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Introduction: The Laboratory of Nature – Science in the Mountains

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This issue on mountain science is dedicated to Charlotte Bigg's grandfather, Michel Poher, psychiatrist and passionate alpinist.

"Today I made the ascent of the highest mountain in this region, which for good reasons is called Ventosum, guided only by the desire to see the extraordinary altitude of the place" (Petrarque [1336] 1880, 6–7). Petrarch's ascent of the Mont Ventoux in 1336, or rather his account of it, established the mountain as a distinctive place for experiencing and understanding nature and self. Since then, the mountain has been sought out in increasing numbers by those pursuing spiritual elevation, bodily exertion, and/or scientific investigation. To this day, a pilgrimage church, several hotels, and an observatory are characteristically perched atop Mont Ventoux. And it is famous among cyclists as a legendarily difficult *étape* of the Tour de France.

If Petrarch fired the opening salvo, it was only from the second half of the eighteenth century that mountains properly began inhabiting the European scientific imagination. A growing body of scholarship has shown how the Enlightenment travelers' scientific and aesthetic "discovery of the Alps" transformed the mountain into a theater both for sublime sensations and natural history investigations. The mid-nineteenth-century craze for mountaineering has been well documented, when European, especially British middle-class tourists and alpinists turned mountains into an increasingly accessible "playground," each heroic ascent became the occasion for moral edification, national glorification, and a display of mastery over body and nature. The political and economic

(agricultural, industrial, tourist) significance of mountains in the modern age has equally been recognized. As the (by no means exhaustive) bibliography below shows, the historiography of the mountain is varied and heterogeneous, with mountains often appearing as subaltern objects of interest in studies dealing for example with bourgeois leisure or literary and artistic preoccupations with landscape.

The ubiquity of science in these accounts is striking, if rarely studied systematically, with scientist mountaineers and scholars often waxing lyrical about the natural affinity of science with the mountains, and the Alps in particular. In regard to thermodynamics in physics and meteorology, Donald Cardwell writes that "it would scarcely be an exaggeration to say that as the solar system was the celestial model for Newtonian mechanics, so the high Alps were to provide a good deal of the laboratory material for eighteenth- and early-nineteenth-century science" (Cardwell 1971, 92; see also Briffaud 1994). What made the mountain so interesting to scientists? This issue explores how the mountain, used here as a generic term, became both a propitious setting for scientific pursuits and an object of scientific investigation in itself; and how scientific interest in mountains partook in wider cultural perceptions and experiences of the mountain – indeed, how science contributed to "make" mountains as we now know them, as Daniel Speich puts it in his study of Swiss Alpine surveying, cartography, and model-making. Beyond the study of how particular sciences and scientists engaged with the mountain, this collection of essays therefore provides a range of answers to the question: what is the *genius loci* of the mountain, that writers since Petrarch have, over and again, expanded upon? What kind of place does the mountain occupy in science and culture?

Focus

The contributions gathered here focus on the high age of scientific engagement with the mountain, which also corresponds to the high age of Alpine mountaineering. The essays run in a roughly chronological order, giving a sense of the increasing popularity and accessibility of mountains from the late eighteenth century to the early decades of the twentieth, when interest in the mountain began to fade. Several contributions explicitly thematize the evolution in the perception and experience of mountains throughout this period. In these articles especially, not only the perspective and activities of scientists are considered, but more broadly the ways in which mountain science partook in the changing roles of the mountain for its visitors in the nineteenth century. The rise and fall of the hotel on mount Faulhorn studied by David Aubin is a typical example of how a combination of infrastructural investments (hotel, railway), a new attention to mountains in literary, artistic, and scientific discourse, and social changes, with the rise of a relatively wealthy middle class, all combined to transform mountains into a favorite tourist playground as well as a scientific object and working place.

The Alps occupy pride of place in this issue since they were the first and the most intensely scrutinized mountains in the period and because they often served as exemplars in the later study of other mountain ranges (notably in the wake of

colonization and cross-cultural encounters, see e.g. Pratt 1992; Raj 2002; Ortner 2001; Cosgrove and Della Dora 2009). As Andrea Westermann suggests here, debates crucial to geognosy and tectonics centered on the analysis of particular Alpine formations, whose names were subsequently adopted as type-names throughout the world. The Glarus Alps, she writes, have recently been added to the World Heritage List as an acknowledgement of their significance in the history of geology. But not all contributions deal with the Alps: Catherine Nisbett Becker on the Andes and North American mountains and Nicky Reeves on the Scottish Highlands provide a comparative perspective.

