16 Geomorphology, Geography, and Science

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ABSTRACT

The centrality and importance of geography to the disciplinary development of geomorphology has been undervalued historically because: (1) geography's intellectual core is not easily identified nor circumscribed; (2) geography's establishment as an academically distinct discipline in North America did not occur until the late nineteenth century; and (3) geography's scientific foundations are not widely appreciated. The relationship between geology and geomorphology, in contrast, is often portrayed as being more substantive and intimate. Nevertheless, the intellectual roots of geography, geology, and geomorphology are closely intertwined and traceable to common Greek origins. Only the institutional infrastructures that have evolved to support these contemporary academic disciplines are distinct and separate.

Geomorphology's contemporary academic status as a subdiscipline of both geography and geology has often been viewed as detrimental, and several geographers and geologists over the last 75 years have advocated academic realignment that favors one or the other. This has resulted in needless caricaturing that serves an injustice upon geographical and geological practitioners, past and present. The situation is especially unfortunate and potentially damaging when the host disciplines are portrayed as having only singular, intrinsic methodologies, and by logical necessity, unique and unifying philosophies. In the case of geography, an interdisciplinary discipline that borrows from several affilitated physical, life, and social sciences (and occasionally the arts and humanities), myriad methodologies and philosophies are employed, encouraged, and critically challenged in attempts to provide integrating and synthesizing perspectives on human-environment interrelations. Geography's most important contribution to geomorphology may well be the breadth and diversity it brings to geomorphological thinking. Such breadth is manifest

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in: (1) an increasing number of subspecializations in geomorphology beyond the traditional cores; (2) an increasing number of methodological and philosophical perspectives being brought to bear on geomorphic problems; (3) an increasing concern with the integrity of geomorphological claims to knowledge, especially those that assume scientific postures; and (4) an increasing appreciation for the necessity of utilitarian research, especially in the face of inexorable alteration of earth's surface by the profound activity of humans, and for the express purpose of ensuring disciplinary survival by demonstrating contemporary relevance. In these contexts, geography serves to inform and heighten geomorphology's awareness of the physical, intellectual, and social pulses of the world around us.

OBJECTIVES AND CAVEATS

The original objective of this chapter was to provide an evaluation and elucidation of 'the ways in which geographic theory and methods have influenced or are currently influencing the development of geomorphology as a science' (Rhoads and Thorn, personal communication). Such an undertaking turns out to be unrealistic for several reasons. First, it accepts, a priori, the existence of theories and methods that are distinctly geographical, their readily identifiable character, their acceptance and use by the geographic community, and their transplantation into the geomorphological corpus. Many have taken exception to such assertions, and Schaefer (1953, p. 227), for one, contends that the '. . . existence of a field ... needs no "methodological" justification'. Yatsu (1992, p. 92) concurs and suggests that 'for the development of scientific knowledge, researchers must use any method available'. Although certain disciplines might easily be characterized on the basis of distinctive theories and methods (e.g. mathematics or engineering), this is neither a necessary nor sufficient condition. Geography, in particular, encompasses a broad spectrum of theories and methods, many of which have evolved in association with developments in other disciplines, and thus, the donor-recipient relationships are not evident.

Second, it implicitly assumes that there is widespread agreement as to the meaning and implications of 'science', that geomorphology is considered to be a science by the broader community of academics, and that we, as geomorphologists, find it desirable for geomorphology to be(come) scientific. These issues are at the very core of geomorphology, and one need only scan the recent geomorphological and geographical literature to get a sense of the prevailing confusion and ambiguity surrounding them (e.g. Richards 1990, 1994; Baker and Twidale 1991; Yatsu 1992; Rhoads and Thorn 1993, 1994; Bassett 1994; Rhoads 1994). Ontological and epistemological concerns are central to these debates but are ordinarily the domain of the philosopher or historian of science. Are geomorphologists prepared to engage these debates or will they reach, once again, for the soil auger (cf. Chorley 1978)?

Third, it is inherently confrontational because it is tantamount to geographical representation in the 'Championship of the Disciplines' (i.e. disciplines most influential to the development of geomorphology). In such endeavors it is often convenient and effective to place in opposition the merits of one discipline against those of another. Supporting arguments and expositions are often based on extremist, opinionated, historically super-

ficial, and logically nondefensible assertions strengthened by hegemonic posturing. They generally fail to appreciate that disciplines are human institutions that have evolved as convenience structures, and that their intellectual, methodological, theoretical, and practical character and concerns are often inextricably intertwined. Furthermore, viewpoints are often divergent, egos are large, consensus is unlikely, and there is no absolute truth or authority to which one can turn for arbitration or resolution. A 'Championship of the Disciplines' may be good sport, but its deeper purpose is far from clear.

In view of these difficulties, this chapter will not follow a conventional tack that updates the comprehensive works of others who have assessed the important contributions of geographers to geomorphology through inventories of publications, citations, or society memberships (e.g. Graf et al. 1980; Costa and Graf 1984; Graf 1984; Marston 1989). Neither will it assert that a particular geomorphic principle, law, theory, or method has a distinct and uniquely geographical origin - this might be the case, but the supporting arguments would be hard to make. The reader is referred to any of several comprehensive histories of geography and geomorphology to search out such truths (e.g. Hartshorne 1939; Chorley et al. 1964, 1973; Dury 1983; Tinkler 1985; Beckinsale and Chorley 1991; Unwin 1992; James and Martin 1978; Walker and Grabau 1993). Instead, the chapter will argue that:

1. The intellectual and academic roots of geomorphology, geography, and geology are inextricably interwoven, and that it is therefore inappropriate and misleading to characterize key historical figures and events as exclusively 'geographic' or 'geologic' or to suggest that they were seminal in the evolution of geomorphology;
2. Geomorphology has evolved into an academic subdiscipline, despite its long-standing intellectual tradition, and has become practically dependent on its host disciplines (primarily geography and geology) for academic survival;
3. Geomorphology has benefited and will continue to benefit intellectually from the breadth and diversity that geography embraces and fosters;
4. Geomorphology's 'scientific' stance may be difficult to substantiate, and such posturing may not readily admit alternative perspectives of practical and intellectual utility to the discipline.

These conditions have profound implications for the future evolution of geomorphology since they lead to the conclusion that geomorphology stands to benefit from a strategy that advocates integration rather than separation. This is true with respect to both its interdisciplinary associations and its fundamental concerns with scale. The bulk of the chapter is devoted to providing the necessary background leading to this assessment.

A CARICATURE OF GEOGRAPHY

Throughout the history of geography, its practitioners have been variously perceived as very scientific, pseudoscientific, or antiscientific. The range of divergent viewpoints about geography's nature and utility are epitomized by the following quotes:

> Geography is queen of the sciences, parent to chemistry, geology, physics, and biology, parent also to history and economics. Without a clear grounding in the known characteristics of the

> earth, the physical sciences are mere game-playing, the social sciences mere ideology *(The Times,* 7 June 1990, p. 13 quoted in Unwin 1992, p. 1).

> During my recent stay in northwestern Europe I could not escape the conclusion that the position of geographers generally is not one of high esteem. I found the field criticized sharply on all sides. Most of the criticism related to a tendency for geographers to attempt research in fields they had insufficient background to enter. One critic flatly denied that geography is a field of knowledge at all, for the reason that it offers nothing unique which may be regarded as its own peculiar technique or method. He denied an appeal to cartographic expression as stoutly as he denied the proposition that all things printed in words belong to the field of literature. He claimed that our techniques are really those of the mathematician, historian, economist, demographer, geologist, engineer, or other specialist, according to the demands of the problem under consideration. He denied flatly that geographers have powers of synthesis that differ from those employed in other disciplines, or special license to stray into the domain of others. My abilities in debate were taxed severely at times (Russell 1949, p. 10-11*).*

The mystery (or ignorance) surrounding geography stems largely from within the discipline - geography has always had difficulty identifying its central concerns and its boundaries. Several authors have made the claim that 'the core of geography is the set of assumptions, concepts, models, and theories that geographers bring to their research and teaching' (Abler et al. 1992, p. 5), yet rarely do these authors provide an explicit listing of these methods and theories. In contrast, Tuan (1991, p. 101) suggests that the central theme of geography is the 'earth as home of Man', and that geographers are unified in their perspective on reality 'which is not so much a conscious program as a temperament or natural disposition' (Tuan 1991, p. 106). As realistic as these assessments may be, they are hardly tangible. As a result, geography has been identified more with its varying contemporary interests and practice than with any enduring, cohesive, and well-delineated subject matter. Whereas the geography of the postwar decades was imagined to involve exploration of exotic lands and cultures, regional syntheses, cartographic expression, and *National Geographic*, the discipline today has been described as multidisciplinary, interdisciplinary, integrative, and even schizophrenic. The recent inclusion of geography as a core subject in the *Goals 2000: Educate America Act* (Public Law 103227) coupled with the development of national geography standards (National Geographic Research and Exploration 1994) as a framework within which to achieve these educational goals may provide the nexus for alleviating much of the mystery and ignobility attached to geography.

GEOMORPHOLOGY'S ROOTS: GEOGRAPHY OR GEOLOGY?

Biased Histories of the Early Years (pre-1850)

Several geographers and geologists have asserted that geomorphology falls within the domain of geology (e.g. Sauer 1924, p. 22; Johnson 1929, p. 211; Russell 1949, p. 4; Bryan 1950, p. 198; Dury 1983, p. 92; Tinkler 1985, p. 3). If held in earnest, a myopic perspective such as this is apt to lend more significance to the role of the marble than the role of the sculptor in the production of the Venus de Milo. More often than not, such

assertions have been made in pragmatic attempts to seek expedient solutions to interdisciplinary tensions. Douglas W. Johnson, for example, suggested that,

> geomorphology itself has suffered, and will continue to suffer, from attempts to include it in the geographic realm. In the history of its development, in its methods, and in its affiliations it is a part of geology (Johnson 1929, p. 211).

