Parts and Wholes--Contrasting Epistemologies

Percy Hammond

ABSTRACT Key Words: : transitivity, hierarchical structure, analogy, determinism, emergence, reductionism, tacit knowledge.
This article discusses three different approaches to human knowledge. The first is that of Peter Simons, a linguistic philosopher, who suggests that language has an underlying algebraic structure. The second approach is that of Ernest Nagel, a philosopher of science, who maintains that the key to knowledge lies in logical analysis. The third approach, due to Michael Polanyi, stresses the idea of tacit integration of parts into composite wholes. All three employ hierarchical schemes, the first two work from the top down, whereas Polanyi works from the bottom up, using the idea of 'emergence' .

Human perception relates to objects. We see houses and trees rather than patterns of light and shade and hear words rather than mere sounds. Our brains organise the visual and auditory sense data into meaningful composite entities. These entities have both internal and external relationships so that they can be analysed into parts and can also be regarded as parts of other wholes. In this article, I examine the views of three philosophers concerning the relationship between parts and wholes. Peter Simons is concerned with the structure of language, Ernest Nagel with the structure of scientific theories and Michael Polanyi with the way in which we obtain knowledge of the external world.

Peter Simons' book *Parts- A Study in Ontology*[1] begins with an account of the concepts and principles of a formal representation of parts and wholes in terms of algebra. He defines the term 'proper part' mathematically by the symbol 'less than'. (The word 'proper' is used to exclude the possibility of the part being equal to the whole.) Simons writes that the term 'part' is so basic and intuitive that 'it seems almost superfluous to offer examples'. However, he provides a table of typical wholes and parts to illustrate the notion. Five of the examples relate to a spatial relation between the whole and the part and two give a temporal relation.

Having satisfied himself that the meaning of parts and wholes is established, Simons then constructs an algebraic structure in terms of symbols. This algebra has such properties as asymmetry and transitivity and includes operations such as summation. The details are discussed fully in the book. Here we merely note that the treatment moves at one step from composite real objects and their parts to the general abstract term 'part' and from that to symbols, such as x and y, subject to algebraic operations. Clearly, these steps are not free of difficulty.

Let us illustrate some of these difficulties by considering the special case of a can of soup, such as might be bought at a supermarket. The soup can be divided into parts by pouring it into various plates. It can be further divided into spoon-fulls. That satisfies the transitivity property: the part of a part is also a part of the whole. However, this division of the soup does not reveal much about its ontology. There are other more interesting ways of dividing the soup into parts. For example, the purchaser is likely to be interested in the ingredients; how much of the soup consists of potatoes and carrots, or of water and salt. It is likely that this information will be given on the can and the label will also give 'nutritional information' about the relative amounts of carbohydrate, fat and protein. The potatoes contain carbohydrate, but it is unclear whether carbohydrate is a

part of a potato, or whether potatoes are parts of the class of substances containing carbohydrate. Nor is it obvious in what sense potatoes are parts of the soup. The generic term ‘part’ hides the wide variety of its usage.

Simons attempts to deal with a number of difficulties by using qualifying expressions to restrict the generality of the term ‘part’. He mentions ‘temporary‘ parts, which an object can gain or lose without prejudice to its identity. These differ from ‘essential’ parts, some of which are ‘permanent essential’. These and other restrictions are difficult to accommodate in the algebraic structure.

There are other difficulties. In the first chapter, Simons insists that transitivity is a fundamental property of the meaning of the term ‘part’. He writes, ‘ if one thing is a proper part of another, and the second is a proper part of the third, then the first is a proper part of the third’, and anyone who seriously disagrees with this has failed to understand the meaning of the term. Later, however, he admits that this is not obvious. As an example he discusses the question, ‘if a handle is part of a door and the door is part of a house, is the handle part of the house?’ He is inclined to think that this is true, but that perhaps the term ‘part’ needs to be restricted to parts ‘making a direct functional contribution’ to the wholes of which they are parts. That is an important restriction.

The motivation underlying this book is the desire for clarity. There is in linguistic philosophy an underlying dissatisfaction with the vagueness of ordinary language and the hope that it should be possible to discover a logical structure within or behind such language. These considerations often cause philosophers to turn to mathematical models, because such models can be expressed in symbols having clearly defined logical connections. Moreover, the symbols are separated from the messiness of common speech and have great generality. There is an even more ambitious hope that the use of logic should lead to ontology, the study of things as they are. Indeed, Simons writes in the preface that his book is about ontology and not about logic.