This issue deals with a selection of scientific involvements with the mountain, from astronomy and astrophysics to geomagnetism, geology, meteorology, geodesy, and cartography to natural history and physiology. It broaches neither botany nor medicine (in particular the conception of the mountain as a pure environment opposed to the disease-ridden, dirty modern city), important components of mountain science, nor does it touch upon the controversial interest of scientists for human or animal inhabitants of the mountain (for instance on cretinism, see Merke 1984). The prime focus here is on the sciences of the earth, the atmosphere, and the universe, many of which were closely related, being practised using similar techniques and sometimes by the same actors (Aubin, Bigg, and Sibum 2010). Jan von Brevern suggests, through his pioneering photographic survey of the Alps, that despite the increasing specialization of scientific work that compartmentalized the study of nature in the later nineteenth century, the mountain, and especially its summit, remained a propitious site for elaborating global views of the heavens and earth, both scientific and aesthetic, as the geographer Aimé Civiale hoped to achieve. Or, as geographer Ramond de Carbonnières put it, "ideas gain in generality what the horizon gains in breadth" (cited in Broc 1969, 27). On the eve of the twentieth century, mountaintop stations and observatories still played an important role in the coordinated study of astrophysical objects, the atmosphere, and terrestrial features. But they also prefigured in many ways the satellite and space probes that reinvented the sciences of earth and space in the latter part of the century and signaled the partial decline of the mountain as a scientific place. Similarly in meteorology, as Deborah Coen writes, "by the 1890s, most meteorologists studying the upper atmosphere were trading their hiking boots for a new generation of unmanned kites and balloons," even if mountaintop stations were revived a few decades later when the spread of aviation produced new needs for high altitude data. In geology, according to Andrea Westermann, with the move from geognosy to tectonics, mountains receded into the background as ocean floors took center stage.

The Mountain as Place and Space

This issue contributes to a growing field of inquiry concerned with the spatial dimension of scientific and cultural practices. As urban geographers and also sociologists,

anthropologists, and historians have suggested since the 1970s, if *place* refers to a geographical, physical location, then *space* can be understood as a "practiced place": "L'espace est un lieu pratiqué" (de Certeau [1980] 1984, 117; see also, e.g. Mitchell 2002; Blackbourn 1999; Schlögel 2003). A space is the constantly evolving product of the practices, imaginations, and negotiations of the users of a given place.

Students of science have taken up these reflections to emphasize the situated nature of scientific work (Ophir and Shapin 1991; Smith and Agar 1998; Livingstone 2003). Noteworthy in this respect is the *Osiris* volume *Science in the Field*, whose editors Henrika Kuklick and Robert Kohler challenged the history of science to face up to its deep-rooted bias towards the laboratory sciences and to acknowledge the importance and specificity of the sciences operating in the field. The volume examined some of "the common properties of enterprises conducted partially out of doors, in uncontrolled settings," the particular forms of social organization, knowledge production, and legitimation that characterized the field sciences in contrast to the laboratory sciences (Kuklick and Kohler 1996, 1). Thirteen years on, the prodigious flourishing of the history of the environmental sciences, but also the history of meteorology, natural history, geology, geography, and paleontology is tangible evidence that things have changed. Narrowing the focus to the mountain, the present issue proposes both to take stock of this recent work and to help bring together what has often evolved as independent strands of investigation.

Like Kuklick and Kohler's field, or the city studied by the sociologists of the Chicago school, the mountain is both the *where* and the *what* of scientific investigations (e.g. Strauss 1968; Gieryn 2006, 11). It is simultaneously the scientific workplace and the object of study. Scientists are immersed in the mountain while they often strive to objectively detach themselves from it. From the scientists' peculiar situation with respect to such places, Thomas Gieryn argues, a scientific rhetoric arises where place is foregrounded "from tacit background to explicit factor in quests for credibility in scientific claims-making" (Gieryn 2006, 28). The strategies, resources, and techniques for surviving in this challenging environment are inseparable from the strategies, resources, and techniques for producing knowledge on or about the mountain. Hence the peculiar presence of the scientists' bodies in their scientific accounts, where the trials and strains inflicted by the environment merge with those that go together with scientific work, as Philipp Felsch shows most distinctly through the example of the physiological study of fatigue and altitude sickness. The mountain environment's extreme conditions were both a curse for its visitors (or the occasion for heroic performance) and a blessing for scientific work, very much in the way that the arctic regions, the high atmosphere, or outer space would become in the twentieth century. It is perhaps not a coincidence that in early films thematizing scientific space travel, such as Fritz Lang's *Woman in the Moon* of 1929, the astronauts are fitted out in full mountain gear, hiking boots, ropes and all.

