Terry Quinn, "Invitation to Functional Collaboration: Dynamics
of Progress in the Sciences, Technologies, and Arts
Journal of Macrodynamic Analysis 7 (2012): 94-122

Invitation to Functional Collaboration: Dynamics of Progress in the Sciences, Technologies,[1] and Arts

Terry Quinn

1 The Problem of Progress and Decline

Long before chemistry emerged as a recognized science, there were patterns of chemical processes and reactions in the world. In some ways, at least, the whole world is chemical. As is well known, for a time there was "alchemy." But a difficult and creative transition period through the 19th century led up to the discoveries of Mayer and Mendeleev[2] and, with them the beginnings of chemistry as a science. Once the periodic table was discovered, chemists began to explain increasing ranges of patterns of chemical processes. Progress in chemistry continues into the 21st century, including ongoing discoveries in organic chemistry. Nowadays, the understanding in physical and organic chemistry, and the levels of control, are far-reaching and complex.

In the chemistry community as a community, and indeed in all other academic communities, we find pattern—patterns of orientations, efforts, tasks, communications and collaborations, successes and failures. When things go well, when we work well together, we often call the patterns *progress*. When things do not go well, then we find the patterns of what we often name *decline*.

1.1 Questions about *progress* and *decline*

- What though are *progress* and *decline*?
- What is it that is (or is not) happening in our lives, our families, our villages, our cities, our academic communities, when things are (or are not) going well, when collaborations result in *progress* (or in *decline*)?

---

[1]By technologies, I am referring generally to "know how" and "making things," which include the engineering disciplines.

[2]The history of the periodic table reflects over a century of growth in the understanding of chemical properties, and that growth culminates in the publication of the first actual periodic table by Dmitri Mendeleev in 1869.

- What are the "dynamics of progress and decline"?

Lonergan posed the main problem in *Insight*, chapter 7.[3] To briefly paraphrase: *What can we do to promote progress and offset decline*? He named the solution *cosmopolis*. In section 7.8 of *Insight*, he worked out various aspects that the solution would need to include. But his breakthrough was in 1965, when he identified the basic heuristics of a solution.[4] In his solution, progress in academic communities is obtained through a flexible eight-fold collaborative division of labor—eight main specializations, each with its own main orientation and task. Tasks are functionally related, so the divisions of labor are called "*functional specializations*."

For those unfamiliar with these ideas, this will be rather vague at this point. My hope is that by the end of the paper, things will start to make some sense and begin to seem feasible.[5] For those already somewhat familiar with functional specialization, the examples and discussions in this article may provide helpful supporting materials. But this paper is relatively short, a pointer only. It is an invitation for further reflection by experts in all disciplines.

More accurately, as will be seen below, the invitation is in fact *history's invitation*—for it is historical process itself that is gradually bringing forth the eightfold division. In that sense, Lonergan's discovery of functional specialization is somewhat analogous to the discovery of the periodic table in chemistry. For functional specialization also can be represented by a Table, now a Global Table. Like chemistry, the Global Table involves an eight-fold "periodicity," now a "dynamic cyclic periodicity." And like chemistry, the eight dominant orientations already are verifiable in ranges of "processes"—not though mere chemical processes, but through "human collaborative processes in communities." Functional specialization then will not be "specialization" in the sense of methods or techniques restricted to particular disciplines. It will instead be an eight-fold division of collaborative tasks that already gradually is beginning to emerge in disciplines, arts, sciences, and technologies.[6] And just as contemporary physical and organic chemistry has been developing in ways far beyond early developments following Mayer and

---

[3] Bernard Lonergan, *Insight: A Study of Human Understanding*, ed. Frederick Crowe and Robert Doran, vol. 3, *Collected Works of Bernard Lonergan* (University of Toronto Press, 1992) (rev. 5th ed., first published by Longmans, Green, and Co., London, 1957), section 7.8.6 (hereafter *CWL* 3). See, in particular, p. 263 ff.

[4] Bernard Lonergan, "Functional Specialties in Theology," 50 *Gregorianum* (1969), 485-504 and *Method in Theology* (Toronto: University of Toronto Press, 1990)(rev. 2nd ed., first published by Longman and Todd Ltd., London, 1971).

[5] Relevant here is that the word 'feasible' has roots in anglo-french-latin words for 'to do' and 'do-able.'

[6] See section 3, below.

Mendeleev, so too we can expect that future functional specialization eventually will lead to developments and differentiations well beyond present-day notions.

1.2 Examples of *division of labor*

"Division of labor" certainly is not new, and goes back to the earliest of human times. More recently, there are shoemakers, bakers, farmers, musicians, instrument makers, assembly lines in factories, and so on. And a shoemaker might have an assistant who enjoys specializing in using some of the machines, while the master shoemaker might enjoy running the shop, talking with customers, and designing new shoes. For towns and cities, there are archivists and historians; there are experts in policy making; experts in working out planning options; experts in design and construction; teachers, and so on and so forth.

In physics, two broadly defined and familiar divisions of labor can be traced back to Galileo's[7] investigations into free-fall (the discovery of a relation between measured distance and measured time). There is the work of experimental physics, obtaining data on trajectories; and there is the work of theoretical physics that focuses on explaining that data. This division in physics now is so well established that, depending on one's interests, one needs completely different academic degrees. Both groups contribute to physics, but, for example, Ph.D.'s in Experimental Physics are very different from Ph.D.'s in Theoretical Physics—there are different curricula, different academic programs, different career paths,[8] and even separate Nobel Prizes.[9] But, within the physics community as a whole, theoreticians and experimentalists have been very successful working together to move the field forward.

We also find results in physics similar to the work of Edward Witten, who in the 1980s worked out what is now known as *string theory* (and later developed into *superstring theory*). Witten was working toward a possible new standard model for particle physics. As it turns

---

[7] Galileo Galilei, 1564 –1642.

[8] The experimental physicists typically get jobs in national labs, while theoreticians more commonly get positions in university departments and theoretical research institutes. Advanced specialized training is required to use the contemporary laboratory technology of particle accelerators. On the other hand, theoretical physicists tend only to need whiteboards, pen and paper, seminars, lectures, and in some cases computer simulations.

[9] Two examples: The Nobel Prize in Physics in 1979 was awarded jointly to Sheldon Lee Glashow, Abdus Salam, and Steven Weinberg "for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, inter alia, the prediction of the weak neutral current"; the Nobel Prize in Physics in 2010 was awarded jointly to Andre Geim and Konstantin Novoselov "for groundbreaking experiments regarding the two-dimensional material graphene." For more examples, see http://nobelprize.org/nobel_prizes/.

out, Witten's speculative theory seems to be more mathematical[10] in nature, and seems to be non-verifiable.[11] It has, though, prompted important foundational questions. And while Witten's *string theory* seems problematic as a possible physical theory, it points to a kind of speculative and future-oriented work that occurs in physics—where the investigator focuses not on available data as such, but on the question, "What might be?"[12]

Engineering also, of course, has several familiar divisions. To evoke a few examples only, one might recall that there are members of the engineering community whose expertise is focused on using already established methods to design buildings; as well as others who, in addition to understanding standard engineering principles, have expertise in on-site *project management*, and are able to make sure buildings get constructed properly, in good order and in good time. There are engineering theories and methods, as well as civil engineers, for instance, who rely on these to design and build bridges, buildings, and city water systems. In addition to professional engineers who "work on site," there are engineering faculty members in universities and engineering schools. There are the tasks of working out engineering policies for engineering societies and schools, policies that to some extent influence work in the engineering community. There are also "*Engineers of the New Millenium*" who focus on "devising new capabilities and designing new technologies." [13]

There are many other familiar divisions throughout the various academic disciplines. To list somewhat randomly, there are theories of education for science, for technology, for engineering and mathematics (taken together often called STEM), as well as for the arts and humanities. Education theories can influence how subjects are taught,

[10] In 1990, Witten was the first physicist to be awarded the Fields Medal for Mathematics, by the International Mathematical Union.