Such an aim involves not only the development of a formal mathematical structure, but also requires that this structure should refer to the ordinary world of human perception. Hence there is a tension between the two aspects of the model, its formal internal relationships and its external applicability. Throughout the book, Simons repeatedly tests his mathematical structure against practical examples. The reader will not soon forget the adventures of the unfortunate cat that lost its tail! However, in spite of this pragmatism, it is clear that the chief concern of the book is with logical structure and analysis. Simons begins with a mathematical model and then seeks to adapt ordinary language to that model.

Readers of a book on ‘parts’ would expect to find an explanation of the ‘wholes’ to which the parts belong. Surprisingly and significantly, there is little discussion of wholes in the book. The author looks at the possibility of *Gestalten* and *Ganzheiten* but is unhappy with these concepts. Instead, he considers wholes in terms of various aggregates of parts such as sums and complexes. However, since these aggregates consist of parts, there is in this a circularity of definition. Wholes are defined as sums of parts and this seems incomplete. Thus in the example of the chain ‘house – door – handle’, the significance of the term ‘door’ is not exhausted by listing its parts such as the door handle. Without a handle, the door might not be so useful, but the significance of the handle derives from the door and not vice versa. If there is no whole, the term ‘part’ loses its meaning.

What then is the meaning of the term 'door' considered as a whole? The author does not tell us except to say that the door is a part of a house. So, once again, the whole is considered as a part of another whole. That is a very important discovery, although it is not made explicit in the book. The inevitable conclusion is that there are no isolated wholes, because each whole is embedded in other wholes. The other end of the chain is equally problematic. The handle is also a whole with parts of its own. It is not merely a part of a door. Handles can be purchased at a builders' merchant without reference to doors. In fact, every item in the chain has a double meaning as a part and as a whole. Nor can the problem be resolved by extending the chain until its last part is an atom or subatomic particle. The fact that such a particle is a part of something else gives no information about its inner structure or possible indivisibility. That question has to be answered experimentally by seeking to isolate the particle and, if that is possible, by then attempting to determine its separability into parts.

Nor is it possible to envisage isolated chains. The author's concentration on the significance of wholes as aggregates of parts suggests that the production of motor cars should depend entirely on assembly lines. Apparently, there need be no marketing department to assess the needs of customers and no design department trying to meet those needs. The ontology of cars involves the use of them as well as their assembly. A single linear chain of parts having other parts cannot represent such an activity. This negative conclusion does not apply only to artefacts. For example, the hierarchical chain often used in biology, 'organism – organ – cell – molecule – atom', suffers from the same problems because each term has multiple meanings in terms of parts and wholes belonging to different systems that are related by a multiplicity of connections.

Although in a sense the author is right to concentrate his attention on parts, because strictly speaking there are no isolated wholes, human perception needs to focus on wholes as separate entities. Such focusing 'reduces' the field of vision and is a necessary means of acquiring understanding. Although it is true that reduction will not lead to ontology in a single leap, there is no means of avoiding it. It is impossible to deal with the totality of all there is with its intricate inner relationships. A 'theory of everything' is a contradiction in terms just like a map of scale 1:1. Hence it is unavoidable that knowledge must be acquired by specialising, although it is a mistake to regard a particular specialism as all encompassing. The need for isolating wholes therefore suggests that a formal mathematical structure will at best have value as a tool in epistemology, but cannot lay claims to any ontological insights. In particular, the replacement of objects by symbols hides the distinction between the role of an object as a part and as a whole. In ordinary language, this distinction is preserved by the context. The apparent lack of clarity is here an advantage of ordinary speech. More specifically, one could think of clarity as having other aspects besides logical connection. For example, in poetry, metaphor and analogy are used to achieve clarity.

The practical examples discussed by Simons are simple objects or sentences. This is appropriate in a book chiefly concerned with philosophical matters. It is, however, insufficient for readers whose special interest is in the application of logic to the study of science. An older book that deals with such matters is Ernest Nagel's *The Structure of Science – Problems in the Logic of Scientific Explanation*.[2] This is a most impressive work, showing the author's astonishing breadth of philosophical and scientific knowledge. It is rightly considered to be a classic treatment of the subject and it is impossible to give an adequate account of the entire book in this short article. I shall confine my attention to Nagel's treatment of parts and wholes and their logical connections.