However, this statement was made in the context of Johnson's 1928 presidential address to the Association of American Geographers through which he was engaging, by necessity, in a disciplinary-wide debate about the circumscription and future of an academically distinct geography. More recently, Worsley (1979) argued for the pragmatic separation of geomorphology from geography and suggested that its placement into any of several geosciences would enhance its utility to society largely because there would be access to better facilities, equipment, well-trained students, and geoscientific respectability. On intellectual grounds, such assertions are difficult to defend, and bold statements about geomorphology's detachment from geography are often followed by convoluted and hidden references to the contrary. Duty (1983, p. 92), for example, suggests that 'if geomorphology should have been located within a single discipline, that discipline should have been geology'. But, he also notes that

> the question of where geomorphology belongs ... is badly structured. Formally, it belongs where practitioners are attached for payroll purposes. Functionally, it belongs on the surface/subsurface interface (Dury 1972, p. 201).

Tinkler (1985) states quite emphatically that '... geomorphology is indisputably a part of geology ...' (p. xii), but then goes on to: (1) acknowledge the existence of institutional affiliations and academic connections between geomorphology and geography (p. xiv) and other cognate disciplines (p. 5); and (2) admit that 'processes of the atmosphere acting on the earth's surface over both the short term and the long term provide the essential catalysts that mediate the geomorphic system' (p. 5), and that an 'intimate relation exists between geomorphology and vegetation, with soil and climate as important mediating agents' (p. 5). Even William Morris Davis, while speaking before the Geological Society of America, professed that 'all geography belongs under geology, since geography is neither more nor less than the geology of today' (Davis 1912, p. 121). Davis's statement seems paradoxical unless one appreciates that: (1) Davis's intellectual allegiances to geography and geology were united; (2) geography had not yet established itself as a full-fledged academic discipline in North America; and (3) Davis's views about the nature of geographical inquiry were largely restricted to physiography but were rapidly evolving with the discipline itself (see Johnson 1929, p. 209, footnote 12). It is to these generally interrelated conditions of geography, geology, and geomorphology that I now turn my attention.

The relationship between geology and geomorphology is admittedly very intimate. During the eighteenth and nineteenth centuries, the dominant concern of geology, both as an intellectual pursuit and an academic enterprise, was understanding the character and evolution of earth's surface (Chorley et al. 1964; Davies 1969; Tinkler 1985). It is noteworthy that the term 'geomorphology' is traceable only as far back as the mid-1800s (Tinker 1985, p. 4), suggesting that there was no practical need to separate the essence of

geology from that which was geomorphology - they were one and the same. Geography, on the other hand, had not yet attained prominence as an academic discipline. Consequently, the importance and intimacy of the geography-geomorphology relationship have suffered from a historical transparency. Accounts of geography's development have tended to consider geography's geomorphological concerns, quite erroneously, as short-lived or marginal. This perspective concentrates more on geography's short academic lifespan than its long-standing intellectual traditions. The situation is further complicated by geography's wide-ranging concerns that extend beyond the earth's surface *per se* into the realm of human nature and behavior. The contemporary situation is rather different. Geomorphology has become a central specialization in academic geography, whereas marginalization of geomorphology and geomorphologists on the part of some mainstream geologists is not uncommon. Even as early as 1958, the retiring President of the Geological Society of America observed that 'Quaternary studies [geomorphology] gradually lost an aura of respectability which is attached to "hard-rock" geology' (Russell 1958, p. 1).

Geography recognizes its beginnings in the writings and speculations of the ancient Greeks such as Homer, Thales, Anaximander, Hecataeus, Herodotus, Plato, Aristotle, Alexander the Great, Pytheas, Eratosthenes, and Ptolemy (James and Martin 1981). Early geographical ideas were largely physical-geographic, if not geomorphologic, and they survive because Strabo's writings on geography were found intact. Strabo described the role of the geographer as explaining 'our inhabitated world - its size, shape, and character, and its relations to the earth as a whole' (quoted in James and Martin 1981, p. 36 from a translation by Jones 1917, pp. 429-43 1). This perspective of earth as consisting of two domains - the habitable and the uninhabitable - can be traced to Strabo's predecessors, Aristotle and Eratosthenes. Aristotle had been concerned with the *ekumene* or inhabited part of the earth (James and Martin 1981, p. 28) which he associated with the temperate zones in the Mediterranean region. Habitability, he suggested, decreased with latitudinal distance toward the equator and toward the poles. Such speculation accorded well with observation, and the remaining task was to explore the reasons for these associations. This laid the foundation for Eratosthenes to coin the term 'geography' and establish its *raison d'etre* as the study of earth as the home of man (James and Martin 1981, p. 31). This theme has been retained in varying form and degree through to the present, and Aristotle's concept of the *ekumene* eerily foreshadowed the paradigms of geographical influence and environmental determinism in geography and other related sciences at the turn of the twentieth century. The focus on earth's surface as the object of study by the Greeks is at the same time geographical and geological, and there is little evidence to suggest that these early philosophers contemplated humans as anything more than passive elements on the landscape. Humans as agents of environmental change is a theme not espoused until much later, first by Georges Louis Leclerc, Comte de Buffon in the late 1700s, and then by many geographers in the late 1800s. Geographers ultimately championed this paradigm in the 1950s (e.g. Thomas 1956), and it remains a central concern in most earth sciences and social sciences.

Up until the mid-1800s, most scholars had interdisciplinary backgrounds and concerns - they were naturalists, scientists, and philosophers. Several individuals during this classical period could claim mastery of the sum of accumulated scientific and philosophical knowledge, and it would be inappropriate in most cases to attach a single

contemporary disciplinary label to them. The storehouse of knowledge had been growing exponentially, however, and disciplinary specialization became inevitable. It is at this phase of transition from a generalized to a specialized academy (roughly from the late 1700s to the mid-1800s) that most modern accounts of the foundational bases of geomorphology, geography, and geology search for their ancestry. Geographers identify individuals such as Immanuel Kant (1724-1804), Alexander von Humboldt (1769-1859), Carl Ritter (1779-1859), Arnold Guyot (1807-1884), George Perkins Marsh (1801-1882), Daniel Coit Gilman (1831-1908), Ferdinand von Richthofen (1833-1905), and Friedrich Ratzel (1844-1904), among many others, as academic forefathers. Geologists, on the other hand, are more likely to point to James Hutton (1726-1797), John Playfair (1747-1819), Charles Lyell (1797-1875), James Dwight Dana (1813-1895), John Wesley Powell (1834-1902), Clarence E. Dutton (1841-1912), and George M. Wheeler (1842-1905) as foundational figures. Are these reasonable and illuminating choices, and why is there little overlap between the lists?

Not surprisingly, such foreshortened retrospective searches for disciplinary roots end up pointing to only a select few that differ depending on disciplinary orthodoxies. This phenomenon has been recognized elsewhere and has been called the Whig interpretation of history (e.g. Livingstone 1984, p. 271), a process by which disciplinary historians judge the merits of affiliation with certain widely recognized scholars according to the contributions they are believed to have made toward establishing modern theories or paradigms (e.g. Brush 1974, p. 1169). Such retrospective reconstructions of academic lineages 'extend from personal viewpoint and experience to selection of material, the time dependence of ideas, the scientific context at a particular time, and the temptation to suggest that consensus of opinion exists where this may not indeed have been the case' (Gregory 1985, p. 2). An inherent danger to Whig historiography is that it 'looks at the past in terms of present ideas and values, rather than trying to understand the complete context of problems and preconceptions with which the earlier scientist himself had to work' (Brush 1974, p. 1169). It searches for a seed when no such beginning may realistically exist. Most 'founding fathers' are usually little more than symbolic figureheads because, in most cases, they founded neither the contemporary academic structures (e.g. departments, institutions, societies) nor the intellectual heritage of the discipline. Disciplinary histories and heroes so created can be very influential because the superficial logic is easy to grasp and because they are often the perceived essence and legitimation of a discipline or a disciplinary paradigm (see Tinkler 1985, pp. 229-230 or Sack 1992, pp. 258-259 for views about the shift from a 'Davisian' to a process-oriented school of thought; or Davies 1989, pp. 7-10 for a broader geomorphological perspective). These perceived essences, rightly or wrongly, appear to have direct bearing on the future evolution of a discipline (cf. Sherman, Chapter 4 this volume).