[11]"String theory makes no verifiable predictions, and so seems to be safe as a mathematical theory, but so far cannot be confirmed or denied." Sheldon Glashow, NOVA, PBS, 2002, http://www.pbs.org/wgbh/nova/elegant/view-glashow.html. The fact that string theory makes no empirical predictions has led to its rejection by some of the leading physicists of the 20th century, e.g., Glashow, Feynman, et al. In O'Raifeartaigh's 2000 review article, we find the following: "The next step in creating a more unified theory of the basic interactions will probably be much more difficult. All the major theoretical developments of the last twenty years, such as grand unification, supergravity, and supersymmetric string theory, are almost completely departed from experience. There is a great danger that theoreticians may get lost in pure speculations." Lochlainn O'Raifeartaigh and Norbert Straumann, "Gauge Theory: Historical Origins and Some Modern Developments," 72 *Reviews of Modern Physics* (2000),15.

[12] On the possibility of *relatively effective* speculation, see the discussion in section 2, on Systematics.

[13] http://www.nsf.gov/news/special_reports/eng_mill/

and to some extent determine trends of the future. Again, in the arts we have art, but also there are theories of art, various kinds of arts councils, funding programs, and so on.

Divisions of labor need not be static, and new ones can emerge. Examples can be found by looking to developments in the late 20th century, when *environmental science* emerged as a discipline. There are now several world environmental groups communicating in historically new ways with governments and other agencies about, for example, the need for reasonable management of "eco-systems." In some places, environmental policies are now being factored into city planning, the development of acceptable technologies, engineering designs for buildings, bridges, and new automobiles. Buildings, though, are not just engineered structures, but also can be architectural works of art. So, environmental policies and engineering strategies play into artistic design options. On the other hand, architectural vision has been known to call forth creativity in engineering methods to help make a creative vision for a building actually possible to construct.

These are just a few of many well known examples of collaborations in the arts, sciences and technologies. Even this short listing, though, helps reveal the fact that within our disciplines and communities, collaborations involve divisions of labor, many of which occur in patterns.

Note also that broadly speaking, these patterns are to some extent temporal. For, in all disciplines, yesterday's events can be part of today's reflections about what we might do tomorrow. So, progress in our disciplines depends on being able to in some way collaborate in the present, to retrieve significant results from the past, and to work toward possible future development. All of our efforts, then, are "present"—both *in the present time* and in the sense of *being present* (to ourselves and to each other). But within the basic temporal flow, patterns of collaboration such as the few listed above, and certainly many more, can and often do repeat—not necessarily in content, but often enough in type of focus and type of task.

1.3 Are there *normative patterns* of collaborative division of labor?

Briefly, then, communities and academic disciplines involve and rely on numerous collaborative divisions of labor, types of focus, orientations, and tasks. We do not, of course, perform all of our various tasks in isolation, and these days there are many hybrid disciplines such as mathematical-biology, biophysics, computational chemistry, biomechanical engineering; music-psychotherapy, music group-therapy, and other kinds of art therapy; physics of neuroscience, chemistry of neuroscience, biology of neuroscience; and so on. Within this emerging and dynamic complex of aggregates of ongoing global collaborations, are there "core" or "generative" types of collaboration? Are there "normative basic orientations" and "normative main tasks" that generate the full dynamic complexity?

Certainly it can be useful to explore collaboration patterns statistically, and that kind of enquiry has a scientific value. For example, there are results on frequencies and relative frequencies of collaborations, represented in "collaboration networks"—represented by graphs "for visualizing large scientific domains."[14] The focus of the present paper though is different. For, rather than the statistical problem of determining relative frequencies of activities of investigators in disciplines, the problem here is to begin to determine core activities: what they are and how are they related. And since this question is about disciplines as they are, basic elements of a solution need to be discernible in disciplines as they are, as we actually operate and function.

1.4 Outline of this paper

As mentioned in section 1.1, in 1965 Lonergan discovered an eight-fold core pattern, a recurrence pattern emergent in history and generative of the dynamics of progress. A diagram for the solution, The Global Table, is given at the end of section 1, and will be referred to in the paper. Much in the way a periodic table given at the beginning of a chemistry text is gradually understood in increasing complexity as one learns more chemistry, so too, the Global Table of Functional Specializations will gradually make more sense and carry increasing refinements, as we learn more about functional specialization. But this paper is only a brief invitation, and fuller treatments will be needed. There is the need of extensive follow-up reflection on the sources, feasibility, and (as it turns out, *omni-disciplinary* [15]) heuristics of *functional specialization*.

In section 2, I use *biology* as a first venue for discussion. Section 3 offers some comments toward heuristics on various follow-up issues. In particular, I draw attention to the relevance of this analysis for other disciplines.

[14] Benjamín Vargas-Quesada and Félix de Moya-Anegón, *Visualizing the Structure of Science* (Heidelberg: Springer-Verlag, 2007). Vertices of graphs represent collaborators; edges of graphs represent collaborations.

[15] See section 3.

GLOBAL TABLE OF FUNCTIONAL SPECIALIZATIONS

Progress oriented tasks; Types of mutual presence; Retrieving past; Toward future

PAST ORIENTED[16]	*FUTURE ORIENTED*[17]
F4 Dialectics C(4,5) →	**↓ C(5,6) F5 Foundations**
F3 History C(3,4) ↑	**↓ C(6,7) F6 Doctrines**
F2 Interpretation C(2,3) ↑	**↓ C(7,8) F7 Systematics**
F1 Research C(1,2) ↑	**←C(8,1) F8 Communications**

Figure 1: Arrows are for central flows of *internal functional* communications between successive specializations: C(1,2), C(2,3), …, C(8,1), C(1,2), … . But, there can be internal communications between all possible specializations (e.g., between Research and Foundations), as well as external communications with those in "orientation 9" (that is, those not in academic disciplines *per se*). So we need to extend the symbolism to a matrix C(i,j), for i, j = 1, 2, …, 8, 9. These various types of *functional communication* will be referred to later in section 3, below.

2. Feasibility of an Eight-fold Division

2.1 Past-oriented functional research, interpretation, history, dialectics

Research: The word "research" often is used broadly. Here, though, *functional research* is the work of obtaining significant data that may contribute to further understanding. This kind of work is known to require ranges and levels of expertise. For example, field biologists at times rely on shrewd and informed "naked-eye" observations.[18] Of course, biologists rely on many sources of data, experimental and laboratory methods and technologies, including, e.g., data for genetic sequences of deoxyribonucleic acid (DNA).[19]

---

[16] Lonergan, *Method*, 133.

[17] *Ibid*.

[18] One convenient example: P.C Stouffer, et al., "Understory Bird Communities in Amazonian Rainforest Fragments: Species Turnover through 25 Years Post-Isolation in Recovering Landscapes," *PLoS ONE* (www.plosone.org), vol. 6, issue 6, June, 2011: e20543.

[19] The existence of DNA was first confirmed through X-ray diffraction patterns, but genetic sequences were later determined by using prescribed gene fragments as probe; and then using micro-arrays to provide bio-chemical-physical data for large numbers of simultaneous reactions.

Interpretation: While there are experimental and field biologists with expertise in gathering data, there also is the work of understanding, or what often is called "interpreting," available data. Does the data reveal the existence of a new species?[20] Or, in a known species, are there cell functions not previously known? Is new data explained by some previously unknown chemical pathway in an organism?[21] Are there newly discovered segments and functions of a gene sequence? And so on. Descriptions of complex data can, as descriptions, be impressive in themselves. But such descriptions are only part of the process toward scientific explanation. What, for example, was data for the discovery of DNA? A now famous X-ray diffraction image, "Photo 51," was one of the final clues for Watson and Crick in 1952. For the untrained eye, it could just as well be an image of a flower. But Watson also had an understanding backed up in quantum-chemistry. Something more happened: "The instant I saw the picture my mouth fell open and my pulse began to race."[22] A new understanding was reached—an understanding by Watson of data—data obtained by a colleague with expertise in experimental methods.[23]

History: The author of a *Review Article* often attempts to explain, not data *per se*, but various lines of development, influences, and trends in sequences of efforts to explain data. I am not trying to define *Review Article*, but to describe a common feature of many Review Articles. But this means that there is therefore a third focus that is operative within biology. It is neither the task of getting data nor the task of interpreting data; it is, instead, the task of explaining lines of development in interpretations of data. *Functional History* then is the work of trying to determine and explain how things actually worked out, or not, what was judged to be correct, or not, for better or for worse, what actually

[20] Min Wang and Josef Settele, "Notes on and Key to the Genus Phengaris (s. str.) (Lepidoptera, Lycaenidae) from Mainland China with Description of a New Species," 48 *ZooKeys* (2010), 21–28; doi: 10.3897/zookeys.48.415, www.pensoftonline.net/zookeys. See also Blanca Huertas, Cristóbal Ríos, and Jean François Le Crom, "A New Species of *Splendeuptychia* from the Magdalena Valley in Colombia (Lepidoptera: Nymphalidae: Satyrinae)," 2014 *Zootaxa* (2009), 51-58.