In the preface to his book, Nagel distinguishes between the logical structures of scientific explanations and the logical structure of scientific concepts. This distinction gives him considerable

flexibility in dealing with different branches of science. Unlike Simons, he does not seek for a single logical structure embodied in a mathematical formalism. In his treatment, both the mathematical symbols and the operators can have a variety of meanings. As an example, Nagel considers the development of the term 'number'. Originally, this referred to positive integers, but the meaning was later extended to include negative integers, fractions, irrational numbers, complex numbers and other mathematical entities. Similarly, the operations of addition and multiplication were extended so that they could be applied more widely. Such extension and adaptation do not imply logical contradiction.

Another example he gives is the extension of the terms of classical mechanics into quantum mechanics. The words 'position', 'momentum', 'particle' and 'wave' are used as analogies of the classical terms when they are applied to quantum theory. This throws light on the problem of indeterminacy. Nagel thinks that the apparent lack of determinism in quantum theory is due to a misunderstanding of the extended meaning of the terms. It is unreasonable to expect that position and momentum can be observed simultaneously because these terms have no separate existence in quantum mechanics. Their use in that theory is different from the use in classical mechanics.

Determinism is for Nagel the supreme regulative principle of science and applies even to so-called chance events. He provides a detailed discussion of the possibility of chance events, distinguishing between relative and absolute chance. His view is that unexpected events may be described by the word 'chance', but only because their determining factors are not known. The question whether statistical events are indeterminate is an open philosophical one that does not affect scientific practice. In its application, even quantum theory is deterministic. Although absolute chance is free from logical contradictions as far as a single event is concerned, a distribution of events in time is always associated with some type of order. Scientific knowledge is, in Nagel's view, essentially the knowledge of causal chains between the phenomena.

Like Simons, Nagel concentrates his attention on the parts of objects or processes rather than on wholes. 'Locutions like wholeness, unifiedness and indivisible unity' are not 'expressions of genuine knowledge'. Only analysis and the study of parts lead to scientific knowledge. This is a much stronger assertion than those made by Simons and goes beyond our previous consideration that wholes are also parts. Nagel dismisses the objection that 'a melody is not the sum of its individual notes' as meaningless for the technical reason that the word 'sum' has not been defined. That is an astonishing statement contrasting sharply with Einstein's view that the chief quality required in scientific research is 'musicality'. Nagel's dismissive attitude is also illustrated when he writes, 'Natural scientists are sometimes motivated by moral and aesthetic aims, and the moral passion and literary artistry with which some of them write about achievements in their domains of enquiry do not automatically impair the objectively warranted content of their expositions'. In spite of this, he writes in the preface that the most precious harvest of the scientific enterprise is the achievement of generalized theoretical knowledge. That sounds as if he thinks that there is more to science than the study of parts. Nevertheless, the dismissal of wholes is dominant. Thus he mentions clocks on several occasions without any reference to their use in telling the time. The total explanation of clocks seems to be obtainable by examining the parts and applying the laws of mechanics to their interaction.

Like Simons, Nagel toys with the idea of *Gestalt*, but he is not impressed by it. He writes that 'such wholes can be analysed into elements standing to each other in specified relations'. This suggests that he has misunderstood the term or, what is more likely, that he is turning his back on it because it does not fit into an epistemology that is dominated by analysis into parts.

Nagel provides an extensive discussion of the doctrine of emergence. As might be expected, he is not sympathetic to this concept. He readily admits that wholes may have properties that differ from the properties of their parts considered in isolation. But he strongly denies that this distinction between the properties can be inferred or deduced by logical reasoning. The point is that it is statements or propositions that can be deduced but not properties. There is no logic of properties unless there is also a connecting theory. Talk of the 'inherent nature' of a whole is meaningless in the absence of an explanatory theory.

The converse of this view is seen in Nagel's rejection of a general reductionism applied to properties or theories. He believes that such reductionism implies the existence of logical connections between theories and in general such connections do not exist. There is also a difference between the usage of different terms in different fields of scientific study. Nagel stresses the criterion of usefulness of particular terminologies and theoretical structures in different branches of science at different stages of development. Any proposal for the reduction of one science to another, such as the reduction of chemistry to physics, must be justified by its fruitfulness in uncovering new phenomena. Nagel's world of science is therefore a very rich one.