An equally viable, if not more realistic, interpretation of disciplinary histories would recognize a common intellectual heritage, much like branches sprouting from the trunk of a tree that is supported by a diffuse root system representing the distant, less visible past. In this way, geographers, geologists, and geomorphologists alike ought to be able to trace their academic branches to Greek roots through a common trunk that spans the post-Renaissance era. However, contemporary academic ties to these distant figures are rather loose, and the notion of a common academic heritage does not sit comfortably with some disciplinary stalwarts. Thus, it is difficult for geographers to look past von Humboldt, or

for geologists to see beyond Hutton, into the seventeenth century to discover a common ancestry in scholars such as Nathaneal Carpenter, Bernhard Varenius, Thomas Burnet, John Woodward, Abraham Gottlob Werner, and Horace de Saussure. These individuals, apparently, do not conform neatly with contemporary images of disciplinary practitioners and paradigms - many of their ideas and beliefs seem simplistic if not foolish by today's standards, and history seems to judge them with prejudice (see discussion by Tinkler 1985, pp. 9-12). Physical and human geographers in particular would have difficulty reaching consensus about which of these seventeenth-century scholars was the most geographic. This is, of course, a direct outcome of our Whig interpretation of history (a forward-looking perspective that recognizes that geography and geology did not exist as formal academic disciplines prior to the 1700s avoids this difficulty), but it has obvious implications for the perceived transparency of the historical link between geography and geomorphology

Turn-of-the-century Developments

The modern period, beginning in the mid-1800s, was an era of increasing academic specialization and professionalization. Geology departments were already widely established by this time - John Woodward (1665- 1728) had endowed and named a chair of geology at Cambridge over one century before (Tinkler 1985, p. 38). But full-fledged departments of geography did not come into existence until the 1870s in Europe and until the turn of the century in North America (James and Martin 1978, p. 3). The relative timing was important to North American geomorphology for three reasons. First, established geographical scholars specializing in geomorphological subject matter had little choice but to affiliate themselves professionally with geology departments. Second, students of geography seeking advanced degrees in North America had similarly few options, and were restricted to geology departments for formal education. In both cases, physical geographers were received openly, collegially, and as peers by their geological colleagues. Third, the academic discipline of geology, which had predominant concerns for the character and evolution of the earth's surface until the 1850s, was fragmenting into specialty areas, such as mining, structural mapping, mineralogy, petrology, paleontology, seismology, and geophysics. These areas of study were gaining increasing prominence in the late 1800s and were beginning to dominate as subdisciplines. As Tinkler (1985, p. 4) describes it,

> **...** geology as a subject exploded in much the same way as, for example, biochemistry has exploded in this century. The explosion left geomorphology as a small part of a vast subject and with its emphasis on, or towards, the present it tended to lose touch with a parent subject so committed to exploring the past and unveiling the origin of the earth.

These three conditions were particularly important to geomorphology because they forced an integration of geological and geographical thought. Into the academic world of geology, stepped several scholars (including Guyot, Agassiz, Gilman, and Davis) who had received formal training in European schools where the intellectual development of geography was considerably advanced over its North American counterpart. In this way, German (as well as French and British) ideas about a 'new geography' were introduced

into geomorphological thinking in geology. This 'new geography' favored inductive methods based on empirical observations over theoretical deduction, sought interpretations and explanations rather than mere descriptions, and was intensely interested in the interaction of humans with their natural environments. For a brief time (loosely, 1880 to 1910) the geomorphological branches of geography and geology grew together - that is, the substance, method, and theory of geography, as they pertain to geomorphology, were those of geology as well.

Harvard was the first North American university to offer specialized training in physical geography (physiography) within a geology department. The key geographer-geologists at Harvard were Nathaniel Southgate Shaler, who was a student of Louis Agassiz (Agassiz was educated in Switzerland, taught at Harvard as a zoologist, and is noted by geomorphologists for his glacial theories), and William Morris Davis (an 'understudy' of Shaler and frequent visitor to Europe). This is not to say that North American geography relied solely on geology for intellectual stimulation. Indeed, it retained specializations and developed subdisciplinary interests outside of the geomorphological realm. At the Wharton School of Finance and Commerce (University of Pennsylvania), Emory R. Johnson, J. Paul Goode, and J. Russell Smith offered advanced education in economic and transportation geography at the turn of the century. Yale University also had a geographic tradition that extended back to 1786 with the appointment of Jedidiah Morse. Geographic instruction at Yale during the latter part of the nineteenth century focused more on ontographical subject matter, and courses were offered by Daniel Coit Gilman, William H. Brewer, Francis A. Walker, and Herbert E. Gregory. Nevertheless, there was relatively little communication between these three groups, and as far as geomorphology (physiography) was concerned, the geological-geographical union at Harvard and elsewhere was natural and unquestioned.

The activities and contributions of the key geomorphological figures at the turn of this century are good indicators of how intimate the linkage between academic geography and academic geology was in the realm of geomorphological subject matter. It is widely acknowledged that John Wesley Powell (1834-1902), Grove Karl Gilbert (1843-1918), and William Morris Davis (1850-1934) played pivotal roles in the development of North American geomorphology. Powell and Gilbert, in particular, are often pointed to as epitomizations of the geological practitioner of geomorphology (e.g. Baker and Pyne 1978) whereas geographers, in retort, claim Davis as their geomorphological champion:

> For American geological geomorphologists, the most important scientific trinity was not structure, process, and stage, emerging from the heuristic synthesis of a Harvard scholar. Rather the critical trinity was Gilbert, Powell, and Dutton ... (Baker 1988, p. 1157).

Such antithetical caricatures are, of course, a variation of the 'Championship of the Disciplines' and it is important to recognize they are not easily substantiated, nor even historically accurate (cf. Sack 1991, 1992).

William Morris Davis was indeed very much a geographer. He was the primary influence behind organization of the Association of the American Geographers (AAG), he presided over the first meeting of the AAG in Philadelphia in December of 1904, was twice the elected President of the AAG (1905, 1909), he authored *The Geographical* Cycle (Davis 1899) and several other essays on geographical research and teaching, and

he was a professor of physical geography who was devoted to geographical perspectives in his teachings and his research. But, he also had a classic scientific and engineering training, worked briefly for a coal mining company, was employed as a summer field geologist by the United States Geological Survey, taught in a geology department, and served as President of the Geological Society of America (GSA). Gilbert, in contrast, was employed as a geologist throughout his professional life, wrote several geological monographs whilst employed by the United States Geological Survey, is revered for his conception and application of the scientific method, and was founding member and twice GSA President. Nevertheless, he was also a founding member of the National Geographic Society, acting President of the National Geographic Society (1904), a founding member and President of the AAG (1908), and considered himself to be a geographer as well as a geologist (Sack 1992, p. 252). Further, he coauthored physical geography textbooks with Albert Perry Brigham, one of Davis's earliest and most influential graduate students. Similarly, John Wesley Powell is best known for his explorations of the canyons of the Green and Colorado rivers under the auspices of the early Geographical, Topographical, and Geological Surveys, and he served as Director of the United States Geological Survey. Yet, he too was a founding member of the National Geographic Society and published extensively on geographical topics including several reports on Indian cultures, changing settlement patterns in the and lands, and physiographic provinces of the United States. Powell even asserted that 'Sound geological research is based on geography. Without a good topographic map geology cannot even be thoroughly studied ...' (Powell 1885, quoted in James and Martin 1978, p. 5). James and Martin (1981, p. 160) contend that Powell might have made considerably more contributions to geographical scholarship had he not encountered official resistance to his work from people in positions of political and financial power intent on selling and developing land 'sight unseen' in the arid west.

One could play the game of ascribing relative merit to the many accomplishments of Davis, Gilbert, and Powell, and then tallying the scorecard to see which side of the geography-geology line they fall. This serves little purpose and belittles the profound contributions that these individuals have made to both disciplines. Indeed, many of their secondary and tertiary contributions have had far greater impact on these disciplines than most researchers' primary contributions. After all, we do not refer to Leonardo da Vinci as just a painter.

The intertwined nature of the disciplinary roots of geomorphology in geography and geology are most apparent in the early histories of the professional societies formed at the beginning of the twentieth century. The birth of the AAG in 1904 is especially revealing. Davis was eager to form an organization such as the AAG because he recognized that American geography could not come of age until a professional society existed in which true geographical scholarship was the main criterion for membership. Although other organizations such as the American Geographical Society and the National Geographic Society were already well established, they catered mostly to philanthropists, explorers, and geographically inclined aristocrats. There was as yet no forum through which academic geographers could speak to each other and to geographically informed audiences about scholarship at the forefront of the discipline. The AAG was to serve this purpose. If one looks at the characteristics of the original 48 members, however, one finds that 19 held positions as geologists, and 15 of these were Davis's past students. In fact, the membership criteria were so heavily skewed that admission in the first year was denied to

J. Russell Smith (a student of Ratzel at Munich, assistant to Emory R. Johnson at the Wharton School, and an economic-transportation geographer by contemporary standards) on the grounds that Smith had not been adequately trained in physical geography (James and Martin 1978, p. 36)!

Despite Davis's best intentions to provide opportunities for scholars with varied academic training to participate and interact within the structure of the AAG, the initial years maintained a strong physical-geographic, if not geologic, presence. Of the 22 papers presented at the first annual meeting in 1904, 13 were on topics that could be considered to be physical geography and an additional 4 on biogeography. In 1908, H.E. Gregory, Chair of the Geology Department at Yale, expressed his concern about the large proportion of geologists in the fledgling society:

> ... I am becoming exercised over the fact that each year the official staff of the Association consists chiefly of men who, to my mind, are geographers only by a stretch of that term . . .. If the organization is large, I see no reason why geologists with geographical leanings would not be enrolled as members; but I think that only rarely should they occupy positions as officers ...
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> ... And would it not be wise for me and Fenneman and certain others who are pretty clearly geologists to resign from this organization, so as to make the cleavage between geology and geography even more distinct? (Gregory letter to Brigham 1912, quoted in James and Martin 1978, p. 47, cit. 7).

It is not unreasonable to conclude, then, that from a historical perspective, geomorphology's roots were, at the same time, geographical and geological. Distinguishing the contributions of geography from those of geology is an artificial and meaningless exercise because:

1. Contemporary disciplinary definitions and demarcations do not apply to past eras;
2. Geography did not exist as a separate academic discipline until the late nineteenth century;
3. Geology was the only academic discipline that had geomorphological concerns and it was dominated by them; and yet,
4. A strong intellectual geographic tradition is recognizable and traceable through academic geology from about the turn of the twentieth century back to the early Greeks.