This had significant consequences for scientific work. In the cases studied here, a diversity of pursuits was superimposed on the mountain. The same slopes and summits

were crisscrossed by artistic, scientific, and sportive, tourist, political, and military undertakings that co-existed, interacted, or interfered, as suggested by Daniel Speich on the mapping of the Swiss Alps, but also by Nicky Reeves in his study of the Astronomer Royal's visit to Scotland, by Jan von Brevern in his analysis of Civiale's photography, by Catherine Nisbett Becker's study of the expeditions preliminary to the setting up of a high-altitude branch of the Harvard College Observatory, or Philipp Felsch's article on the different kinds of speechlessness that the mountains above the tree line elicited from writers, artists, and scientists. Their accounts point to the hybrid nature of the populations that gathered on mountains, but also show how these were often inseparably bound by underlying common values: masculinity, nationalism, and a fascination for extraordinary landscapes and physical exploits nurtured by the literary or artistic outpourings of previous generations.

For the same reasons, the mountain was rarely a completely controlled scientific place, and the challenges arising from remoteness, social isolation, extreme weather conditions, but also interference from or necessary reliance on a diversity of non-scientific actors shaped the pursuit of science in mountains in fundamental ways. The trustworthiness and reliability of local helpers – guides, porters, water carriers, amateurs – are persistent concerns in mountain scientists' reports and writings, as they generally were for nineteenth-century field scientists, from natural historians to physical anthropologists and ethnographers. Catherine Nisbett Becker argues that these factors could play a significant role in deciding whether or not to set up a permanent station in a particular location. While isolation seemed often to guarantee the scientific results produced high up, and peace and loneliness were sometimes thought productive by scientists, scientific workers in the mountains could never deny their utter dependence upon the proximity and the goodwill of local communities.

Conversely, not only was mountain science irrevocably shaped by its reliance on non-scientific actors and the constraints of the harsh environment, but it was itself, like other field sciences, particularly entangled in political matters. Most obviously, the surveying and mapping of mountainous regions was carefully monitored and encouraged as a means of binding remote regions and populations more tightly into national frameworks. Nicky Reeves, in his account of Astronomer Royal Nevil Maskelyne's measurements "on a boggy Scottish hill side" suggests that the astronomical enterprise was both made possible by previous surveys and was supported by local powers in the hope that it would help to improve maps of the region. The cartography of the Swiss Alps studied by Daniel Speich enabled a greater control and administration of these territories. Further, the scientific studies of mountains were in the nineteenth century frequently integrated into the symbolic construction of the mountain as a component of national identities as Deborah Coen suggests for Austria, Nicky Reeves for Scotland, Daniel Speich for Switzerland, Stéphane Le Gars and David Aubin for France.

Within the scientific world, the mountain could occupy a variety of positions with respect to the urban laboratory or observatory. Frequently, as in the case of

Victorian glaciology studied by Bruce Hevly, mountain science was opposed to metropolitan, laboratory, or observatory science (Hevly 1996, 66; see also Kohler 2002 and Aubin 2002). Stéphane Le Gars and David Aubin analyze here a debate about the merits of mountaintop astrophysical work compared to the alternatives offered by urban scientific environments. Though the physiology of fatigue studied by Philipp Felsch began in the mountains it continued in the laboratory. But mountain science could also be complementary to urban science, as in the case of the Harvard College Observatory's branch in the Peruvian Andes, which was to produce otherwise unobtainable astrophysical data thanks to its position both on a high mountain and in the southern hemisphere. As Catherine Nisbett Becker insists, the Arequipa station was subordinate, with the processing of its data and its publication being carried out in Harvard. In all cases, scientific workers in the mountains always endeavored to stay in contact with urban centers and the wider scholarly community. Even in the most remote locations, scientists arranged for postal communication to be maintained, disruptions in the delivery of post being considered at least as disastrous as that of food.

The move from the late nineteenth century towards the establishment of altitude (semi-) permanent stations constitutes one of the most distinctive features of mountain science. These stations were set up with the explicit aim of reproducing, as far as possible, the sheltered conditions, both social and material, of the laboratory or the observatory. They often functioned as high-altitude branches of well-established urban institutions or as stations in national and international (usually meteorological or geodetic) networks. In this way the mountain was colonized and integrated into the scientific landscape on a permanent basis – when, that is, the epistemological and practical challenges of making such exceptional places produce useful and reliable scientific knowledge could be met. Deborah Coen and Catherine Nisbett Becker discuss the troubled histories of two such high-altitude stations, the Sonnblick meteorological observatory in Austria and Harvard Observatory's search for a suitable high-altitude astrophysical observatory, while Stéphane Le Gars and David Aubin take a look at the short-lived Mont Blanc observatory. These essays demonstrate the persistent tension between the requirements of isolation and communication that all mountain stations, whether meteorological or astrophysical had to manage. Finding the right balance often determined the success or failure of this kind of mountain science.