[21] An ordered series of chemical reactions in a living cell or organism, in which each step is catalyzed by a specific enzyme; different biochemical pathways serve different functions in the life of the cell or organism.

[22] James D. Watson, "The Double Helix [1968]," in *The Double Helix: A Personal Account of the Discovery of the Structure of DNA* (New York: Atheneum, 1968/1970), 168. *Ibid*., 73.

[23] In 1953, James D. Watson and Francis Crick suggested what is now accepted as the first correct "double-helix" model of DNA structure in the journal *Nature*. James D. Watson and Francis H. C. Crick, "A Structure for Deoxyribose Nucleic Acid," 171 *Nature* (1953), 737–38.

happened, or not—typically in some specialty area, over some period of time.[24]

Dialectics: It is often because of past and present developments that investigators are prompted to strike out on new lines of enquiry. But, how do we know just what the past or present developments are, or what the main or essential contributions to biology really are? There is a problem here that needs some attention, which is underlined somewhat by the fact that identification of the present state of development of biology lacks consensus within the community.

Accounts given of lines of development are numerous and diverse. One kind of diversity, easily seen, is due to the fact there are investigators from many different sub-disciplines—such as biophysics; biochemistry; developmental biology; evolutionary biology; environmental science, etc. But in addition to normal differences coming from different areas of interest, we also find differences based on fundamentally opposed views, views that openly are at odds with each other, both within and across areas of interest. Take, for example, "systems biology,"[25] a name for several recent interdisciplinary efforts to provide "unity" by explanations that take into account all relevant "levels" and factors of biological "systems." But, "system," "unity" and "interdisciplinary" have many meanings, depending on the investigator, and so there result "dueling discourses in interdisciplinary biology."[26]

---

[24] Examples of this kind of focus can be found throughout the literature. For instance, Marian Wong and Segal Balshine (2011) note that the "conundrum of why subordinate individuals assist dominants at the expense of their own direct reproduction has received much theoretical and empirical attention over the last 50 years. … In particular, the freshwater African cichlid, *Neolamprologus pulcher*, has emerged as a promising model species for investigating the evolution of cooperative breeding, with 64 papers published on this species over the past 27 years. … Overall, we clarify what is currently known about cooperative breeding in N. pulcher …" Marian Wong and Segal Balshine, "The Evolution of Cooperative Breeding in the African Cichlid Fish, *Neolamprologus Pulcher*," *Cambridge Philosophical Society*, 86 *Biological Reviews* (2011), 511–30. The authors include other things in their paper as well, but there are various shifts in functional focus. See section 3.1, below.

[25] Institute for Systems Biology (http://www.systemsbiology.org/).

[26] Jane Calvert and Joan H. Fujimura, "Calculating Life? Dueling Discourses in Interdisciplinary Systems Biology," 42 *Studies in History and Philosophy of Biological and Biomedical Sciences* (2011), 155-163. Instead of seeking unifications, there are others who instead advocate "a type of pluralism that does not require general unification and that explains why innovative and productive explanations are possible in the absence of a unified theoretical framework." Sandra Mitchell and Michael Dietrich, "Integration without Unification: An Argument for Pluralism in the Biological Sciences," 168 *The American Naturalist* (2006), S73–S79. Some in systems biology seek "unification" through "multi-scale" models, that is, "deterministic" as well as "stochastic" models that often are considered "computable" (thinking to take advantage of the power of today's supercomputers). (A "multi-scale" model

Moreover, the abundance of diverse and variously opposed perspectives in biology is ongoing and is not at this time showing signs of approaching any kind of resolution.

With so many different views, how is one to know where the discipline has been and is at present, what the most important results have been and are, and what their significance probably is? Individual investigators and research teams regularly take a stand on things and evaluate or relegate the importance or significance of known developments. In other words, evaluation of past and present results (data, interpretations, and histories) already tacitly is part of biology. But the basis of such evaluation is not (yet) generally adverted to in any explicit way. Instead, these evaluations usually are spontaneous, with sources and presuppositions more or less hidden within the spontaneous operative orientations of investigators. At the same time, such evaluations play a major role in the science, determining what investigators make of past and present results, criteria by which results are accepted or not, and how they are ranked. Think, then, of the advantage of bringing that dynamics of evaluation into the open. This would mean having "teams" of some kind, investigators in biology working together, not only toward evaluating histories, interpretations and data sources, but also attempting to advert to otherwise hidden premises, sources, and presuppositions of evaluations.[27] This fuller kind

---

simultaneously involves measurement and computational scales of two or more of the known scales—elementary particle, atomic, molecular, inter- and intra-cellular, cellular pathways, aggregates.) Other systems biologists look for "system-wide emergent properties." By contrast, one systems biologist says: "What we have got to emphasize is a molecular level analysis, so we need to be able to trace back emergent properties or life or biology, phenotypes, whatever we're looking at, to the molecular underpinnings." Quoted in Jane Calvert, "The Commodification of Emergence: Systems Biology, Synthetic Biology and Intellectual Property," 3 *Biosocieties* (2008), 383-398, at 388. Again, there also are some molecular biologists for whom higher unity as such is not an issue, since everything is considered to be molecular, and other macroscopic features will be explained by knowing enough biochemistry. But, there are evolutionists who cite Dobzhansky's article, "Nothing in Biology Makes Sense Except in the Light of Evolution," Theodore Dobzhansky, 35 *The American Biology Teacher* (1973), 125-129.

[27] What are some of the sources of differences and inconsistencies? Is one investigator talking about described "unity" in data of experience, while another is thinking of "unity" in terms of a *unified system of mathematical equations* verifiable in aggregates of described data of experience? Are the equations of one investigator statistical in nature, while the relations of another the basis for defining properties that occur statistically? Might a developmental biologist focus on unity in terms of *sequential structures and transitions of systems*? And so on. Can any of these differences in perspective of investigators be reconciled within some more complete account? This is not a question of doing more functional history, for historical analysis as such is an effort to explain lines of development, not an effort to bring into the open one's

of evaluation then will be not merely spontaneous, but will, in a practical sense, be *enlightened*—for investigators working on this task will include a focus on cultivating a self-luminousness about one's operations and evaluations.

Will this be the work of *biology*? It may seem more like "philosophy of biology." If we use this terminology, we could easily call it a "*practical philosophy of biology*." This is because this kind of work evidently is needed, and promises to be a basis for a kind of *practical wisdom in biology*. Would this kind of work really be practical? Perhaps we can continue to leave premises, operations, and presuppositions implicit within the spontaneous dynamics of evaluation? But then, among other things, inconsistencies in opposing viewpoints will probably neither be resolved nor removed, for the simple reason that sources of inconsistencies will neither be brought out for review nor shared openly with the community. Without attempting this kind of fundamental and explicit evaluation we can expect a continuing *ad hoc* remixing of "dueling discourses" and other opposing views. In fact, lacking self-luminosity about fundamental premises, operations, and presuppositions, even the significance of important new discoveries will to some extent necessarily remain obscure.[28]

The task envisaged here is called *functional dialectics*. The dynamics already are implicit and somewhat emergent in biology—but obscurely so, within the spontaneities of investigators who take a stand on the past and present. Again, this dialectical task will include the best-effort-to-date by teams working on determining where we really are at present. In order to benefit the community, reflections will be shared and compared among team members, and eventually with the entire community. Results will promote and depend on becoming increasingly self-luminous about one's very base of operations, one's often otherwise hidden premises and personal presuppositions. Certainly, we should not expect uniformity, but this task would help make basic *positions* and *counter-positions*[29] more explicit and so would provide a ground for more effective team assessments of past and present achievements.

Dialectics then will provide increasingly self-luminous evaluations of past and present results, and therefore also a basis for looking toward future projects. But, looking to future projects brings us to the next phase of the eight-fold division, namely, the four functional specializations that constitute future-oriented tasks.

---

premises and presuppositions that ground evaluations of histories. See also the discussion below on *functional foundations*.

[28] In fact, the more profound the new insight, the greater is the reach beyond contemporary perspectives, and therefore also the more difficult to evaluate its full significance.

[29] *CWL* 3, at 413.