GEOMORPHOLOGICAL GROWING PAINS

Academic Geography Comes of Age

Geography's intellectual and practical contributions to geomorphology during the twentieth century are commonly perceived as weak. In part, this condition can be ascribed to geology holding a privileged academic position over geography among the scientific disciplines. As noted in the previous section, geology evolved at a time when knowledge was expanding and disciplinary boundaries arose naturally - these boundaries were flexible, translucent, and ill defined. Geography, on the other hand, evolved during a period of academic specialization and interdisciplinary competition in which disciplinary boundaries were contemplated consciously and defended vigorously. Debates about the

nature and purpose of new disciplines relative to their established peers observed an unspoken formalism, not unlike the unquestioned authority of parental roles within a familial structure. The roles of rival siblings however, require definition and redefinition as the members age and the family evolves. In this way, the status and subject matter of geology have not received scrutiny to the same degree as those of geography, neither from within nor without. Johnson, in the early part of this century, noted that

> ... geology, and certain other sciences took their rise in a day when knowledge was more limited, methods were more crude, and standards were lower. Their youthful errors were less harshly judged by less competent critics than exist today. Geography suffers the penalty of late development in the midst of sciences already advanced to maturity, and in the presence of experienced judges admirably documented in a variety of related fields. Assuredly the test is a severe one, and we must expect for a time to suffer in comparison with our elder associates. But we need not be unduly anxious in respect to this particular difficulty. Youth is a disease which cures itself (Johnson 1929, p. 205).

In the first decades of the twentieth century, geography began to assert itself as a true academic discipline with established university departments and several geographical societies. North American departments of geography were graduating substantial numbers of Ph.D.s, and this provided a new membership pool for the AAG. The physiographic tradition was beginning to be usurped by ontographic concerns, and geologists and physiographers became the minority by the 1920s. This was, at once, an exhilarating and frustrating stage in the evolution of geography - the future direction of the discipline was not at all clear, but the possibilities were manifold. The age of specialization had allowed other disciplines, especially those in the physical and biological sciences, to flourish through a research strategy that purposefully isolated processes under study from the complicated interactions inherent to natural systems. These complexities, however, are the essence of geography. It is not surprising, then, that there was great confusion and uncertainty within the discipline. The search for the answer to 'What is geography?' was leading geographers down many different paths. Nevertheless, they had one common bond in their widespread rejection of things geological. It was recognized by all that academic separation from geology was necessary so that the fledgling discipline could assert itself on its own terms. Even as late as 1939, Hartshorne (1939, p. 29) in his clarion call for a 'regional geography', felt it necessary to reassert that 'Geography is not an infant subject, born out of the womb of American geology a few decades ago, which each new generation of American students may change around at will.'

The need to demarcate geography from geology required a new definition for the discipline, one that established its core and its bounds, and incorporated humans as something more than a casual afterthought. Debate focused not so much on whether humans were to be central to the newly evolving and vulnerable discipline, but in what way humans were to form the nexus for study relative to their environmental platform (James and Martin 1978, p. 51). Some scholars even argued that to make the separation of geography from geology complete, it was necessary to reject intellectually the physical grounding of geography on earth's surface and not to 'cling to the peripheral specialisms to which reference has been made - to physiography, climatology, plant ecology, and animal ecology - but . . . relinquish them gladly to geology, meteorology, botany, and

zoology, or to careers as independent sciences' (Barrows 1923, p. 4). Such debates about the true (and desired) nature and substance of geography were not always articulate nor assertive (consider, for example, the ineffectiveness of the arguments put forth to avert the elimination of geography at Harvard as described by Smith 1987), but they obviously were necessary. There was some reluctance on the part of the majority of academic geographers to disown geomorphology completely because earth's physical surface was recognized as an essential component of geographical processes. Nevertheless, in the wake of widespread rejection of 'environmental determinism' and 'geographical influences' (e.g. Brigham 1903; Semple 1911), there was negative reaction to the historically privileged position of geomorphology and there was reluctance to admit it to positions of academic and intellectual power within geography. Further, the expansionist era associated with the American frontier and European colonization was coming to a close, and the new explorations were into social rather than physical spaces (Smith 1987, p. 168). Geomorphology was ignored, much like a child left to self-amusement in the midst of parental disputes about family finances. This was not unfamiliar territory for geomorphology - several decades earlier, geologists had 'left [geomorphology] behind, like a hapless rural milkmaid at the pit head, as the miner climbed below' (Tinkler 1985, p. 80). To compound matters, there was a distinct absence of charismatic leaders with novel approaches to the subject, or at least, a reluctance to embrace such figures and their ideas professionally. As a consequence, North American geomorphology faded into the academic background of both geography and geology (Dury 1983). Most geomorphologists retained a Davisian outlook and were silently searching for evolutionary order in the ever-increasing stock of concordant surfaces, denudation chronologies, climatic anomalies, and variants thereof. Exceptions, of course, are many and have been remarked upon extensively (e.g. Tinkler 1985; Chorley et al. 1973; Beckinsale and Chorley 1991; Yatsu 1992). Human geographers, on the other hand, were engaged in heated and protracted debates about how to interface more closely with the social sciences and the humanities and about what constitutes appropriate geographical subject matter, methods, and theories. Geographers participated in (and defended fervently) three types of activities through the war decades:

1. They returned to their traditional roles involving the sterile, but careful and elaborate, collection, classification, and cartographic representation of worldly data especially pertaining to those places not yet explored.
2. They embarked on holistic studies of particular places as unique and interesting entities.
3. They engaged in generalizing and theorizing about earth-surface processes with the goal of formulating widely applicable laws to recurring events.

Ensconced in these debates were hidden tensions regarding spatial versus temporal studies, idiographic versus nomothetic objectives, scientific versus humanistic methods, and the role of humans as passive versus active agents of change. At various times, then, geographers adopted concerns for human ecology (e.g. Barrows 1923), chorology (e.g. Sauer 1924, 1925), regionalism (e.g. Hartshorne 1939; Finch 1939), historical geography (e.g. Brown 1948; Sauer 1941), geomorphography (Kesseli 1946), antiexceptionalism (e.g. Schaefer 1953), and applied geography (Ackerman 1945).

Ultimately, geography followed the trend of most other earth and social sciences during the 1960s and 1970s and entered into an era dominated by quantification. An unflattering assessment of this trend suggests that it was fueled by a desire to 'look more scientific'. Geographers quickly discovered, however, that a 'scientific geography' was not what everyone thought the discipline should be, and it has since entered into an age of diversity that advocates exploring alternative, if not unusual or radical, approaches to understanding the world (cf. Dear 1988). Some have caricatured it as the age of 'isms' and examples include positivism, humanism, realism, possibilism, feminism, existentialism, scientism, relativism, idealism, materialism, structuralism, and of course, postmodernism.

Finding an Academic Home

What happened to geomorphology in the meantime? The hiatus in geomorphological activity during the war decades facilitated a certain intellectual separation from the past, especially from the geomorphology of Davis (Tinkler 1985, p. 198). New geographical domains were being explored and this led to advances in coastal, karst, aeolian, tropical, periglacial, glacial, island, tectonic, climatic, and soils geomorphology. Intellectually, geomorphology was about to benefit immensely from stimuli derived from innovations external to both geology and geography (e.g. Dury 1983). In addition, geomorphology, which had been neglected, if not orphaned, by geography during the war years, was about to be readopted by geology. Unfortunately, this readoption was more in spirit than in devotion, and it is ironic that it arose as a by-product of geography's continuing debates about degree of attachment to earth's physical landscapes. The strengthening of the academic linkages between geomorphology and geology in North America was therefore not a renaissance in the sense that practicing geologists were reinvigorated with geomorphological spirit. Rather, it was the outcome of the public posturing of two widely respected earth scientists: Richard J. Russell and Kirk Bryan.

Russell and Bryan served as presidents of both the AAG and GSA, positions of considerable authority and influence. In their presidential addresses to the AAG in 1948 and 1949, respectively, both men remarked on the growing interest in geomorphology that was taking place outside of geography (Russell 1949; Bryan 1950). Bryan (1950, p. 197) suggested that the 'revival would warm the heart of Davis and would also yield him many misgivings ... [because] ... there is among the geographers much indifference and even a modicum of hostility'. More importantly, both Russell and Bryan made emphatic claims about geomorphology having its historical roots and intellectual/academic home in geology - the bulk of their addresses were concerned with how geomorphology might provide better service to the geographer. In Russell's subsequent presidential address to the Geological Society of America (Russell 1958), he even went so far as to imply that physiographers following Davis's tradition (meaning 'physical geographers') hampered the development of geomorphology because they lacked the requisite training in geophysics and geology (Russell 1958, p. 2). He then offered a prescription for how geomorphological - geologists might improve on this lamentable condition. Russell and Bryan admitted that there was (or could be) a close relationship between geography and geomorphology, but their vision clearly had geography on the receiving end of geomorphological inquiry - the former had little to contribute to the latter.

In retrospect, it seems that these two presidential addresses, although altruistic in intent, did much violence to the image of the geographer-geomorphologist. The perceived weakness of the historical linkages between geography and geomorphology became officially entrenched in the literature through their musings. Fortunately, some of the more significant advances in twentieth century geomorphological thought were coming not from retrospective introspection about the prescribed subject matter of geography or geology, but from sources that were completely unaware of or impartial to such inter- and intra-disciplinary reconditioning. Strahler (1950, 1952) is to be acknowledged for warning the geomorphological community that much of the relevant and substantive research on erosional and dynamical systems was being conducted by engineers, and that '... few geologists seem aware of this progress and there has been little evidence of geomorphologists adapting the information and methods to landform research' (Strahler 1950, p. 211). Useful innovations were coming not only from engineering, but also from hydraulics, biological systems, hydrology, thermodynamics, and statistical mathematics. The course of developments since the 1950s should be familiar to most geomorphologists, and it includes phrases and concepts such as tectonic and isostatic uplift, timebound and timeless models, reductionism, morphometric analysis, mechanics and dynamics, hydraulic geometry, magnitude and frequency, systems theory, allometry, equifinality, entropy, indeterminacy, equilibrium and thresholds, characteristic forms, process-response suites, and numerical modeling. It is also appropriate to acknowledge the advanced and insightful works of researchers such as O'Brien, Hjulstrom, Rubey, Shields, Bagnold, Leighly, Sundborg, and Yatsu who were somewhat peripheral to the mainstream of geomorphology of their time. Bagnold, for example, is now widely acknowledged for his exploration of the North African deserts and for his many contributions to our understanding of the nature of aeolian dune systems and the mechanics of sediment transport. His academic contributions span a period of almost six decades, beginning with the publication of many seminal works in the 1930s and 1940s, after having retired from a distinguished army career! The Royal Geographical Society of London awarded him the Gold Medal in 1934, the US Academy of Sciences awarded him the G. K. Warren Prize in 1969, whereas the Geological Society of America waited until 1970 to honor him with its Penrose Medal. These awards were followed by the Wollaston Medal from the Geological Society of London in 1971 and the Sorby Medal from the International Association of Sedimentologists in 1978. The geomorphological community, on the other hand, failed to recognize Bagnold's achievements officially until 1981, at which time he was awarded the David Linton Award from the British Geomorphological Research Group.

