Katja was interviewed twice (at 15, 6 besides 11, 8 in her case). The challenge to coordinate religious and scientific accounts clearly stimulated her, and possibly contributed to her intellectual growth. The same holds for Ursula and other adolescents who, at the second interview, presented an original synopsis and displayed a rich, highly personal intellectual life: "Not only do I know more now, I also reflect much more" was a typical statement (by Bernhard). In contrast, such adolescents as Richard, who had decided on a ho-hum view of things (i.e., against intellectual adventure), gave an impression of intellectual dullness, even barrenness. Richard's, no doubt, is at least partly a hen-or-egg-first problem, not separated from the rest of intellectual life; but the present issue, which involves transcendence (see, e.g., Luckmann 1987), seems very stimulating (Reich and Oser 1989). Not surprisingly, it has been shown that thinking in terms of complementarity seems to be a necessary condition for reaching the higher stages of religious development, whether conceived according to Fowler or to Oser and Gmünder.

From both the conceptual and the empirical perspectives, the complementarity of science and theology can be better justified, and may be heuristically more fruitful, than is assumed by Barbour and possibly even by MacKay.

NOTES

1. Although MacKay writes about faith (a concept that involves affective aspects as well as personal identity), it is clear—from his insistence on the nature of complementarity as a logical concept, as a logical relation, and from his examples—that he means primarily cognition. *Confrontation* is presumably meant to signify "meeting face to face," rather than unavoidable conflict. For Barbour (1976, 68), religion means "first and last, a way of life; its main interest is practical rather than theoretical." His religious models "summarize the structural elements of a set of myths. . . . [They] offer ways of ordering experience and of interpreting the world. . . . [In addition to] these *cognitive functions in the interpretation of experience*, . . . religious models can also fulfil many *non-cognitive* functions of myth, particularly in the *expression of attitudes*" (1976, 27, 28; emphasis in original). Thus, despite the different expressions, MacKay and Barbour discuss essentially the same issue. If complementarity is admitted as a relation between science and religion, the same presumably goes for science and the corresponding theology.

2. When Hugo Bedau and Paul Oppenheim (1961) analyzed the logic of complementarity in quantum physics, their analysis involved the compatibility of conjugate nondispositional properties Ch′ and Ch″ of the reference as well as that of dispositions D1 and D2 relative to a given theory. Ch′ and Ch″ are noncompatible (i.e., neither compatible nor incompatible) if their exact observation, at the same time, is inconsistent with the given theory but implied by it at different times (under differing circumstances). And the same for D1 and D2. Reich (1989b, 1990, in press) has extended this analysis to Chalcedonian Christology.

3. Christopher Kaiser (1976, 43–46) discusses eleven formal ontological relations between the respective modes of being (wave and particle in quantum physics, divinity and humanity in Jesus Christ, etc.), as well as the "interchange of attributes and coinherence." The latter concept characterizes the admixture of an interchanged attribute, such as Jesus' freedom from sin (Hebrews 4:15): The Divine Word "is in" the flesh. The question of a realist interpretation of these considerations stays open (Russell 1988, 373, note 35).

4. From Robert Sellers's translation (1953, 210f.) of the Chalcedonian definition.

5. For instance, children may need to age many years before they understand that the friendly person who often visits the family and brings presents is not really an uncle or aunt, whereas the baby who visits them occasionally, together with their youngish grandmother, *is*. Similarly, young people are usually well into adolescence before they understand that a savings and loan association can function, and pay salaries to its employees, because of the difference in interest rates for savings and loans. Psychological explanations range from the "novice-expert shift" (Carey 1986, 1125–26) to the child's changing theories about the object or phenomenon under discussion (Carey 1986, 1129), to changes as a result of an evolving epistemology, including a lay theory of mind (Reich and Oser 1989).

6. As examples, the situations described in Matthew 4:1–11, 26:37–38, 26:39–41, 27:50; Mark 2:10–11; and John 8:11, 58 have been analyzed elsewhere (Reich 1989b) from such a perspective.