2.2 Future-oriented functional foundations, doctrines, systematics, communications

Foundations: For an entomologist, part of the work can involve being able to recognize what various species of butterfly look like in the field. Indeed, new species often are discovered this way.[30] But, in studying the biochemistry of butterflies, some investigators study gene expression for wing patterns.[31] Certainly, the images and understanding one reaches by identifying a genetic subsequence of DNA are very different from the images and insights for being able to describe a visible wing pattern. These are just two examples to help illustrate that as we work ahead on a project; we each have our ways of going about things, our ways of doing things, kinds of questions we are likely to ask, the kinds of insights and meanings that we reach. We also blend, mix, and distinguish these ways of meaning. We do not normally confuse a photo of a wing pattern of a butterfly with a diagrammatic representation of a genetic segment of a DNA double-helix for wing patterns—although both images can be visually complex, fascinating in their own right and even lovely. These images and insights also are not confused with the symbols and meaning of a system of chemical reaction-equations for an identified cluster of biochemical pathways. Moreover, all of these images and insights may for a biologist refer to a single species of butterfly. So, biologists spontaneously integrate various ways of imagining, understanding and meaning.

Our ways of meaning, though, can shift and develop through a lifetime. Starting out in biology as a young student, one may learn to recognize the appearance of various species of plant and animal and, with the help of elementary microscopes, even some "microscopic organisms." Later, after considerable effort, one may learn something about biochemistry, and perhaps the Kreb's cycle. Following on that understanding, one's orientation may open toward discovering all biochemical pathways of an organism. Working in contemporary biology, one will need to incorporate into one's basic perspective some understanding of Crick and Watson's 1952 discovery of the DNA molecule, a molecular structure common to known living things. But, as evidenced from Watson's discovery in Photo 51, molecular structures are to some extent dependent on quantum physical properties. And so understanding in biochemistry expands to include quantum-physical-chemistry of organic molecules as part of biological explanation. Or again, statistical method now is part of contemporary biological

---

[30] For example, Min Wang and Josef Settele, "Notes on and Key to the Genus Phengaris (s. str.) (Lepidoptera, Lycaenidae) from Mainland China with Description of a New Species," 48 *ZooKeys* (2010), 21–28, doi: 10.3897/zookeys.48.415, www.pensoftonline.net/zookeys

[31] For example: Patricia Beldade and Paul Brakefield, "The Genetics and Evo–devo of Butterfly Wing Patterns," 3 *Nature Reviews Genetics* (June 2002), 442-452.

understanding.[32] More recently, other types of mathematics and mathematical modeling are becoming increasingly used in biology.[33] There are large (sometimes *multi-scale*) systems of ordinary and partial differential equations, as well as stochastic versions of these;[34] there is the mathematics of random walks in bioinformatics, used for instance to understand the statistics and probabilities of genetic sequence mutations along evolutionary pathways. The rise of mathematics in biology has resulted in some investigators focusing more on "the beauty of mathematics"—concentrating less on biological organisms *per se*, and more on the *mathematics of biology*.[35] For some, part of one's meaning in studying biology may have originated in a childhood interest in living things, and may eventually have grown into a kind of "mature love for all things living." Again, in talking about a DNA molecule, an organism, a cell, a butterfly, in each case we grasp some kind of unity. A "reductionist"[36] may make the effort to devalue or relegate the significance of that grasp of unity, while a developmental biologist may make that grasp of unity a central issue. The significance that biologists attach to that grasp of unity can and does vary. But being able to discuss it reveals that, whatever its significance, grasping unity is a kind of meaning that is present throughout biology.

These are just a few random samplings, "pointings" to the fact that there are many kinds of meaning and shifts in meaning that occur in biology. Again, we each have our various ways of questioning,

---

[32] Some of the common distributions used in contemporary biology include: normal distributions; poisson distributions; and extreme value distributions (especially in bioinformatics and genetics).

[33] Joel E. Cohen, "Mathematics Is Biology's Next Microscope, Only Better; Biology Is Mathematics' Next Physics, Only Better," 12 *PLoS Biology*, (December, 2004), 2017-2023, e439, www.plosbiology.org; Alan Hastings, et al., "A Bright Future for Biologists and Mathematicians?," 299 *Science* (2003), 2003-2004.

[34] Simon A. Levin and Bryan Grenfell, "Mathematical and Computational Challenges in Population Biology and Ecosystems Science," 275 *Science* (1997), 334-343.

[35] Mathematics of biology: mathematical problems inspired by biological problems. Examples are plentiful in the literature. See, for instance, James Benson, C. Chicone, and J. Critser, "A General Model for the Dynamics of Cell Volume, Global Stability, and Optimal Control," 63 *Journal of Mathematical Biology* (2011), 339-359. The Abstract reads: "Here we examine a natural extension of this general model to an arbitrary number of solutes or solute pathways, show that this system is globally asymptotically stable and controllable, define necessary conditions for time-optimal controls in the arbitrary-solute case, and using a theorem of Boltyanski prove sufficient conditions for these controls in the commonly encountered two-solute case." Some clinical parameters are used. But, the main content of the paper is mathematical, worked out under various hypothetical boundary conditions.

[36] I am not assessing a perspective here. I refer loosely to the many perspectives that claim or are given that name.

understanding, meaning; and as we develop, we sometimes experience shifts and developments in how we reach for meaning—sometimes through subtle differentiations in perspective or approach, sometimes through perspective-changing differentiations. If, though, we are in fact moving forward with our questioning, then there is an at least tacit consent and choice of approach. As long as that consent and choice remain operative, we have what we could call a *relatively stable personal foundation*. There are the quality and intensity of our attentiveness, kinds of data to which we attend, kinds of questions that arise, kinds of insights and meanings we reach, criteria we require, possible objectives and aims we consider, various means we consider in order to reach those aims and objectives, decisions we make. As we move forward in our questioning and deliberating, we each have a *personal foundation*. In other words, our *personal foundation* is not only the sum of our present knowledge, but includes our orientations, our questioning, and our desiring. And in as much as we are moving ahead with some new project in some heuristic patterns, there is an at least tacit consent to, and choice of, the ways that we are moving—the ways of those heuristic patterns.

Three observations then: (1) As biology develops, foundations develop, new differentiations can and do emerge. (2) Moving forward, there is at least tacit consent to and choice of foundations. And (3) Personal foundations are a major influence on development in biology. Would it not then be practical for biology if, as in Dialectics, investigators were to make the effort to bring these foundational dynamics into the open? What could we expect by following through with the reach and scope of this implicit dynamics? There will be the task of thinking out, uncovering, discovering, exploring, consenting to and choosing possible ways of meaning—not in a hidden or merely spontaneous way, but explicitly—expressed to oneself and to others. The already implicitly operative dynamics of consent and choice point to the orientation and task of creatively seeking the best-possible expansions and differentiations of one's holistic foundations—expansions and differentiations that one can explicitly identify and commit to as (at least for now) "best-possible."

There are of course connectivities between dialectics and foundations, for both tasks seek to make explicit what otherwise is merely implicit. But unlike dialectics, functional foundations will work toward advantageous and creative expansion of one's base of operations. For functional foundations will be geared and oriented toward generating new and improved integral foundations. Where dialectics includes: "What are the ways that I, and we, have been getting along so far?," foundations will be a different and radically expansive future-oriented questioning that includes: "In order to go on, what are the best and possibly new ways to which I, and we, can commit?"

Doctrines: In 1838, Schleiden and Schwann proposed the "cell doctrine" that there are *cells* that form the fundamental structural and functional units of all living organisms. Certainly, biology has advanced since the 19th century, but the cell doctrine remains a part of biological understanding. What kind of understanding is it? Explanations of cell-life have developed enormously, and now include proton pumps, bio-physics of cell membranes, biochemical pathways, DNA replication, cell-cell "communication," and much more. What new explanations may emerge is yet to be determined. What, then, is a cell? Whatever the explanations are that are to be reached, so far, at least, cells are still considered to be a fundamental structural unit to be explained.

In biochemistry, there is the "central dogma of molecular biology," the conjecture that producing proteins is an irreversible process.[37] Crick and the community have used this "dogma" not as an "absolute," but as a Central Hypothesis. There have been ongoing developments explaining the intricacies of DNA replication, RNA transcription, and translation to protein, but the "central dogma" so far remains.