The Laboratory of Nature

The term "laboratory of nature" was coined by the great eighteenth-century Swiss naturalist and early scientific mountain explorer Horace-Bénédict de Saussure. In his *Voyages dans les Alpes* of 1779 the naturalist wrote that

> the physicist, like the geologist, finds in the high mountains great objects of admiration and study. These great chains, whose summits reach into the elevated regions of the

> atmosphere, seem to be the laboratory of nature, and the reservoir from which it draws the goods and evils that it spreads onto our Earth, the rivers that irrigate it, and the torrents that ravage it, the rains that fertilize it, and the storms that desolate it. All the phenomena of general Physics are displayed there with a greatness and majesty of which the inhabitants of the plains have no idea; the action of the winds and of aerial electricity exert themselves there with surprising strength. (Saussure 1779, vol. 1, viii)

A century later the metaphor had become commonplace, with the Parisian architect Eugène Viollet-le-Duc, author of a geological survey of the Mont Blanc range, for instance speaking in the 1870s of the "high laboratories" in which "the phenomena of Nature manifest themselves with more greatness" (Viollet-le-Duc 1876, vi and vii).

Beyond his typically Enlightenment attempt at rehabilitating the Alps as an aesthetically and economically valuable area, Saussure's expression nicely captures the different roles for the mountain in science that are thematized in this issue. The mountain is firstly a laboratory of nature because the phenomena of nature can be experienced there "with greatness and majesty," on a larger scale, in a purer state, or are more impressive, more intensive than in the plains. Here mountains are laboratories in the sense that they are "enhanced environments," "extreme places in which extreme milieux are produced" (Knorr-Cetina 2002, 45; Latour 1992, 299). In this conception, mountains naturally offer physical conditions (atmospheric pressure, telescopic visibility, temperature) that can otherwise only be produced in a man-made laboratory (or observatory), or in extreme cases, that are even impossible to achieve in dedicated scientific places. Physicists for instance use the mountain to study universal phenomena such as the decrease of pressure with height, making them distant successors of Florin Périer, the executor of Blaise Pascal's celebrated barometric measurements of 1648 atop the Puy-de-Dôme (Périer to Pascal, 22 September 1648, in Pascal 1970, vol. 2, 681–7). Knowledge produced on the mountain is here frequently in competition with that produced in urban laboratories or observatories. This corresponds to what Deborah Coen calls the "replicative" approach, found not only in meteorology, but also in astronomy, astrophysics, or physiology.

In a second, more metaphorical sense, the mountain is a laboratory where Nature engineers the globe. Mountains are "the reservoir from which it draws the goods and evils that it spreads onto our Earth"; they shape the landscape and weather of the plains. The idea that mountains are the source of meteorological or geological phenomena lends them special significance for science. Thus for Saussure, only in the Alpine relief, and preferably from the top of Mont Blanc, could the expert eye hope to decipher the history of the earth and formulate "theories of this globe." Later geologists, as Jan von Brevern and Andrea Westermann suggest here, were equally convinced that geological science could be built up from the study of particular mountain formations. In a comparable manner, in Deborah Coen's account, mountains were considered crucial to the formation of cyclones by some nineteenth-century meteorologists.

In a related, third modality, mountains are conceived to be a microcosm of the Earth as a whole, based on an analogy between latitude and altitude; where for instance arctic botanical, meteorological, physical conditions are thought to be comparable to the conditions in the high Alps. Saussure, and especially Alexander von Humboldt, helped transform the mountain into a favorite setting for the elaboration of a new type of field science in which geology, meteorology, geomagnetism, but also the study of mountain plants, animals, and inhabitants were brought together into a cosmic whole that the mountain displayed in miniature (Humboldt 1807). David Aubin suggests here that this conception of the mountain was relatively widespread among mountain scientists in the second half of the nineteenth century. These last two conceptions correspond to what Deborah Coen calls the "chorological" approach, which focuses on "individual mountains as objects of geographic inquiry in their own right." Mountains in this mode are properly objects of investigation for field sciences such as geology, cartography, meteorology, or botany.

As these examples suggest, the disciplinary orientation was determinant in deciding which of these roles the mountain was to play in a given scientific project – though they frequently overlapped, even within the same discipline. In practice, scientists often also took the opportunity of an expedition or a sojourn in an altitude station to undertake a wide variety of investigations, typically barometric and thermometric readings, weather observations, perhaps a little surveying or astronomical measurements, or the collection of mineralogical and botanical samples. Ultimately, it was the combination of these roles that made the specificity of the mountain. The notion of the mountain as a laboratory of nature captures the scientists' marvel at this place that offered phenomena that were at once natural *and* exceptional, placing it at the intersection of the laboratory, observatory, and field sciences.

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