Nevertheless, it is not a world of scientific discovery. It is significant that the name of Karl Popper appears only in two footnotes. The use of hypothesis in the formulation of theories receives little attention. Although Nagel is keenly aware of the use of analogies between different properties and theories, he does not mention the use of such analogies in scientific research. Although he mentions Maxwell's comments on mathematical analogies between different physical processes, he does not show the manner in which Maxwell used the analogies to guide his discovery of the electromagnetic theory of light.[3] Nagel's work leaves the impression that the only weapon in his armoury is the, admittedly powerful, weapon of logical analysis.

An altogether different approach to the acquisition of knowledge is given in the work of Michael Polanyi.[4] Not only does he regard the parts as subsidiary to the whole, but he warns that the process of analysing a whole into its constituent parts may make it impossible to understand the whole object. Thus the recognition of a face as a whole is due to an integration of the knowledge of the parts and may be impeded by analysing the features. Another example he cites is the skillful diagnosis of the condition of a patient by an experienced physician. This involves, in Polanyi's view, the physician's concentration on the whole person rather than on the various symptoms presented by the patient. Polanyi distinguishes between the physician's tacit knowledge of symptoms and his focal knowledge of the patient. The doctor attends *from* the symptoms *to* the patient. He uses the tacit knowledge as a tool in the diagnosis. Polanyi's experience as a medical practitioner lends weight to this approach.

It is interesting that Nagel also speaks of tacit knowledge in the context of medical diagnosis. His explanation is that the physician uses logical deduction tacitly in arriving at the diagnosis. That explanation sounds implausible because it suggests a well-ordered set of verbal connections in the doctor's mind. Polanyi stresses that tacit knowledge is essentially tacit. He writes, *'we can know more than we can tell'* [5](*TD*, 4) and considers this ability to be the basis of all skillful activity. Thus, a pianist uses his tacit knowledge of the muscular control of his fingers in giving his attention to the music that he is playing. If he were to focus attention on his fingers, he would not be able to play the musical piece. Of course, this does not deny the usefulness of finger exercises, but these represent different wholes rather than parts of a composition.

Polanyi distinguishes the *proximal* knowledge involved in the perception of an object from the *distal* knowledge of its meaning. Tacit knowledge establishes a relation between the two kinds and so provides ontological knowledge. The proximal component involves a personal *indwelling* in the particulars of the objects that we are seeking to understand. These ideas enable Polanyi to apply his theory not only to physical objects but also to the understanding of comprehensive entities such as scientific theories.

It is clear that Polanyi's view of wholes involves tacit integration rather than the logical analysis used by Simons and Nagel. In fact, Polanyi believes that knowledge is essentially concerned with wholes and not with parts. As soon as a part is brought into focus, it becomes a whole. In his view, the lucidity aimed at by Simons and Nagel is liable to destroy rather than explain a comprehensive object.

A difficulty common to the three accounts of parts and wholes that I am considering is how to explain the process of the scientific discovery of wholes. An analysis of existing wholes into their parts does not help. Unlike Simons and Nagel, Polanyi is keenly aware of the problem. He mentions Plato's paradox in the *Meno*. How can it be possible to search for something that is unknown? Polanyi's answer is that our tacit knowledge reaches beyond explicit logical deduction and supplies us with hunches for possible answers to problems. Correct answers show their correctness by leading to the solution of further problems and so enlarge our general understanding.

Polanyi pursues this question of the existence of wholes in a process of discovery by using the idea of *emergence*. He approaches this concept by considering the arrangement of parts and wholes in hierarchical chains similar to Simons' example of the chain house – door – handle. However, he reverses the direction of the chain by proceeding from the parts to the wholes. One of the examples concerns the making of a speech. Polanyi constructs the chain: voice – words – sentences – style – literary composition and ascribes to it a structure of five levels associated with five laws. Each level has its own laws, which are respectively the laws of phonetics – lexicography – grammar – stylistics – literary criticism. The notion of 'level' is linked to the notion of 'complexity'. Polanyi regards complexity as an emergent property. This property is controlled by the laws operating at the level under consideration and these laws are also subject to those of the level below. For example, the use of words is subject to the rules of grammar and to the vocabulary. This 'dual control' provides the connections between the hierarchical levels.