Cellular and molecular structures are not the only "units" in biology. In systems biology, "systems" are asserted to be a kind of "fundamental unit." In developmental biology and evolutionary theories, developmental and evolutionary trajectories are asserted to be fundamental. Indeed, throughout biology, there are different schools of thought with various foundations. But, whatever one's foundations, biology is a work in progress, is on the move. Of course, as discussed above, there is much that is learned from all four types of past-oriented work (functional research, interpretation, history, dialectics), all of which can help prepare one for future-oriented foundational development. But, even while searching out improved or perhaps radically new explanations, we don't perpetually start from scratch. Do we not in fact carry some results forward in our future-oriented searching? Are there not "lessons gleaned from history"? There are personal foundations as well as already held provisional explanations. But foundations are the chosen *ways* of moving forward; and provisional explanations might be replaced. What, then, are "lessons of history"? Are there not various descriptive facts and values that we hold to, at least for the time being? What are they exactly? Of course, that will always depend on the stage of development of the discipline. For whether it is a "cell doctrine," a "central dogma of molecular biology," an "evolutionary doctrine," or a "biology education policy," these all are determined within the hard-won historical progress of biology. But, these are not explanations. They are instead descriptive results that call for explanation, that are spontaneously factored into the quest for possible explanations. Of

---

[37] Francis Crick, "Central Dogma of Molecular Biology," 227 *Nature* (1970), 561–3. First articulated by Crick in 1958 in "On Protein Synthesis," *Symposium of the Society of Experimental Biology, XII*, 139-163. (http://profiles.nlm.nih.gov/SC/B/B/F/T/_/scbbft.pdf, pdf, early draft of original article.)

course, in the future-oriented phase, it would not be progress-oriented to either ignore developments within dialectics or expansions and differentiations from functional foundations. So, descriptive facts and values from history are (i) to be clarified by dialectics and (ii) to be newly and more adequately contextualized within one's most up-to-date foundations.

Whether expressed or not, as we move forward toward possible new explanations, we hold various descriptive truths and values. In biology, such facts and values can generally be called *doctrines*, and they occur within the explanatory context of the science. The tasks of identifying, ordering, and expressing those descriptive facts and values for biology will therefore be the work of *functional doctrines*.

Systematics: Biologists have been working toward understanding biological entities—their kinds and numbers—emergence, development, evolution, spatial, and temporal distributions. As pointed to in our discussion of *functional interpretation*, at any time in history there are up-to-date explanatory models and explanations of available data. But, present explanations are not complete. How can we best go forward toward improved, or perhaps radically new, explanations? As an example of thinking toward new possibilities, Johnson and Kwan Lam speculate: "Although there are not rigorous experimental examples, it is nonetheless useful to discuss some ways the cell could harness self-organizing processes evident in well-studied geophysical systems. … Another possibility that might change the way one thinks about the cell and how gene products work therein is that instead of using transport mechanisms with great specificity (such as vacuoles), the cell could simply mark its many export products with an identifier, and then send them into streams flowing through the cytosol."[38]

Here the authors have suggested two possible new lines of enquiry. Their ideas may or may not bear fruit. However, the problem for the present paper is the progress of biology as a whole. At any one time, for a range of questions, there can be various speculative lines of enquiry emerging within the discipline. Are some of these in some ways equivalent, or related, or compatible, or perhaps incompatible? Normally, at least some rationale usually is given for considering a new particular line or lines of enquiry, but it is generally *ad hoc*. Might it not be helpful for the community to have an expansion of the implicit dynamics here, by making a deliberate study of possible lines of enquiry and development, within a fully explanatory context?

Speculation about new lines of enquiry of course is to be in the context of the most up-to-date knowledge in the community. And biology seeks to take advantage of past progress, including knowledge of

---

[38] Brian R. Johnson and Sheung Kwan Lam, "Self-organization, Natural Selection, and Evolution: Cellular Hardware and Genetic Software," 60 *BioScience* (2010), 879-885, at 881 (www.biosciencemag.org). I don't cite here the technical papers referred to within the quoted text from Johnson and Lam.

approaches that didn't work out. Were there missed opportunities in past efforts? Were there some theories tried that had promise but might now need development, or revision, or adjustment? Or are there completely new ideas that might be explored? "What might we make of all of this?" where the "all of this" includes the ingredients that are the *progress oriented sum* of all that the prior specialties have to offer at a given time. For there are the *cumulative* results: of the past-oriented specialties up to dialectics; of refreshed or deepened or extended future-oriented integral foundations; together with suitably contextualized up-to-date descriptive biological doctrines.

Evidently, there is another task here, to some extent already operative in biology, a task grounded in the results of the preceding functional specialties, for there is the task of creatively working out possible new lines of enquiry, possible directions of development. In order for the effort to be effective, the task necessarily will include bringing some ordering to possibilities, within an explanatory context. This functional task will be the work of "master biologists," for it will depend on having a sufficient mastery of the discipline to ground advanced, theoretic, creative, explanatory speculation—not mere speculation, but foundationally sound (and so *relatively effective*[39]) speculation. Based on where we are at a given time, what might be a truly feasible kind of next step, or steps, or truly feasible lines of development? Will we need to include principles of "self-organization,"[40] probabilities, emergence, evolution? In what way might we need to include, or not, the notion of "unity of an organism"? Types of organism emerge and develop within developing eco-"systems." Moreover, our understandings of emergence and development of organisms in eco-systems also is emergent and developing—for there is development of, and within, theories and systems (which themselves occur in developmental sequences). In other words, both eco-systems and our understandings of eco-systems develop. In its fullness, then, this next task will be a reaching to conceive of and order all reasonably possible or truly feasible developments, time-ordered possibilities, developmental sequences of systems. Using the word 'genetic' in its inclusive sense that pertains to all development, this seventh functional task will therefore be a *functional genetic systematics*, or abbreviated merely to *systematics*.

Communications: What is the next thing to be done? Any prospective explanation needs to be verified in the field or in the lab. But systematics provides only speculative time-ordered possibilities in highly theoretic terms. Which possibilities are we to select? And once selected, how, for instance, are they to be verified? To get supporting data (or non-supporting data) will be the work of functional researchers. But researchers have their own zone of expertise which does not as such

---

[39] See note 12, above.

[40] Johnson and Lamb, note 40 above, "Self-organization."

require "*developing* new theory." In any case, because "new theory" is *new*, not all of its details or implications will be part of the researchers' otherwise up-to-date knowledge of the discipline. So, do we not have some inklings here of an eighth task within biology?

There will be a kind of work that depends on (a) understanding theoretic results as well as implications of results provided by systematics, and (b) having the wisdom to make optimal selections from those time-ordered possibilities. But private selections do not yet contribute to progress in the community. So, an eighth task will culminate in communications within the community that will include mediation of these selections to functional researchers. This will help researchers design experiments, figure out what data to look for, and perhaps even how to get it. Putting all of this together, an eighth task in biology therefore will be grounded in a *maximal command* of the entire discipline: a theoretic grasp of the fruit of systematics and implications; a reaching perspective needed to make selections; a relatively comprehensive heuristics of communications in biology; and a widely adaptable range of abilities, techniques, and technologies to actually communicate and mediate results to researchers of diverse backgrounds and expertise.[41]

We have then come full circle. Eight functional specialties have been identified. Four are past-oriented: research, interpretation, history, and dialectics; four are future-oriented: foundations, doctrines, systematics, and communications. Historically, these are not yet explicitly identified in the biology community, but as revealed in the discussions above, each specialty corresponds to dynamics, orientations, and operations that already are present in biology (either somewhat explicitly as in the case of data research and theoretical interpretation of data, or in more hidden ways, such as in evaluation, consent, and choice that are intrinsic to dialectics and foundations).

3. What More Can We Expect from Functional Collaboration?

By appealing to examples, eight distinct orientations in biology have been revealed, as well as the potential advantage of identifying corresponding tasks. The discussions of Section 2 also provide preliminary evidence on some of the difficulties that result from not including dialectical analysis and foundational reflection. There is, therefore, at least a minimalist view possible, on the basic feasibility and

---

[41] For the moment, the focus here is on communications with other scientific investigators. But, the fuller reach of *functional communications* will extend to the whole community, including, e.g., educators, administrators, etc. Exploring these further aspects of this eighth task is beyond the scope of this introductory article. But functional communications can be compactly symbolized by C(8,*), where * = 1, 2, …, 8, 9. See Figure 1 of section 1. There will be a similar expansion of functional research. See section 3.5, "All data in biology," below.

practicality of an eightfold functional division of labor. However, further questions soon arise. So this last section is based on data accumulated in this article, but provides comments intended as preliminary heuristics, impressionistic pointings to further issues, further implications inherent in the eightfold functional division. This of course will be only a thinnest contact with these further issues. Not only do many books need to be written in various disciplines, but eventually, once functional collaboration is implemented, ongoing differentiations and potentialities of the methodology gradually will be worked out by future investigators.