The evolution of geomorphology during this period was affected not only by intradisciplinary debates within geography and geology, but also by social, political, and economic climates - that is, the 'internal' and 'external' histories (e.g. Livingstone 1984, p. 27 1; Yatsu 1992, p. 94). The latter tend to facilitate or hamper developments in certain disciplines both directly and indirectly. The opportunities afforded geology by the boom in petroleum and mineral exploration in the 1960s and 1970s, for example, eventually steered geological interests away from geomorphological subject matter. In a 1971 survey of geomorphological offerings in North American geology departments, White and Malcolm (1972, p. 146) warned that

> ... the number of departments having dropped or still having not offered geomorphology is surprising. This eventually may prove to be ill-timed, not only for geology as a science but also for man on this planet.

Geography, by contrast, was at this time concerned with its scientific image and became infatuated with quantitative and statistical enumeration. It availed itself easily of geomorphological research, especially the quantitative aspects of hydraulic geometry, morphometry, hypsometry, network analysis, and general systems. A minority of geographers even went so far as to suggest that the description and classification of landscape attributes in precise and nongenetic ways ought to be the primary activity of geomorphologists in geography departments, thereby arguing for a distinctive and mutually exclusive division of geomorphic labor between geography and geology (e.g. Zakrzewska 1967, 1971). Most physical geographers, fortunately, were dissatisfied with such sterile descriptive treatments of the earth's surface and were becoming more concerned with Man-land [sic] interactions and with the internal adjustments and dynamics of physical systems (e.g. Chorley 1962). In this way, the transition to a process paradigm in geomorphology seems to have been facilitated, if not encouraged, by a close association with geography (cf. Robinson 1963; Dury 1983).

It is interesting to note that claims to specific geomorphological heritages within geography or geology have invariably led to contradictory or paradoxical associations in the historical evolution of geomorphic thought. Geomorphological research by geographers is often characterized as being quantitative and process-oriented (e.g. Baker 1988; Baker and Twidale 1991). Yet, the roots of the process paradigm are claimed to be geological and are usually traced along a branch that comprises the activities of various United States Geological Survey employees such as Wolman, Langbein, and Leopold, and ultimately Gilbert using a 50-year graft. In contrast, the strong claim that many Quaternary geologists often make to a historical-genetic perspective or method in their geomorphological research (e.g. Baker and Twidale 1991) 'found its most eloquent expression in the writings of a geographer, William Morris Davis' (Baker 1988, p. 1158). These are somewhat inaccurate and inconsistent portrayals of contemporary thought in these disciplines.

CONTEMPORARY GEOMORPHOLOGY: A TAIL ON THE GEOGRAPHICAL DOG?

Although the intellectual and academic roots of geomorphology are difficult to disentangle, it must be acknowledged that the academic disciplines of geography and geology, by centering themselves over specific intellectual terrain and by setting bounds on their domains, have had a pronounced influence on what geomorphology has become. What it has become is a subdiscipline. James and Martin (1978, p. 7) suggest that four conditions need to be created before a field of learning (i.e. an intellectual discipline) is able to assert itself as a learned profession (i.e. an academic discipline):

1. Interaction of a significant number of scholars with an accepted body of concepts, images, and rules of professional behavior;

2. Establishment of university departments offering advanced (graduate) training in concepts and methods;
3. Creation of opportunities for qualified scholars to find paid employment in their areas of expertise;
4. Establishment of an organization or professional society to serve the interests of the profession and to provide focus for professional activities.

The academic discipline, therefore, encompasses both the subject matter that constitutes the basis for disciplinary inquiry and the formal and informal structures that facilitate and perpetuate that inquiry in academe.

As we have seen, scholars throughout history have speculated about and discussed earth's dynamic surface - the intellectual discipline boasts a long and noble tradition. Employment opportunities for geomorphologists seem to be adequate, if not plentiful. Geomorphologically oriented venues for scholarly exchange and professional interaction have arisen recently, and they include the British Geomorphological Research Group, Guelph Biannual Symposia, Binghamton Annual Symposia, Quaternary Geology and Geomorphology Division of the GSA, Geomorphology Specialty Group of the AAG, American Geomorphological Field Group, Friends of the Pleistocene, International Conference on Geomorphology Series, Catalina Island Workshop Series, and the Canadian Geomorphology Research Group. Nevertheless, geomorphology has not yet demonstrated the centrality, utility, popularity, or novelty that might warrant the widespread establishment of independent academic departments focusing exclusively on geomorphological subject matter, notable exceptions such as the Department of Biogeography and Geomorphology at the Australian National University aside. Geomorphology is not presently a viable academic discipline, and it remains dependent on host disciplines for academic survival.

In this context, terms such as 'geographical geomorphology' and 'geological geomorphology' seem astigmatic and inappropriate because they have the 'tail wagging the dog'. They invert the primacy of the host disciplines' role relative to that of the geomorphological subdiscipline. Further, they ignore the claims that other host disciplines, such as geophysics, oceanography, or engineering, might advance for a specialization in geomorphology - there are potentially many dogs, all with geomorphological tails. And most importantly, terms such as these are inaccurate and potentially damaging because of their implicit association of method or theory with the host discipline. 'Geographical geomorphology' and 'geological geomorphology' imply that it is accurate, indeed reasonable, to portray geography and geology as having only singular, intrinsic methodologies, and by logical necessity, unique and unifying philosophies. As we have seen, these are grossly oversimplified caricatures of geographic and geologic inquiry that serve an injustice on their practitioners, past and present. Terms such as 'geomorphological geography', 'geomorphological geology' (the latter term is credited to Powell by McGee; see Tinkler 1985, p. 4), or 'geographer-geomorphologist' (following the syntax of Robinson 1963, p. 16; Baker 1988, p. 1158; Butzer 1989, p. 48; Johnson 1929, p. 209) are more appropriate, although they seem awkward and perhaps unnecessary in the contemporary academic environment (see Campbell 1928, for views on the importance of logical terminology).

If we acknowledge geomorphology's position as an academic subdiscipline, we must also realize that neither the geomorphological tail nor the disciplinary dogs are particularly

large relative to other tails and dogs. Surveys of the status of geomorphology within geography, conducted in the 1980s (Graf et al. 1980; Graf 1984; Costa and Graf 1984; Marston 1989), showed that geomorphologists accounted for only 4.3% (283 members in 1983) of the total AAG membership and 9% (1140 members in 1981) of the total GSA membership, with many of the latter considering themselves to be Quaternary geologists rather than geomorphologists. Recent figures (Graf, personal communication) show that the total number of North American geomorphologists has increased overall, with the relative percentage in the AAG increasing to 6.7% (473 members in 1994), while the relative percentage in the GSA has decreased to 7.5% (1255 members in 1994). These changes are consistent with trends identified in the early 1980s which suggest that geomorphology is increasing in relative importance in geography, but decreasing in relative importance in geology (e.g. White 1982; Costa and Graf 1984). A survey of 17 journals likely to publish articles on geomorphological subject matter (covering the period 1976-86 and listed in the *Science Citation Index* and *Social Science Index)* showed that slightly more than 50% of the contributions were from geographers even though geomorphological-geographers only account for about 22% of the geomorphological community (Marston, 1989). More importantly, only 20% of the articles published in these journals were on geomorphological subject matter, suggesting that our geomorphological 'bark' is rather muted.

Concerns about the status and importance of one's subdiscipline among recognized academic disciplines are, of course, not unique to geomorphology. Klemes (1986, p. 177S) laments the

> unsatisfactory state of hydrology [which] is, in the final analysis, the result of the dichotomy between the theoretical recognition of hydrology as a science in its own right and the practical impossibility of studying it as a primary discipline but only as an appendage of hydraulic engineering, geography, geology, etc. As a consequence, the perspectives of hydrologists tend to be heavily biased in the direction of their nonhydrologic primary disciplines and their hydrologic backgrounds have wide gaps which breed a large variety of misconceptions . . . with consequent dangers both to scientific development of hydrology and to its practical utility.

Klemes goes on to present a convincing case for the establishment of separate university departments or units of hydrology. Eagleson (1991) similarly argues for recognition of the hydrological sciences as a distinct geoscience. Echoes of such sentiments are often heard within the geomorphological community. Perhaps the recent discussions about the creation of an American geomorphological society or group (much akin to the British and Canadian examples) to which geographers and geologists alike could pledge allegiance are a first step toward such a separate academic identity for geomorphology. Nevertheless, there may be lessons to be heeded from the hydrology example. Little progress has been achieved in establishing a distinct academic identity partly because of widespread dissension among the ranks of hydrologists who prefer affiliation with their host disciplines (Klemes 1986, p. 177S).

WHERE'S THE SCIENCE?