Polanyi proceeds to apply his model to biological organisms. But before he does so, he has a reference to engineering. He draws attention to the 'operational principles' of machines, which cannot be inferred from a knowledge of physics and chemistry, although machines are subject to the laws of physics and chemistry. In Polanyi's view, these laws are located therefore at a lower level than the operational principles. They determine the possibilities of failure of the machine, but are incapable of accounting for the function of the machine as a comprehensive entity. The function of clocks is to tell the time. That is their operational principle and it controls the laws of mechanics obeyed by the motion of the clock. Polanyi describes the operational principles as the boundary conditions for the laws at the lower level and speaks of a *principle of marginal control*. This, he believes to be a general principle that can be recognised in all human performances and also in all biological organisms. He believes that it is the principle behind the evolution of human beings and that it is far more general than the principle of selective improvement of species.

In spite of its attraction, Polanyi's theory of emergence faces grave difficulties. One of these is his use of boundary conditions to provide a connection between a lower and a higher level. In physics, boundary

conditions are needed to supplement the equations before these can be applied to a particular situation. The function of boundary conditions is to isolate a region in which the equations operate from the rest of the external world. This requires that the boundary conditions act at the same level as the equations. Thus the equations of the electromagnetic field require boundary conditions in terms of electric charge and current. Although at a 'higher level', the field may transmit information; there is no logical connection between the content of the information and the field. Nagel repeatedly, and correctly, asserts that reduction or emergence depend on the existence of connecting theories by which the terms at one level can be related to the terms at another level.

The chief difficulty with the idea of emergence lies in the asymmetry between parts and wholes. Whereas it is easy to divide complex wholes into parts by analysis, there is no method of synthesis by which wholes can be assembled from parts. In his description of levels, Polanyi is aware that the properties at the higher level cannot be inferred from those of the lower levels. A related difficulty arises from the absence of links between the levels. In Polanyi's example of words and sentences, there is such a link, because words are an essential part of sentences. However, in his example of machines, there are no essential links between the operational principles and the embodiment of those principles. There are many different ways of constructing devices to tell the time.

I have previously mentioned the use of analogy by James Clerk Maxwell in his discovery of electromagnetic radiation. Maxwell writes,

> In using such words as electric momentum and electric elasticity in reference to the known phenomena of the induction of currents and the polarisation of dielectrics, I wish merely to direct the mind of the reader to mechanical phenomena which will assist him in understanding the electrical ones. All such phrases in the present paper are to be considered as illustrative, not as explanatory. In speaking of the Energy of the field, however, I wish to be understood literally.[6]

Thus the term 'energy' anchors Maxwell's analogical description of electromagnetics to its underlying mechanical description. Polanyi's analogies in his doctrine of *emergence* lack such an anchor.

This is not surprising when we refer back to his idea of tacit knowledge. If indeed we 'know more than we can tell', it must be impossible to devise an explicit, objective hierarchy of levels for our knowledge. That there exist such levels of parts and wholes is indisputable. It is also obvious that there exist levels of organismic development. But the process Polanyi proposes for this emergence cannot explain the existence of levels. Polanyi's greatest insight is that all knowledge is personal. This is the missing ingredient in Nagel's analysis of science. As a result, Nagel cannot and does not put forward a theory of scientific discovery. Polanyi does have such a theory in his idea of tacit knowledge. It is surprising that in his attempt at an explanation of emergence, he seems to omit the personal element.

The final word in this discussion of parts and wholes can perhaps be given by Maxwell in an excerpt of some humorous verses he wrote as comments on the presidential address at the meeting of the British Association for the Advancement of Science in 1874. He wrote:

> First then let us honour the atom, so lively, so wise, and so small;

The atomists next let us praise, Epicurus, Lucretius, and all;
Let us damn with faint praise Bishop Butler, in whom many atoms combined
To form that remarkable structure, it pleased him to call – his mind.
Last praise we the noble body to which, for the time, we belong,
Ere yet the swift whirl of the atom has hurried us, ruthless, along,
The British Association – like Leviathan worshipped by Hobbes,
The incarnation of wisdom, built up of our witless nobs,
Which will carry on endless discussions, when I, and probably you,
Have melted in infinite azure – in English, till all is blue.[7]

Endnotes

[1] Peter Simons, *Parts – A Study in Ontology* (Oxford University Press, 1987).