Comments below are ordered as follows: 3.1 points to additional data on the need for and potential control of meaning, by drawing attention to present mixings of orientations within works; 3.2 is on sub-disciplines and the functional unity of biology; 3.3 anticipates the future development of specialized communications C(i,j). (See Figure 1, Section 1.) 3.4 touches on the problem of categories of meaning, and notes that functional specialization itself will introduce new categories; 3.5 points to the fuller range of data that is relevant to biology; 3.6 draws attention to the need for future dialectics and foundations to be omni-disciplinary; 3.7 is on the relevance of functional specialization to other disciplines; 3.8 points to the probable impossibility of (effective) revision of the functional division of labor; 3.9 is on all disciplines together; finally, 3.10 raises the question: What are we to do?

3.1 Further evidence for need of the division

Despite normal standards of "best-practice,"[42] authors often inadvertently combine, mix, and blend various orientations. For example:[43] "Overall, we clarify what is currently known about cooperative breeding in *N. pulcher* (*history oriented*), address discrepancies (*traces of history and dialectics*) among studies (*traces of history*), caution against incorrect inferences (*traces of both past oriented dialectics and future oriented foundations*) that have been drawn over the years (*a blend of history and dialectics*) and suggest promising avenues for future research (*future oriented)* in fishes and other taxonomic groups (*traces of systematics*)."[44] For what audience, though, might this kind of blend of differently oriented results be efficiently useful? Research, interpretation, and historical analyses in the article quoted are not complete; dialectical comments are random and indirect; future-oriented work is fragmentary and *ad hoc*. Section VI Future Directions includes both past and future oriented statements and

[42] I am thinking of the normal standards of appealing to data, seeking to understand correctly, providing rationales, reporting on one's "methods, aims, hypotheses, materials," etc.

[43] I note orientations in italics.

[44] Wong and Balshine, "The Evolution of Cooperative Breeding in the African Cichlid Fish, *Neolamprologus Pulcher*," 86 *Biological Reviews* (2011), 511-530.

topics. But suggestions for future biological work also are woven into several paragraphs in other sections of the article. For example, in Section III Do Helpers Really Help? (*question for explanation/ interpretation*) we find: "Future research should aim further to clarify, using larger sample sizes under natural conditions (*intimations of a policy for statistical method in biology—future oriented doctrinal*), the relative frequency with which helpers *versus* other conspecifics from outside the group share in parentage within groups" (*traces of future oriented systematics*).

The point here certainly is not to single out the excellent article by Wong and Balshine. Instead, I wish to draw attention to what in fact is prevalent at this stage in history. For we find spontaneous blendings and mixings of orientations randomly and inadvertently laced throughout works, down to the levels of paragraphs, sentences, and phrases.[45] And this random mixing of orientations is not practical, for among other things, it diffuses expressions and meanings of contributions. In section 2 (above) some examples were given to draw out the need of dialectical analysis. Here we see further sources of difficulties, namely, a lack of control regarding orientations within individual communications. This is not to suggest that functional investigators ever would be "required" to work exclusively within any one functional specialization.[46] Nor would functional collaboration ever put limits on creativity. But there are in fact eight distinct (and already operative) orientations.[47] By making these explicit and dividing and focusing tasks accordingly, we can expect that the dynamics of functional collaboration will foster better control of meaning and expression, and increased effectiveness. In particular, the aim of Wong and Balshine to "address discrepancies" will be swept up by the effective and efficient eightfold cycling of functional tasks.

3.2 Investigators in sub-disciplines in biology

There is an extensive and expanding range of sub-disciplines in biology. A few of the more familiar are: anatomy, astrobiology, biochemistry, biogeography, biomechanics, biophysics, bioinformatics, biostatistics, botany, cell biology, cellular microbiology, chemical biology,

---

[45] The present article is a pre-functional communication toward the future possibility of functional collaboration and future functional communication.

[46] Although, by looking to already existing pre-functional divisions of labor (between, e.g., experimental physics and theoretical physics), because of normal human limitations we can expect that reaching competence in any one functional specialization normally will be a career-worthy achievement in itself. Still, just as now there are some individuals whose expertise embraces ranges of theory and experiment, in the future, circumstances, talent, and energy may make it possible for some gifted individuals to be competent in more than one functional specialization.

[47] For preliminary comments on the economy of the "eight," see section 3.8, below.

chronobiology, conservation biology, developmental biology, ecology, epidemiology, epigenetics, evolutionary biology, genetics, genomics, histology, human biology, immunology, marine biology, mathematical biology, microbiology, molecular biology, mycology, neuroscience, nutrition, origin of life, paleontology, parasitology, pathology, pharmacology, physiology, quantum biology, systems biology, taxonomy, toxicology, zoology. Based on present day training, how is an investigator to know and communicate how his or her work might contribute to biology as a whole? Following on 3.1 regarding future control of meaning and expression, functional collaboration would help investigators know better what *function* their work might serve in the community. In particular, instead of investigators necessarily having to struggle within a "view of their results restricted to a subset of sub-disciplines," functional specialization will promote the possibility of investigators having a "*functional view* of their results within the *functioning whole* of biology." There are more comments below on the possibility of working toward heuristics for the "whole of biology."

3.3 Functional communications within the Global Table (Figure 1, section 1)

The question of how biological results are communicated within biology features in both 3.1 and 3.2 above. Nowadays, experimental results are communicated according to standard procedures, within the developing complex of up-to-date understanding. However, the ways that lab or field results are shared with the community differ from the ways that theoretical results are shared. This also partly depends on the intended audience. And for both research and theory there are different aims, different norms, standards, criteria. Similarly, standards of presentation for historical analyses are different from those of theoretical works explaining particular experimental results. And so on. Within functional collaboration, we can expect analogous developments to emerge—differences in aim, standards and criteria for the various functional communications such as research to interpreters; interpreters to historians; …; systematics to communications; etc. There are also the various sub-disciplines, such as those listed in 3.2 above. So, we can expect that future functional collaboration eventually will lead to increasingly differentiated controls of meaning and expression that at this time are expressed very compactly in the preliminary symbolism C(i,j) of the Global Table (Figure 1, Section 1).

3.4 *Categories* of meaning

Recall from the discussion on *functional foundations* in section 2 that biology involves integrations of various kinds of meaning. One may describe an organism in the field, or even under a microscope. But a biochemist can make use of lab measurements obtained from aggregates.

Such measurements also can be described but also can be subsumed and understood within a network or system of biochemical reaction equations for pathways in an organism; or, in some cases, for aggregates in some environment. In all of this, we can advert to and investigate shifts, combinations and integrations in kinds of meaning.[48] So we can expect future functional dialectics and foundations to work toward embracing all relevant varieties, species, genera of meaning.[49] In that way, we can expect ongoing freshenings, expansions, and verifiable delineations to be part of the ongoing dialectical and foundational developments of functional collaboration.[50]

Functional collaboration will be new. And so we can expect differentiations in meaning and types of communication inherent in developments in functional collaboration.[51] Functional foundations will therefore also seek grounds of the functional division itself.[52]

3.5 All data in biology

Following on 3.4 above, describing what a butterfly looks like in the field is different and serves a different function than described lab data for a DNA sequence. Many of the difficulties observed in section 2 seem, at least in part, to come from inadvertently mixing expressions and types of meaning. So, we can expect functional collaboration to call forth increasingly refined dialectical and foundational control regarding achieved and possible meanings and expressions.

But this means data that are expressions of biologists will be included as part of the data of biology taken as a whole. It is not to

---

[48] Three main levels seem to be involved in biology: sense experience; various types of understandings of various types of sense experience; and reflection on those various types of understandings of various types of sense experience.

[49] See section 3.6 below.