Geomorphology's status as a subdiscipline forces it to carry the same public personae as its hosts. That geology is a science is not ordinarily open to debate. That geography is a

science seems less certain, especially in the contemporary academic climate. In the eyes of the public, geology is a science and geography is about maps, capital cities, and longest rivers. In the eyes of the physicist or chemist, geology is a 'soft' science and geography is about maps, capital cities, and longest rivers. In the eyes of the economist or sociologist, geology is a 'hard' science and geography is sometimes useful. In the eyes of the artist, geology and geography are fascinating. Most geologists, in contrast, consider themselves to be fundamentally scientific. Most geographers also consider themselves to be scientific, although some choose to differentiate between natural and social science, whereas others reject science and all that it stands for. Are all these views accurate, and what are the implications for geomorphology?

Most geomorphologists believe that geomorphology is a science. The title of this symposium presumes this very stance, and Rhoads and Thorn (1993) offer an informative framework within which to examine its rationality. Nevertheless, the difficult work of arguing geomorphology's status as a scientific discipline remains to be done. I doubt whether many geomorphologists have actually contemplated their research within the framework of a scientific method or even interrogated their implicit claims to being scientific. Fortunately, just 'appearing scientific' can be advantageous because the existing intellectual and social structure of academe rewards this position with respectability. Adopting a scientific stance is a matter of convention rather than conscious choice in most disciplines, and it may not reflect actual practice.

Prescriptions for scientific practice have been examined in detail by many philosophers including Kuhn, Popper, Feyerabend, Bhaskar, Lakatos, and Chalmers, and I do not wish to engage these complicated debates further. The reader is referred to Haines-Young and Petch (1986) and Rhoads and Thorn (1994) for cogent summaries of philosophical debates as they relate to geomorphology and physical geography. It is fair to say, however, that out of these debates comes one conclusion: it is extraordinarily difficult to come up with a definition of science that is, at the same time, mutually agreeable to all scientists, exclusionary of nonscientific endeavors, prescriptive of the practice of science, *and* a realistic portrayal of the history of scientific investigation in all disciplines. An example will serve the point well. Several years ago, while arguing the case for inclusion of an introductory physical geography course within the curriculum of the 'Natural World' subcategory of the General Education program, I found myself defending against repeated attacks against a few of the laboratory exercises on the grounds that they were not sufficiently scientific. I questioned the criteria on which these judgments were being made, but none of the panelists were able to provide an informative response. Their weak criticism was that these geography exercises had no 'hands-on' component that required students to be in a laboratory setting using scientific instruments. Despite the absence of articulated criteria defining a laboratory exercise, they held firm to their belief that it was generally understood what constitutes a scientific laboratory exercise and that they could easily pass judgment. Among the examples they offered was the 'classic' biology experiment of frog dissection. This intrigued me, and I asked them how it was that cutting open a frog and looking inside its belly constituted a scientific experiment as opposed to simple observation. Where was the theory? What was the hypothesis? What was being tested? How were the results evaluated critically? And if such dissection constituted science, how was it different from a geographer or geologist examining a topographic map or stereoscopic air-photo pair and taking measurements of terrain attributes? They finally

conceded, somewhat reluctantly, that the frog dissection experiment required elaboration and that map analysis might be interpreted as scientific in the same vein as measuring the size, mass, and relative positioning of the internal organs of the frog. What struck me the most about this exchange, however, was that these truly well-respected, 'hard-core' scientists had never contemplated what the scientific enterprise was about. They were basing their judgments of curricular materials on preconceived notions and grade-school definitions of science rather than a full appreciation for the underlying principles guiding their day-to-day practice. They were hiding beneath the cloak of scientific hegemony and had no awareness of it.

After these meetings, it occurred to me that my training and employment as a geographer had served me well. Contemporary philosophical debates in geography, mostly by human geographers, obligate the physical geographer to defend the legitimacy of scientific claims to knowledge (e.g. Eliot Hurst 1985; Dear 1988; Marcus et al. 1992). These debates force an awareness of a broad range of philosophies including those pertaining to 'hard' sciences (e.g. positivism, rationalism, realism) and those that distance themselves from it or would undermine it (e.g. existentialism, idealism, relativism, postmodernism). The challenge to science by the 'onslaught of the isms' is predicated on the position that science is hard to define and difficult to differentiate from other knowledge-seeking enterprises, that it is fallible and subjective, that its logic has been refuted for decades, that its methodology fails miserably in the understanding of societally relevant issues, and therefore it should hold no preferred status within the division of academic labor nor in the eyes of society. The challenges against science are challenges against geomorphology if one accepts that geomorphology is a science. Why are these challenges important? In short, they encourage us to understand something of ourselves and our practice. They force us to distinguish good science from bad science. They guard against academic complacency, and demand us to question whether geomorphological research is indeed scientific, to justify these claims, and to interrogate the activities of the discipline. Geography helps in this effort because it is not completely and comfortably nestled within the sciences. It straddles both - the natural and social sciences, and even borrows and develops an appreciation for artistic views of the world. While human geographers tend to be highly critical of physical geographers and vice versa, geographers in general are receptive to alternative viewpoints and perspectives.

Several recent papers by geographers have initiated an examination of the scientific bases of geomorphology, especially the role of theory (Chorley 1978; Rhoads and Thorn 1993) and the philosophical perspectives that might be most appropriate to contemporary geomorphic practice (Richards 1990, 1994; Yatsu 1992; Bassett 1994; Rhoads 1994; Rhoads and Thorn 1994). Most academics have rejected a science predicated on the extreme edicts of Baconian-style logical positivism, and many also remain unconvinced by Popperian prescriptions of critical rationalism (Haines-Young and Petch 1986), although these philosophies come closest to a popular image of scientific investigation. Some philosophers of science, such as Chalmers (1990), have attempted to define a middle ground by reconciling the orthodoxy of classical science with anarchical critiques of science (e.g. Feyeraband 1975). Chalmers (1990) suggests that the aim of science should be the 'establishment of generalizations governing the behavior of the world' (p. 29) with 'some means of substantiating those generalizations' (p. 38) and an 'emphasis

on the growth and improvement of knowledge' (p. 37). As regards method and standard, Chalmers (1990, p. 39) simply requires that

> candidates for scientific laws and theories should be vindicated by pitching them against the world in a demanding way in an attempt to establish their superiority over rival claims ... [and in the physical sciences, this] will usually involve artificial experimentation and that the successful prediction of novel phenomena will be especially significant.

Unfortunately, Chalmers' middle ground cannot be used to evaluate whether disciplinary practice within geomorphology is scientific (1990, p. 116):

> While the aim of science can be *distinguished* from other aims and epistemological appraisals distinguished from other appraisals, the scientific practice involved in the pursuit of that aim cannot be *separated* from other practices serving other aims.

Richards (1990, 1994), Yatsu (1992), Bassett (1994), and Rhoads (1994) call for the adoption of a realist perspective by geomorphologists to guide their practice. Richards (1990, p. 195) even contends that 'Many geomorphologists will perhaps be unsurprised to discover that their geomorphology is essentially realist.' In part, this may be due to the broad range of colorations within the realist spectrum. One common theme among these brands of realism is that scientific observation is theory-laden and that theories tend to become more truth-like as the scientific enterprise continues. That is, former knowledge may be modified and improved, but it is rarely totally usurped as in the Kuhnian model of scientific revolutions. Little effort in geomorphology has been devoted to determining the extent to which geomorphic practice conforms to any philosophy of science, and Rhoads and Thorn (1994, p. 99) suggest that 'The challenge for realists is to show how many theoretical constructs embodied in the Davisian view of geomorphology, including references to unobservables, have been preserved in contemporary geomorphic theories.' Bishop (1980, p. 310) attempted to analyze the scientific quality of Davisian theory and concluded that:

> ... in Popperian terms, the cycle is not a scientific theory on at least two grounds. Firstly, the theory is irrefutable in a central, essential concept, that of stage; secondly, the theory has been modified in an ad hoc manner to account for those objections that could be brought against it ... Davis's 'outrageous' hypothesis might have been of more value had it been expressed in such a way as to permit its testing by falsification.

Perhaps geomorphology will turn out to be less scientific than most geomorphologists would like (cf. Sherman, Chapter 4 this volume).

Recently, we have been informed that postmodernism has 'hit geography like a tidal wave' and that it 'has flourished, because it constitutes the most profound challenge to three hundred years of post-Enlightenment thinking' (Dear and Wassmansdorf 1993, p. 321). Proponents of postmodernism claim that rationalism is not a viable philosophy, that theoretical argument and self-evident truths are invalid, and that the search for universal metanarratives is hopeless (Dear and Wassmansdorf 1993). Although the rhetoric is most impressive, postmodern arguments are hardly unique - they have been voiced by many others under less formal philosophical labels. What is disturbingly common to post-modern discourse, however, is the consistent and relentless attack on science. The post-

modern left is particularly blatant in its attempts at self-legitimation through deconstruction of the scientific enterprise, and these seem ill-directed and driven by passion rather than reason. Ironically, the broader message of postmodernism - that competing claims to privilege or authority are not capable of being reconciled or resolved and therefore should be avoided and renounced (Dear and Wassmansdorf 1993) - seems to have been conveniently overlooked by these extremists. Although I am unable to imagine a useful and practical 'postmodern geomorphology', I am sympathetic to the postmodern appreciation for alternative perspectives. This position is, in fact, perfectly consistent with a 'scientific geomorphology', as pointed out by several geomorphological-geographers, and it merely requires that geomorphologists resist the temptation to don the cloak of scientific hegemony. Yatsu (1992, p. 115), for example, calls for the 'elimination of authoritarianism and the like' and suggests that, 'totally free discussions, and thus libertarianism are the first step toward the advancement of the science [of geomorphology]'. Similarly, Rhoads and Thorn (1994, p. 99) state that, '... adopting a realist perspective does not necessitate that a truly scientific approach implies that all geomorphological problems must be described in the language of physics. Contemporary scientific realism explicitly acknowledges that no scientific discipline has privileged status with regard to the truth.' A postmodern view simply extends the realm to all disciplines, whether scientific or not.