[2] Ernest Nagel, *The Structure of Science – Problems in the Logic of Scientific Explanation* (Hackett Publishing Company, 1979).

[3]The process by which James Clerk Maxwell arrived at his theory of the electromagnetic field is described by him in the three papers: 'On Faraday's Lines of Force' (*Trans. Camb. Phil. Soc,* Vol 10, Part 1 1855/56) 'On Physical Lines of Force' (*Phil. Mag.*,Vol 21, 1861/62) and 'A Dynamical Theory of the Electromagnetic Field' (*Trans. Royal Soc.*, Vol 155, 1864). An insightful discussion of the third paper is given by T F Torrance in the edition edited by him, which also has an appreciation of Maxwell from Einstein. (Scottish Academic Press 1982). All three papers are discussed by T K Simpson in his book, *Maxwell on the Electromagnetic Field- A Guided Study* (Rutgers University Press 1997).

[4] Most of the discussion in this article is based on Polanyi's opening two chapters in *The Tacit Dimension* (Doubleday & Co, 1966). These chapters complement discussion in Polanyi's great work, *Personal Knowledge – Towards a Post-Critical Philosophy* (Routledge & Kegan Paul 1958).

[5] *The Tacit Dimension*, 4.

[6] 'A Dynamical Theory of the Electromagnetic Field' (*Trans. Royal Soc.*, Vol 155, 1864).

[7] These verses and several others are quoted in H. H. Skilling, *Exploring Electricity – Man's Unfinished Quest* (New York: Ronald Press, 1948).

Notes on Contributors

T. Percy Hammond (percy @pop3.soton.ac.uk) is a retired UK professor of electrical engineering with specialist interests in the electromagnetic behaviour of electrical power apparatus. He is a fellow of the Royal Academy of Engineering and the Institutions of Electrical and Mechanical Engineers.

Yu Zhenhua (ecnuyu@hotmail.com) is Associate Professor of Philosophy, Department of Philosophy, East China Normal University (ECNU), Shanghai 200062, China. He has a Ph.D. in Chinese philosophy and has published his dissertation *How Is Metaphysical Truth Possible—-A Systematic and Critical Exposition of Modern Chinese Philosophy* (ECNU Press, 2000). Now he is working on a doctoral project on tacit knowledge under the framework of an exchange program (which is dubbed "Maco-Polo") between the Center for the Study of the Natural Sciences and the Humanities (SVT) at University of Bergen, Norway and the Department of Philosophy at East China Normal University. He has published a couple of articles on Michael Polanyi in various journals in China.

Phil Mullins (mullins@mwsc.edu) has been the editor of *Tradition & Discovery* since 1991. In addition to interest in Polanyi, he has special interest in the philosophy of technology. Mullins is the guest editor of a forthcoming issue of *Techné: Journal of the Society for Philosophy and Technology* on Albert Borgmann's recent book *Holding on to Reality.*

Submissions for Publication

Articles, meeting notices and notes likely to be of interest to persons interested in the thought of Michael Polanyi are welcomed. Review suggestions and book reviews should be sent to Walter Gulick (see addresses listed below). Manuscripts, notices and notes should be sent to Phil Mullins. Manuscripts should be double-spaced type with notes at the end; writers are encouraged to employ simple citations within the text when possible. MLA or APA style are preferred; because the journal serves English writers across the world, we do not require anybody's "standard English." Abbreviate frequently cited book titles, particularly books by Polanyi (e.g., *Personal Knowledge* becomes *PK*). Shorter articles (10-15 pages) are preferred, although longer manuscripts (20-24 pages) will be considered. Consistency and clear writing are expected.

Manuscripts normally will be sent out for blind review. Authors are expected to provide a hard copy and a disk or an electronic copy as an e-mail attachment. Be sure that electronic materials include all relevant information which may help converting files. Persons with questions or problems associated with producing an electronic copy of manuscripts should phone or write Phil Mullins. Insofar as possible, *TAD* is willing to work with authors who have special problems producing electronic materials.

Phil Mullins
Missouri Western State College
St. Joseph, Missouri 64507
Fax (816) 271-5680
Phone: (816)271-4386
E-mail: mullins@mwsc.edu

Walter Gulick
Montana State University, Billings
Billings, Montana 59101
Fax (406) 657-2187
Phone: (406) 657-2904
E-mail: WGulick@msubillings.edu