[50] Advances in biological understanding are partly determined by insights into biological data. So, we can expect that future foundational work will investigate dynamics of biological insight "into" biological data, using instances that are both elementary and complex. Preliminary results on generic patterns of dynamics of understanding and deciding are presented in the diagrams of Appendix A, in Bernard Lonergan, *Phenomenology and Logic: The Boston College Lectures on Mathematical Logic and Existentialism*, ed. Philip McShane, vol. 18, *Collected Works of Bernard Lonergan* (Toronto: University of Toronto Press, 2001). Amazingly, further relevant details (on mixed steps involved in this dynamics) are outlined in: Thomas Aquinas, *Prima Secunda*e, Questions 6-17.

[51] See, e.g., *Method in Theology*, section 5.3.

[52] See, e.g., *Method in Theology*, section 5.3. There will be the future work of determining in a contemporary context how the dynamics of both references of note 50 combine and complexly weave through each of the eightfold divisions of labor; and also how those dynamics relate to the overall eightfold division itself.

suggest that all data are the same. But functional research will not only seek significant data of sense experience of biological organisms (in the field or as obtained in the lab), but also data of sense experience that are significant expressions of biologists who are human-organisms talking or writing about sense experiences of (or obtained from) biological organisms. We can expect this more inclusive functional research to vastly increase the significance, depth, and reach of future functional collaboration; and it will certainly factor into the developments of communications C(i, j) (Figure 1, section 1).

3.6 An *omni-disciplinary* foundations

There are many sub-disciplines in biology, and understanding in biology evidently has extensive "intersection" with physics, chemistry, and for some higher organisms, sensitive psychology. Also, as mentioned above, functional collaboration will promote development in control of meaning of the human organisms who are biologists. But the dynamic mesh of kinds of meanings that link within biology seems to have no simple boundary, and includes, for example, the aesthetics of flowers. This draws attention to the challenge, that unless we are to risk leaving unknown or arbitrary blind spots in our biological foundations, dialectics and foundations will need to include some kind of heuristics for how all disciplines fit together. This promises to be an especially full and rich heuristics, for this future heuristics will include all possible categories of meaning and types of expression. In particular, we can expect future functional collaboration will help us gain some light on the questions of what "unity" can mean: for a merely biological organism; for a human organism; and for biology as a whole.

3.7 Disciplines other than biology

The focus so far has been biology. But the overlaps and intersections mentioned in 3.2-3.6 point to the fact that the eightfold functional division of labor will be relevant to all other disciplines, including engineering and technologies. In fact, since art is generated by human organisms making artistic use of various technologies, the arts also come under this functional reach.

A few details on other disciplines may be helpful. In environmental science, Arne Naess (1912-2009)[53] independently identified four "forward looking" groupings of tasks[54] that link closely with the four future-oriented functional specializations of foundations, doctrines, systematics, and communications. But environmental science has developed considerably over the last decades and now includes, for

---

[53] Arne Dekke Eide Næss (27 January 1912 – 12 January 2009) was a Norwegian philosopher, the founder of the field called "deep ecology."

[54] Arne Naess, "Deep Ecology and Ultimate Premises," 18 *The Ecologist* (1988), 128-31 (http://www.theecologist.org/).

instance, its own Ph.D. programs at major institutions around the globe. That is, environmental science now has a past. We can therefore expect future functional collaboration in environmental science to include both the functional core of the four tasks indentified by Naess and four functional tasks for retrieving results of the past.

In the engineering community, there are drawings, technical works, designs, documents of many kinds, bridges, buildings, electronics, and so on. In other words, there is the data of the engineering community (of both constructions and expressions); data can be interpreted or explained; bridge building, water-supply methods and transportation technologies all have advanced from ancient times—i.e., there are histories and lines of development in engineering. But, as in biology, different engineers and engineering scholars can have fundamentally different perspectives and can be at odds with each other in their orientations, understandings, meanings. So, there is the need of dialectics for engineering. Ways of doing engineering can develop, so there is the need of foundations; there are engineering policies, engineering education policies, and many other dynamics revealing the need for functional doctrines. As indicated in note 13 above, there is, for example, *Engineers of the New Millenium*, indicative of the fact that engineering progresses thanks partly to ongoing speculative work toward possible new lines of development. And of course results need to be, and are, communicated throughout all quarters of the engineering community.

In music there are the data of piano scores, recordings, books of Etudes, some of which include pedagogical instructions from the composer to the student pianist, written theories of music, texts and documents on philosophies of music, histories and biographies lived and written about, and so on. But, there is the possibility of trying to explain these data, so there will be functional interpretations in music; and so on, through the other six functional orientations.

The minimalist view on the basic practicality of functional collaboration in philosophy is presented in Henman's article.[55] The relevance and need of the division of labor to economics, musicology, linguistics, law, women's studies, and language studies has been pointed to by McShane, Gillis, Anderson, and Benton, respectively.[56] Additional

---

[55] Robert Henman, "An Ethics of Philosophic Work," 7 *Journal of Macrodynamic Analysis* (2012), 44-55 (above).

[56] Philip McShane, *Economics for Everyone: Das Jus Kapital* (Edmonton: Commonwealth Press, Edmonton, 1996) [reprinted Axial Press, 1998]; McShane, "Metamusic and Self-Meaning," chapter 2 in *The Shaping of the Foundations* (Lanhan, Md: University Press of America, 1976) (musicology—written in 1969); McShane, "Modernity and the Emergence of Adequate Criticism," chapter 5 in *Lonergan's Challenge to the University and the Economy* (Lanham Md: University Press of America, 1980) (literary studies); Bruce Anderson, *Discovery in Legal Decision-Making* (Dortrecht: Kluwer

reflection will be needed by investigators from all disciplines. Already, though, the relevance and practicality of the eightfold functional division of labor to all of the arts, sciences, and technologies now seems to be more than feasible.[57]

3.8 Regarding the probable impossibility of (*effective*) revision

From the discussion in section 2, we find that there can be at least eight divisions of labor in biology, corresponding to eight significantly distinct orientations already operative in the discipline. This ordering seems to be some kind of natural ordering. For, understanding in biology is understanding of biological data, and so the task of Research naturally precedes the task of Interpretation; history in biology gives some explanation of lines of development in interpretations, and so Interpretation needs to precede History in the functional ordering of main tasks. And so on. The eight tasks climb up, and round, cumulatively increasing helix-wise, to a maximal perspective appropriate to the task of being able to select, communicate, mediate, and execute the best possible up-to-date progress-oriented choices within the community. But these choices and their consequences in turn generate further experiences, further data in the community, and so new work for Research.

In addition to being in some way natural, the eightfold cyclic ordering also seems to be non-amenable to permutation. For instance, there would be the impracticality of trying to understand what an organism is without having sufficient data on the organism; there would be the impracticality of trying to understand a particular line of development in the discipline without knowing what individual contributors to that development said or meant; there would be the difficulty of working toward new possibilities, without knowing the significance of what already has been achieved, and in particular without knowing what might or might not be new. These are just samplings, but it seems that any attempt at internal revision of the basic eightfold cyclic ordering would lead to similar difficulties.

A further question, though, may arise: Granted that (i) *eight* orientations are operative in biology; and (ii) that the ordering seems to be natural and more or less not subject to internal permutation, perhaps there is some main orientation and task X not yet included in the eightfold division of labor?

Academic Publishers, 1996); Alessandra Gillis Drage, *Thinking Woman* (Halifax, N.S.: Axial Press, 2005); John Benton, *Shaping the Future of Language Studies* (Halifax, N.S.: Axial Publishing, 2008); Bruce Anderson, "The Nine Lives of Legal Interpretation," 5 *Journal of Macrodynamic Analysis* (2010), 30-36 (http://journals.library.mun.ca/ojs/index.php/jmda /article/ view/ 180/125).

[57] See also *Method in Theology*, 364-367.

This question points to the future need of advanced foundational development. But, already it seems that some descriptive comments are possible. We could anticipate that the supposed orientation X and task-type X will involve some kinds of understandings of some data. But, functional foundations seeks to determine all possible categories of meaning, and so would include some foundational grasp of X-meanings. For the community to advance in a way that includes X-meanings, will not an investigator need data on X-expressions?; interpretations of X-expressions?; explanations of lines of development of X-meanings within the community?; evaluations of X-meanings?; possible expansions of X-type meanings? And what might be basic descriptive truths and values grounded in X-meanings? What new types of development might be possible by including X-meanings and X-doctrines? How will selected and newly anticipated X-developments be shared with or mediated throughout the community?