Several earth scientists had expressed postmodern sentiments even before postmodern movements were constituted. Leighly (1955, p. 318), for example, was concerned with the academic and intellectual constraints that Davisian dictates had imposed on geomorphological thinking for over 50 years, and while arguing for a more process-oriented physical geography, he suggested that:

> It would be good if we could again approach the earth with unhampered curiosity and attempt to satisfy that curiosity by whatever means the problems we encounter suggest. In particular, we should discard a restriction that has long been laid upon us: the prohibition of concern with processes. Let processes be restored to the central position they deserve ... The land, the sky, and the water confront us with questions whenever we look at them with open eyes. These questions, and the privilege of sharing in the quest of answers to them, are a part of our birthright.

At least one recent paper arguing for the reenchantment of geomorphology (Baker and Twidale 1991) is also surprisingly postmodern in its outlook when it speaks of the 'awe and wonder' of landscape appreciation (p. 89), when it encourages geomorphologists to become 'mavericks' (p. 90) and to 'hypothesize outrageously' (p. 96), and when it argues that an '. . . overemphasis on methodology, either for theoretical abstraction or "objective" measurement has made geomorphological study increasingly remote from the realities of the Earth's surface which constitutes its *raison d'etre'* (Baker and Twidale 1991, p. 74). This is at once a plea for a more personal 'oneness' with the land and a rejection of scientific conservatism within geomorphology. Unfortunately, the enlightenment advocated by Baker and Twidale (1991) is dimmed considerably by the authoritarian and often contradictory statements that imbue the text. Readers are encouraged to think open-mindedly about alternative geomorphological perspectives (outrageous hypotheses) as long as they appreciate that 'The survival of old forms and surfaces serves as a timely reminder that Geomorphology is historical in nature and that it is an integral part of Geology' (Baker and Twidale 1991, p. 92). With regard to the value of geographical

perspectives and research, Baker and Twidale (199 1) opine that 'It had been demonstrated that academic life could continue and indeed flourish without Geography' (P. 76), and that geography's *raison d'etre* should be 'to form a bridge between the natural and social sciences, and as an attempt to see the world in the round' (p. 76). Apparently, Baker and Twidale (1991) would have geographers act as lowly carpenters in the service of the sciences! In this, they have missed a crucial point. The bridge does not need to be built it already exists. The challenge is to travel that bridge in order to appreciate the view from the other side, which may be considerably different. To sit on one side and ignore the other, is to deny knowledge. Even worse, to deconstruct the bridge and deepen the chasm, is to deny the existence of other worlds. This is the postmodern critique of disciplinary hegemony, and it is unfortunate that some geomorphologists remain blissfully uninformed of it.

Geomorphology, it could be argued, has been inconsistent in its treatment of the scientific enterprise. It has accepted the benefits of appearing and 'acting' scientific while failing to uphold the obligations and standards of rigorous scientific practice. Baker and Twidale (1991), for example, never question whether geomorphology is a science, yet they deplore the insidiousness of 'the substitution of elegantly structured methodology and theory for spontaneity, serendipity, and common sense' (p. 73) in geomorphological research. In so doing, they call for a rejection of methodology, theoretical abstraction, and objective measurement and interpret them as symptoms of intellectual sterility and indifference to nature when, in fact, these are at the very heart of the scientific enterprise (cf. Rhoads and Thorn 1994). Baker and Twidale (1991) uphold the primacy of a *geologically* rooted historical/genetic approach to geomorphological investigation, of which Davis's *geographical* works are the epitomization, and they do so in the face of Strahler's (1950) and Bishop's (1980) challenges to its scientific quality while at the same time reverencing the 'process-oriented' concepts of G. K. Gilbert. Are these deliberate obfuscations meant as postmodern prods to our conceptual, methodological, and theoretical complacency and sedentariness, or are the inconsistencies and contradictions truly revealing of the conceptual state of geomorphology? In either case, it may be beneficial to question whether geomorphology is best served by adopting an academic posture situated squarely and exclusively within the sciences. Much of what geomorphologists undertake in their research amounts to little more than specialized observation and speculation, as difficult as this may be. Experimentation and hypothesis testing are all but impossible, except perhaps, under reductionist strategies such as those in flumes, wind tunnels, or small experimental plots. This recognition, however, should not to be misconstrued as license to practice poor science, but rather, as an appreciation for the limitations of the scientific enterprise. We should never compromise on the quality of our science, but we should also not be reluctant to admit that there are alternative routes to knowledge. The field of medicine is a good example of a discipline that has its foundation firmly rooted in a scientific platform even though its practitioners readily admit to a dependency on skillful artistry in medical practice.

FUTURE PROSPECTS: INTEGRATION OR ELIMINATION?

In the 1950s, Bryan (1950, p. 198) remarked that, 'Natural as it may be for exponents of a subject to claim independence and to extol the unique virtue of their favorite field of

effort, geomorphology can hardly claim the pre-eminence of separateness'. Some 20 years later Dury (1972, p. 200) advised that, 'This would appear to be no time to carve up the geomorphic frontier.' The twenty-first century is quickly approaching and it is worth taking stock to see if much has changed over the last 50 years. Is geomorphology's academic status sufficiently improved to entertain a complete academic separation from geography and geology, or would it be in our best interests to retain our subdisciplinary status and exploit this position?

Geomorphology may be defined as the area of study that leads to an understanding of and appreciation for landforms and landscapes including their geometry, structure (internal and external), coexistence with other forms (biotic and otherwise), and dynamics (mode of evolution and processes integral to their existence and evolution). A separate academic discipline that focuses on mere description and classification of landforms and landscapes has already proven to be too inert to be palatable. A discipline concerned with landform changes alone would find many of its practitioners idle waiting for change to occur, or, even worse, making inferences based on secondary data sources. A discipline that examines processes in the absence of the landforms *per se* loses touch with the essence of geomorphology. Conversely, a separate discipline that provides comprehensive coverage of all the many facets embodied in the definition would likely be untenable because the current demarcation of academic disciplines is too entrenched and because there are too many disciplinary claims on geomorphological spheres of knowledge. The example of the hydrological sciences is revealing in this context. Thus, the challenge for the future of geomorphology, at least in the short term, may be one of integration and synthesis.

Interdisciplinary Academic Associations

Dury (1983, p. 90) remarked that:

> discussions of disciplinary location have been largely by-passed by the general quantitative revolution of the natural sciences (and of part of the arts), by the growth of interdisciplinary research, and by the knowledge explosion, the result of which is that traditional departments are now too small for what they must do.

Many of society's contemporary concerns are focused on environmental problems such as those involving pollution, resource utilization, urbanization, spread of disease, sustainable agriculture, species-habitat preservation, and alteration of regional or global conditions. These are broad areas of research in which geomorphologists could and should play a role. Although the need for a more societally relevant geomorphology has been recognized for a long time (e.g. the 1970 Binghamton Symposium was on environmental geomorphology) and is being met by a select few (e.g. Goudie 1990; Graf 1994, and Chapter 18 this volume), there has been reluctance on the part of the broader geomorphological community to engage in this type of research. Perhaps this is because these fields of interest are nontraditional and have an applied flavor or because they require us to interact with researchers from other disciplines. Disciplinary traditions are subject to change, however, and there may be distinct advantages to working in multidisciplinary and collaborative groups during periods of economic hardship (e.g.

Church et al. 1985; Smith 1993). The shift to such a flexible academic 'culture' seems to be taking place in other disciplines, and one need only consider the number and popularity of environmental studies/sciences programs, schools, and institutes that have been established recently in universities and colleges worldwide to get a sense of future trends. Funding agencies such as the National Science Foundation have also expressed increasing interest in long-term, multi-institutional projects that are interdisciplinary and concerned with issues of environmental and social relevance and significance (e.g. Human Dimensions of Global Change program).

Several years ago, Coates (1971, p. 6) noted that:

> the science of geology has become increasingly compartmentalized at a time when many of the intriguing problems have become interdisciplinary. The geomorphologist, as the surviving generalist in earth science, can play a vital role in bridging this communication and intellectual gap.

In this regard, geomorphology's association with geography would seem to be advantageous, but only in so far as geographers are able to deliver on their claims of being synthesizing, integrative, and interdisciplinary. This may not be easy given the factionalism that is as pervasive in geography as in other disciplines - the AAG currently recognizes almost 50 specialty groups within its structure. It has been suggested that human geographers have generally failed to recognize the importance of the physical environment in their research:

> How long our colleagues in human geography will be able to maintain their distaste for the proposition that people can be strongly (and usually adversely) affected by the behaviour of the physical environment I am not prepared to guess; but until they give at least some ground, I should expect to find the separation of geomorphology from geography, in the intellectual if not in the locational sense, to widen (Dury 1983, p. 97).

It is also true that geomorphologists are generally reluctant to bestow the same privilege to humans as agents of change. Geomorphological research is still largely concerned with 'natural' systems despite a general awareness that pristine environments are the exception and that humans will continue to contribute to, if not dominate, environmental change (e.g. Goudie 1990; Nordstrom 1992). It has been estimated, for example, that humans now move more sediment on an annual basis than any other geomorphic agent (see Monastersky 1994). The notion of distinctive 'urban' climatologies or hydrologies has been recognized for decades, and it is thought that the hydrologic balance of the North American continent may have been altered perceptibly by increased surface-water storage in reservoirs created by dam closures. The interaction of individuals or societies with their geomorphological environments has found its most profound expression in natural-hazards research which will require geomorphologists to interface more directly with social scientists in the future (e.g. Gares et al. 1994). The potential contributions of other disciplinary practitioners to these efforts cannot be denied, and interactions with them should be encouraged. We need to be proactive about such interaction, and it is revealing to note that, of an estimated 1430 geomorphologists or Quaternary specialists in North America in 1983 (Costa and Graf 1984), only 48 belonged to both the GSA and the AAG (13 geologists belonged to the AAG, whereas 35 geographers belonged to the GSA).