7. Of the several meanings and usages of *analogical* (e.g., Barbour 1976, 16–19, 30–32, 73–74; Gerhart and Russell 1984), none applies fully here. Starting from the assumption that one is dealing with an *identity* (e.g., between the human nature of Jesus and that of any other person), one discovers little by little that—notably on account of the coinherences—one is dealing with an analogy rather than an identity: some aspects are the same, but others are not.

8. See note 3.

9. Very briefly, thinking in terms of complementarity develops as follows (Oser and Reich 1987, 182). At level 1 there is usually a single choice of description/explanation A or B. At level 2, both choices are considered to be possibly right, maybe with rather different weighting factors. At level 3, both A and B are judged to be needed, at least partially. At level 4, A and B are consciously connected, their relation is analyzed, and

the dependence of their explanatory weight on circumstances may be hinted at. At level 5 (few cases studied empirically thus far), a generalized synopsis is reconstructed, possibly using supplementary descriptions/explanations and including reconstructed parts of A and B.

10. Notwithstanding the many critiques (e.g., Modgil et al. 1983), efforts at improving it (e.g., Sternberg 1984), and going beyond it (e.g., Commons et al. 1984, 1989), a basic contention of Piaget's theory seems to have stood the test of time: cognitive development results from neither simple maturation of a native endowment nor exclusively from appropriate external stimuli, written initially on a *tabula rasa,* but from continual refinement of the cognitive structures by a person's constructivist interaction with his or her natural, social, and cultural environment.

11. Just as analogical and dialectical thinking are conceived variously, thinking in terms of complementarity is, unfortunately, referred to in a stricter (Bedau and Oppenheim 1961) or looser sense in the literature. A consensus is presumably difficult to reach, but it should be clear which definition has been adopted when dealing with the theory. Empirically, a range of implicit definitions is observed (Oser and Reich 1987).

12. Dedre Gentner (1989) reports extensively on such schemata. Whereas the schemata are the same, notice that their application here differs from that referred to in note 7. There the aim is to discover and clarify any shift in meaning of the terms used, here to clarify the common and the conjugate features of *A* and *B*.

13. Michael Basseches's schemata (1984, 74), no. 9–12, 14, 15, and 24.

14. In addition to the function discussed in this section, complementarity reasoning also helps to explain such seeming paradoxes as the Trinity, the two natures of Jesus Christ, theodicy, etc. (Reich 1990, in press) that might otherwise adversely affect religious development.

15. Both James Fowler and Fritz Oser, who developed their theories from the mid-seventies on, recognize their debt to the kindred developmental theories of Jean Piaget, Lawrence Kohlberg, Robert Kegan, and Robert Selman. The theories of Piaget and Kohlberg were recently compared and critiqued (Nipkow et al. 1988). Fowler's theory, which ranges more widely than Oser's, has six dimensions: (1) form of logic, (2) social perspective taking, (3) form of moral judgment, (4) bounds of social awareness, (5) locus of authority, and (6) form of world coherence—all of which are capped by what he calls *symbolic function.* The sixth stage is termed *universalizing faith and the God-grounded* self. (See note 17 for Oser and Gmünder.)

16. Four obstacles (Reich 1990), are: (1) insufficient motivation to overcome various resistances (survival value of one-sided action; vastly higher frequency of yes-no or better-worse decisions in everyday life; Western tradition of "excluded third" and negative connotation of paradoxes; greater ease of maintaining an identity by taking a one-sided position); (2) unfamiliarity with the logic involved; (3) wrong root metaphor (e.g., naive realism); (4) as yet inadequate cognitive level.