It seems, therefore, that (i) the basic eightfold functional division of labor cannot be internally reorganized in any way that would not compromise the efficiency, effectiveness or possibility of progress; and (ii) that the eightfold structuring of functional collaboration seems to be self-consistent, at least in the sense that it already heuristically embraces any hypothetical basic functional task X.

3.9 All together now getting along

From 3.7 above, functional collaboration will be relevant to all sciences, arts, technologies, disciplines. And so it may already have occurred to you that omni-disciplinary dialectics and foundations will be similarly needed in any discipline. But there are differences between disciplines, so within omni-disciplinary foundations, we can expect connectivities between the various disciplines. Yet what are these connectivities? How will the functional work of the various disciplines fit together? Where will the differences be found, for even if dialectics and foundations are omni-disciplinary, there are of course differences between the expanding ranges of arts, sciences, and technologies.

To get a few clues on how we can expect this to work, let's start by looking at physics and chemistry. In functional research, the data of physics are not identical with data of chemistry. But there are linkages, such as when X-ray diffraction images of molecular structuring are used in chemistry.[58] So, through the physics of quantum-chemistry, the data of chemistry includes at least some data of physics. Moving to functional interpretation, explanations in physics are of course not identical to explanations in chemistry. But, again, some chemical explanations "include" some explanatory elements from physics. The nature of that "inclusion" is an important matter of ongoing debate in the community. Still, in whatever way it will be accounted for in the future, the present

[58] See, e.g., Crick and Watson's Photo 51.

fact is that explanations in chemistry in various ways knit together layerings of physical and chemical aggregates of data. What then about functional history? Do not the stories of both physics and chemistry become increasingly inter-connected as we try to account for historical lines of development?

In the past-oriented phase in functional collaboration, then, we will have both chemistry and physics each climbing in perspective from research to dialectics, but at the same time there will be increasingly complex connectivities between the two sets of perspectives, converging toward a shared omni-disciplinary dialectics.[59] A reversing of this convergence can be expected as the functionally collaborative community turns toward the future. For, while continuing the climb in functional perspectives (from foundations to doctrines, systematics, and communications), a common omni-disciplinary functional foundations will be integrated up through all future-oriented specialties. Explicit differences will increase, culminating in the mediation of nuanced functional communications with sub-communities of sub-disciplines, including the sub-communities of general audiences and the public at large.

This is all merely impressionistic, but it is based on the data and results we have so far. If functional collaboration is implemented, it seems that not only will a functional unity of individual disciplines gradually emerge,[60] but there is the promise of a dynamic *functional unity* of all disciplines. And as sketchily pointed to by the discussion above on physics and chemistry, this unity will normatively seek to embrace distinctions, layerings, inter-disciplinary inclusions and connectivities.[61]

---

[59] Dialectics and foundations will then be a kind of "inflection zone." For, while continuing the movement of progress, a deceleration will be needed to adequately pause over dialectical and foundational issues.

[60] See, e.g., sections 3.2 – 3.7, above.

[61] See "The Global Table," figure 1, section 1. This topic goes beyond the scope of this introductory article. But, for future reference, it may be useful to add a few comments. Nowadays, inter-disciplinary results are developed and communicated within disciplines, and between disciplines, in *ad hoc* ways (depending on perspectives, foundations, positions, interests). Communications will be less *ad hoc* once functional collaboration is implemented. For example, within the functional flow, a physicist doing functional research may communicate results to functional interpreters in physics, symbolized by, say, $C(1,2)^{physics}{}_{physics}$. But, an internal communication might also be made to interpreters focusing on biochemistry, or perhaps functional historians in biochemistry, and so on. We can expect differences in such communications, heuristically symbolized by, say, $C(1,2)^{biophysics}{}_{biochemistry}$; $C(1,3)^{biophysics}{}_{biochemistry}$, etc. We can therefore expect a developing control of increasingly differentiated communications not only between functional specializations, but also across developing and emerging sub-disciplines. These will be future achievements heuristically symbolized by, say, $C(i,j)^{A^*}{}_{B^*}$ -- superscripts A* and subscripts B*

Emergent then is the need and the practicality of a normative eight-fold collaborative division of labor that will weave through all of the arts, sciences and technologies.[62] There was the question at the beginning of the article: What are *progress* and *decline*? But in view of our results so far, we can expect that *progress* and *decline* will be determined and measured through functional collaboration. This may seem like quite a claim. Yet it seems that (i) functional collaboration cannot be (*effectively*) revised; and (ii) that implementation promises to be a "normative pattern of recurrent and related operations yielding *cumulative* and *progressive* results"[63]—generating ongoing progress in "conception, affirmation, and implementation"[64] of the dynamic unity of the entire omni-disciplinary human enterprise.

There are vast aggregates of events and occurrences, including large numbers of biochemical-human organisms experiencing, desiring, understanding, deliberating, doing, struggling, succeeding, failing, experiencing sorrows and finding joys. If functional collaboration is implemented, it seems that by its very progress-oriented functionality, it will be uniquely and increasingly effective at embracing and promoting progress while offsetting decline, in our total historical and human omni-disciplinary community enterprise—our past, our present, and our

---

to accommodate differentiations within disciplines and sub-disciplines A and B.

We will have then some kind of grouping of operations: for any functional specialization and discipline, there will be developments within that specialization that are compatible with the norms and criteria of that functional specialization, within the full unity of the total functional division. So, the descriptive word "connectivity" will eventually be replaced by some more precise notion of "connection." Such a connection will be a way of tracking intrinsic variation. But communications between specializations will aim to carry variations and results of one specialization to other specializations. This means that in some sense to be determined, functional communications between specializations will be "connection preserving"—in the sense that through internal communications, results from one functional specialization will be dynamically grafted into the functionally directed work of a possibly different specialization. But all of the functionally specialized work will be part of the entire functional unity. So, we can expect a dynamic unity that will, as mentioned above, be a "measure of progress"; and connections proper to functional specializations will then be restrictions of some kind, layerings of secondary determinations of dynamics corresponding to subgroupings of the full connection of the full dynamic human group unity. There will therefore be some kind of dynamic community gauge grouping—itself and ourselves developing in time.

[62] See also Bernard Lonergan *A Third Collection*, ed. Frederick Crowe (New York, Paulist Press, 1985), 204-208, speaking of, *inter alia*, "General Dynamics," and "common concern of associations of scientists"; and see note 5 there (regarding "a framework for collaborative creativity").

[63] *Method in Theology*, 4-5.

[64] See the definition of 'metaphysics,' *Insight*, *CWL* 3, 416.

emergent future. Or, as mentioned in section 1.1, the fundamental conclusion is that functional collaboration is the answer to the overwhelming problem and challenge raised by the longer cycle of decline. In *Insight*, that answer is designated by an X named *cosmopolis*; in *Method*, that answer is obliquely sketched under the rubric of functional specialization.

3.10 What are we to do about functional collaboration?

Functional collaboration will be radically new and will involve considerable challenges. But it will be neither strange nor artificial, for the eight basic orientations already are emergent in disciplines, and to some extent the corresponding tasks already are pre-emergent. Also, the practicality of the eightfold division of labor increasingly is evident. History gradually is bringing us toward and into functional collaboration. History, then, is inviting us to a new stage of development that will involve a growing self-luminosity in and about what we are and what we do. On the other hand, in this paper I also have drawn attention to some of the problems associated with not adverting to orientations and operations.

There remain therefore questions for investigators, both present and future: What do we want? What are we to do about functional collaboration? Will we assist history in bringing forth the struggling-to-emerge functional unity that will more effectively promote human progress and offset decline? Or not? What will be our work and joy of choice?

Terry Quinn's Ph.D. was in C*-algebras, (Dalhousie University, Halifax, Canada, 1992). He did one year of postdoctoral work at Trinity College Dublin School of Mathematics, and two years with the National University of Ireland (1993-1995), University College Cork. In the USA he has held positions at Texas A&M International University, and Ohio University Southern. Currently (2012) he is professor of mathematical sciences at Middle Tennessee State University where he also served as Chair (2006-2009). He has publications in science and the philosophy of science: operator algebras (historically the mathematics from quantum physics), applications of Lie groups to differential equations; mathematical modeling for certain areas of medical research; computational methods for DNA studies; mathematics and science pedagogy; and foundational issues in the sciences. Much of his recent work and collaborations are directed toward foundational developments in the sciences and human sciences, especially regarding the origins, emerging significance, and future possibility of functional collaboration.