Scale Integration

The challenge with regard to scale will be to transcend artificially constructed boundaries delineating spatial and temporal domains that are a logical necessity of our attempts to understand a complex world in a simplified way. Invariably these compartmentalizations reflect disciplinary strictures rather than natural divisions because the spatial and temporal scales of a problem are dictated by the methods used to attack them. This is a fundamental issue that may have to be addressed at the philosophical level before any methodological or practical advances can be made:

> Contention in contemporary geomorphology centers on differences in regulative principles, types of scientific arguments, and characteristics of theory employed by scientists, all of whom consider themselves geomorphologists (Rhoads and Thorn 1993). Although the point of contention is scientific methodology, the contention itself is clearly philosophical in nature. In other words, it is not possible to resolve conflicts between competing methodologies within science itself, instead, resolution of these differences must occur within philosophy (Montgomery 1991) (Rhoads and Thom 1994, p. 99).

Contemporary research in geomorphology has been characterized as either 'historical' or 'process-oriented' (e.g. Baker and Twidale 1992; Kennedy 1992). Associated with these terms are tacit spatial and temporal scales. 'Historical' geomorphological research tends to be concerned with understanding landscape evolution as a sequence of events, and therefore it requires explicit identification of distinct time (space) elements. 'Process-oriented' geomorphological research, in its purest form, has no well-defined spatial or temporal reference points - that is, the processes can take place anywhere at any time. Nevertheless, generalizations about processes are often derived from case studies, and there will always be some idiographic component to geomorphological studies. Unfortunately, this latter reality is not easily admitted by the use of terms such as 'timelessness' and 'equilibrium', and this has caused considerable confusion and has led to needless posturing within the discipline (cf. Schumm and Lichty 1965; Kennedy 1992).

Practically, it should be clear that every process, by definition, must play itself out across space and through time. Process-oriented research tends to be reductionist because small spatial and temporal scales allow the researcher to reduce the degrees of freedom in any particular problem through control strategies. However, reductionism does not constitute diametric opposition to historicism. Kennedy (1992) offers an especially penetrating and insightful analysis of this fallacy. She argues that it is impossible to divorce the historical from the process approaches because to do so

> reduces the historical event to a boundary or initial condition ... But if one does so often enough, there is the risk of forgetting that boundary conditions must inevitably change, as part of the expectable, but inherently unpredictable sequence of endogenetic and exogenetic events ... the search for 'dynamic equilibrium' advocated by Strahler and by Chorley thus has the paradoxical effect of turning perfectly straightforward high-magnitude/low-frequency events into catastrophes (Kennedy 1992, p. 248).

In this context, our uncritical application of general systems theory has failed us miserably. The 'systems manual' has inspired us to a reductionist disassembling of Hutton's Earth Machine - to identify and classify components; to observe and describe

their workings; to further dismantle these components into individual parts; to examine and describe those parts and their workings, and so on. Unfortunately, it is silent on methods of reassembly, and the essential chapter revealing to us what we truly seek - the internal workings of the Earth Machine - remains missing.

Other disciplines, such as chemistry, astronomy, and physics, have begun to take steps toward reconstructive efforts. Schweber (1993, p. 34), for example, points out that 'the reductionist approach that has been the hallmark of theoretical physics in the 20th century is being superseded by the investigation of emergent phenomena, the study of properties of complexes whose "elementary" constituents and their interactions are known'. The term 'emergent properties' refers, not to the theoretical or mathematical constructs that represent the fundamental laws which most reductionists seek, but rather, to the characteristic behavior of solutions to the mathematical expressions that describe natural phenomena. Recent research on nonlinear dynamical systems in geomorphology (e.g. Phillips 1992 and references therein) seems particularly germane in this respect. The identification of emergent properties is not a straightforward task because it involves more than simple reconstruction (i.e. putting the deconstructed pieces together). This was recognized by Anderson (1972, p. 393) who suggested that:

> the more the elementary-particle physicists tell us about the nature of the fundamental laws, the less relevance they seem to have to the very real problems of the rest of science, much less to those of society ... The constructionist hypothesis breaks down when confronted with the twin difficulties of scale and complexity. The behavior of large and complex aggregates of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles.

Anderson (1972) also argued that each scale level should have its own fundamental laws (i.e. its own ontology) and therefore, its own complexities and emergent properties.

These ideas about distinctly different scale levels have found partial support in contemporary geomorphological practice (e.g. de Boer 1992; Sherman and Bauer 1993; Phillips 1995). At the smallest scales, it is not uncommon for scientists to favor concisely expressed, deterministic relations that invoke force balances or conservation principles (of mass, momentum, vorticity, entropy, or energy). At intermediate scales, much of the mathematical formality is retained, but some of the deterministic physics or chemistry are replaced by parameterizations that invoke phenomenological or constitutive coefficients such as conductivity, diffusivity viscosity, elasticity, erodibility, porosity, and permeability, or the various coefficients of drag, friction, cohesion, and strength. These coefficients are used to relate the principal variables in a given process-response interaction when accounting for individual particles and their behavior is no longer possible. Ensemble averaging over domains of interest (representative elemental volumes) becomes necessary. At the largest scales, descriptions of system behavior usually assume probabilistic (indeterministic) properties or an idiographic and historical character. One of the challenges for geomorphologists, then, is to identify the existence and domain of these scale levels - their bounds, fundamental laws, and emergent properties.

It is worth remembering, however, that some 'laws' may transcend scale in the sense that they will be characteristic of several contiguous levels. The law of gravity, for example, applies to most scales of geomorphological interest, as might the principles of least action, sufficient reason, and uniformity of nature (Yatsu 1992, p. 88). Geomorph-

ologists should continue the search for general or 'universal' laws or principles, but with the proviso that they be scientific rather than metaphysical. The formal analysis of Church and Mark (1980) into the character of proportional relations in geomorphology and their interpretation as allometric or self-similar 'growth laws' is exemplary in this regard. Research addressing both emergent and universal properties is necessary if geomorphology is to evolve toward a societally relevant discipline with nomothetic explanations and predictive powers.

SUMMARY REMARKS

Traditional accounts of the development of geomorphology have suffered from Whig historiography which adopts a backward-looking perspective that interprets the relevance and importance of past figures and events in the context of contemporary values and paradigms. Because contemporary geomorphology considers itself to be scientific, it often traces its roots selectively to those figures and events that lend credence to this scientific image. Such posturing is usually based less on the realities of current practice or reasoned direction than on misrepresented images and value-laden emphases. Although there are tangible benefits to such posturing, especially since scientific activities are generally held in high esteem by society and within academe, there are accompanying costs. It is paramount that we identify explicitly these costs and benefits because there are implications for the future of the discipline (cf. Raguraman 1994).

Popular histories of North American geomorphology are biased in that they fail to recognize the relative importance of geography to geomorphological disciplinary development. In part, this may be ascribed to geography's relatively recent arrival as an academic discipline in North America, despite its long-standing intellectual traditions that extend to the ancient Greeks. The important contributions of geology and geologists, although central, are unduly stressed, and such preferential representation may be misleading in several ways. First, it is not evident that the intellectual discipline of geomorphology, with its focus on earth-surface phenomena, can or should be traced to any single geological or geographical seed or root, whether a person, institution, event, or activity. Intellectual interest in the world around us is a human trait that has persisted throughout history, even before there were disciplines. Disciplinary demarcations are socially constructed institutions that have become necessary only recently because individuals can no longer 'know it all'. Imposing contemporary disciplinary structures on academic thought during historical periods is therefore inaccurate, inappropriate, and unwarranted. Further, it ignores the malleable and evolving nature of disciplines - their cores, their boundaries, and the knowledge contained therein are subject to change through time.

Second, the academic roots of geomorphology are intertwined with those of many disciplines, not just geology or geography, and it is not self-evident that one discipline can be asserted to have had a more profound role than another - the 'Championship of the Disciplines' is unwinnable. Moreover, the distinctions made between geology and geography, and between geologists and physical geographers, are often matters of trivial caricaturing. North American departments of geology during the nineteenth century, for example, retained the services of geographers, biologists, and anthropologists, and only by

one very pragmatic definition would they be labeled as 'geologists'. Geomorphology has been (and continues to be) practiced in geology departments by geographically oriented researchers, and vice versa. To label key geomorphological figures such as Gilbert, Davis, and Powell as either 'geological' or 'geographical' is a gross misrepresentation of their character and an unfortunate oversimplification of their research interests and contributions. Similarly, commonplace assertions that the process-oriented and historical approaches to geomorphological research are characteristically 'geographical or geological', 'scientific or nonscientific', and substantively antithetical are not substantiable. Such caricaturing damages the integrity of geomorphology and polarizes its practitioners during a period when academe is facing some of the most profound challenges to its intellectual and theoretical foundation, disciplinary and administrative structure, social relevance and utilitarian worth, and long-term financial survival.

Finally, whether geomorphology views itself as being dominantly geological or geographical in character has implications for how it is perceived by other academicians and how its practitioners conduct their research, and indeed, what problems are deemed to be of importance. The geological persona of geomorphology seems to be more 'scientific' and also more academically privileged. The geographical persona is more diverse philosophically and methodologically, and potentially more interdisciplinary and integrative. Geomorphology and society would best be served by encouraging future development of both. I end this chapter by reiterating the sentiments of R.J. Russell in his presidential address to the AAG almost 50 years ago:

> Whether geomorphology belongs to geography or geology seems to be a question unworthy of the debate it has occasioned . . . I feel somewhat happy when I notice attempts of either geographers or geologists to claim the subject, and somewhat dejected when I see either trying to pass it over to the other (Russell 1949, p. 11).

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