17. The relationship between an individual and the Ultimate Being is analyzed in terms of seven bipolar dimensions: transcendence vs. immanence, freedom vs. dependency, trust vs. fear, the holy vs. the profane, hope vs. absurdity, eternity vs. ephemerality, and functional transparency vs. opacity. Stage O is labeled *perspective of internal-external dichotomy* because of the cognitive inability to differentiate between external agents (Oser and Gmünder [1984] 1988, 81). Some consideration has been given to stage 6, but lack of empirical data has not yet allowed a consolidation (Oser and Gmünder [1984] 1988, 94–96). See Bucher and Reich (1989) for an interdisciplinary critique of the theory of Oser and Gmünder.

18. Part of the necessary mental operations is akin to what Wolfgang Welsch calls "Transversale Vernunft" in his discussion of present-day modernity, sometimes wrongly referred to as postmodernism (Welsch 1988, pp. 295–310). If sectorially different rationalities (economic, social, moral, etc.) are accepted as basic, and the existence of any overarching encompassing rationality is ruled out of court on principle, then "transversale Vernunft" must solve the task to delimit the sectorial rationalities, and to establish bridges across them. In circular complementarity this activity

follows the particular rules pertinent to the problem structures discussed here.

19. Robert John Russell (1989) draws attention to the fact that Niels Bohr introduced the concept of complementarity into quantum physics in order to discuss the altered connection between a spatiotemporal description and a causal explanation. Whereas a player in a game of billiards rightly explains his insuccess with a given stroke by invoking the force and direction of the cue, a player in a game of dice cannot argue the same way because he ignores the detailed givens of a throw. A physicist doing a quantum physics experiment on principle has to separate the event description from a causal explanation, the latter being intrinsically of a statistical nature. Russell tentatively argues *theologically* that part of the Creation vs. "Big Bang" and evolution debate (as well as the problem of theodicy) arises because protagonists argue like billiard players and not in terms of complementarity.

20. Aquinas wrote: "An error about the world redounds in an error about God" (*Summa contra gentiles* II, 3). Fowler (1987, 41) indirectly elaborates on this statement, as follows: "When theoretical physicists begin to speak of superforce—the combined and integrated effects of the four basic forces that maintain pattern and symmetry in the universe—it should not be surprising that a theologian thinks of the loving energy and unifying spirit of a creative God." Rolston (1987, vii) adds a further perspective: "The religion that is divorced from science today will leave no offspring tomorrow. From here onward, no religion can reproduce itself in succeeding generations unless it has faced the operations of nature and the claims about human nature with which science confronts us." However, Rolston adds an important caveat: "The religion that is married to science today will be a widow tomorrow. The sciences in their multiple theories and forms come and go." Among the many testimonies to this fact, Stephen Hawking's (1988, 50) recent "conversion" comes to mind: "So in the end, our work became generally accepted and nowadays nearly everyone assumes that the universe started with a big bang singularity. It is perhaps ironic that, having changed my mind, I am now trying to convince other physicists that there was in fact no singularity at the beginning of the universe . . . it can disappear once quantum effects are taken into account."

21. Arthur R. Peacocke (1981, xiii) indicates eight ways of relating science and theology: (1) science and theology are concerned with two distinct realms: the natural/the supernatural; the spatiotemporal/the eternal; the order of nature/the realm of faith; the natural (physical)/the historical; the physical-and-biological/mind-and-spirit; (2) science and theory are interacting approaches to the same reality; (3) science and theology are distinct, noninteracting approaches to the same reality; (4) science and theology constitute different language systems; (5) science and theology are generated by quite different attitudes in their practitioners; (6) science and theology are both subservient to their objects and can only be defined in relation to them; both are confessional enterprises and intellectual disciplines; (7) science and theology may be integrated; (8) science generates a metaphysics in terms of which theology is then formulated. Peacocke (1981, xviii, n. 11) looked at the possibility of labeling his relation (2) *complementarity,* but then decided against it because of a possible ambiguity. I hope to have explained my differing view, which is more or less compatible with relationships (2)—provided there is agreement on *interaction*—and (6), but not with the others.

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