- Sub-Kingdom II, Algae
  - Class 1, Peridineae (Dinoflagellata)
  - Class 2, Bacillarieae (Diatoms)
  - Class 3, Chlorophyceae
  - Class 4, Phaeophyceae
  - Class 5, Rhodophyceae
- Sub-Kingdom III, Fungi
  - Class 1, Phycomycetes
  - Class 2, Ascomycetes
  - Class 3, Basidiomycetes
  - Class 4, Lichenes
- Sub-Kingdom IV, Embryophyta
  - A. Bryophyta
    - Class 1, Hepaticae
    - Class 2, Anthocerotes
    - Class 3, Musci
  - B. Pteridophyta
    - Class 1, Filicineae
    - Class 2, Equisetineae
    - Class 3, Lycopodineae
    - Class 4, Psilotineae
  - C. Spermatophyta
    - Class 1, Cycadophyta
    - Class 2, Coniferae
    - Class 3, Gnetales
    - Class 4, Anthophyta (Angiosperms)

DOUGLAS HOUGHTON CAMPBELL
STANFORD UNIVERSITY

GUADALUPE ISLAND: AN OBJECT LESSON IN MAN-CAUSED DEVASTATION

IN these days when conservation of natural resources is happily coming to occupy an important place in the nation's thought and plans, it may be of value to consider a most striking example of the utter ruination which man, within comparatively few years, is capable of effecting in nature's long-developed scheme. I refer to Guadalupe Island, a volcanic peak which rises out of the ocean some 150 miles west of Lower California and which I have twice visited during the past two years in the interests of the Natural History Museum of San Diego.

In contrast with most of the other islands on the west coast of the peninsula, which are completely arid, Guadalupe's crest is lofty enough to tap the clouds, and as a result its summit was blessed in bygone days with forests of cypress, oak, pine and palm, as well as with many other smaller shrubs and flowers. This flora became a natural refuge for many birds, although Guadalupe was too far from the mainland to be entered by any land mammals. Through the ages, many of the plants and birds, by their long isolation, became differentiated from mainland forms, and this gave the island a unique natural history interest.

The first event to shock the tranquility of the place, so far as our knowledge goes, was the discovery by sealers, about the end of the eighteenth century, of several rookeries of fur seals (*Arctocephalus townsendi*) on the rocky shores of Guadalupe. In the ensuing years, Russians, British and Americans seem all to have had a hand in the slaughter of the seals, which was continued relentlessly till about 1830. It is believed that many of the skins were used in the Oriental trade, which was flourishing at that time. During this period stone houses were erected for the seal-hunters, the walls of which still remain. It was probably as a result of these first human invasions that the common house mouse was introduced on Guadalupe and, with it, the domestic cat. These two animals, so foreign to the natural fauna of the island, were destined later on to play a lamentable part in the overturning of nature's balance. When the fur seal rookeries became so depleted as to offer their exploiters no further profit, the sealers left the island, although they had not completed the extermination of the animals.

The next, and by far the most serious intruders upon Guadalupe were the whalers, although, during their brief visits, they did not stop much longer than was necessary to fill their water casks. However, to the whalers is attributed the grave responsibility of having liberated goats upon the island. It is supposed that their idea was to have a convenient place where fresh meat might be obtained on later cruises. No doubt their plan was logical, so far as it concerned themselves, and for a time their demands may have prevented undue increase of the goats. But, with the advent of more settled routes of transportation and boats with better facilities, the goats that had been released on Guadalupe were forgotten and left to their own resources. The place proved to be a goats' paradise, for with plenty of low herbage and not a single enemy, they had life their own sweet way. They increased by tens of hundreds, devouring everything green that was in sight and gnawing their way into the very heart of the primeval forest.

Meanwhile, the northern elephant seal (*Mirounga angustirostris*), another native resident of Guadalupe and its adjacent waters, began to be sought after and persecuted. Whales were becoming scarce and their hunting grounds more distant. Therefore, when the great blubbery elephant seal could be found sunning himself on the sandy beaches, he fell a ready prey to the whaler and his try-pot. At this time, gold had been discovered in California and the demand for whale oil was tremendous, for it filled the place of kerosene in those early days. Man, in his greed, turned to the easiest thing obtainable and the elephant

seals were reduced to the verge of extinction. In fact, for many years leading authorities thought that they had been exterminated. Nevertheless, in 1892, a party of scientists led by Dr. C. W. Townsend was gratified to find that a small group of elephant seals still existed on Guadalupe Island.

In the case of the fur seal, too, nature had done her best to recuperate. In the early eighties, word was passed about that a few fur seals could still be found on the island. Free lance seal-hunters at once set out from the coast of California and relentlessly pursued the unfortunate seals, invading even the caves to which the last of the herds had retreated. Even though certain of these caves were accessible only during the lowest tides, the protection thus afforded did not save the remnant of the fur seals from complete extermination. Had a few been left to survive, it is possible that the seals might have regained their strength and might to-day be netting Mexico a handsome sum annually, through the sale of their pelts, just as the fur seals of the Pribilof Islands yield to the United States a revenue of about a million dollars a year.

In spite of the damage to Guadalupe Island's bird and plant life that must already have been wrought by mice, cats and goats, Dr. Edward Palmer, well-known government botanist, who visited it in 1875, described it as a "naturalists' paradise." It would seem, however, that he arrived only in the nick of time to secure a few of the vanishing birds and plants and thus preserve their memory forever in the annals of science. After his departure, some of the birds were never again seen by ornithologists. If Guadalupe was a naturalists' paradise in 1875, what must it have been in its unspoiled glory!

Following the history of this luckless island till modern times, we find that, for a short time in the end of the nineteenth century, it was used as a penal colony by the Mexican government. However, the effect on natural conditions of its habitation for this purpose was probably negligible, since the island had already given nearly all it had, directly or indirectly, to human greed.

In the first part of the twentieth century, man again turned his eyes toward Guadalupe, this time with his attention on her unnatural possession—the hordes of goats. Corrals were built about the water hole on the summit of the island and vast numbers of the goats were butchered for their pelts and tallow. But they had increased to such an extent that the inroads of several of these expeditions had no appreciable effect upon their abundance. During the World War the goats were again exploited, being taken to San Pedro and San Diego, where they were kept for fattening. However, the many years of over-population had had its effect upon the size of the goats and the quality of their flesh, and the project was a failure owing to the high cost of transportation and feed.

My own acquaintance with Guadalupe Island dates only from 1923, when the overwhelming goat population, by devouring every green thing within reach, had for many years prevented the natural increase of any form of plant life. The condition of the island at this time has well been described as that of a "biological sepulcher." There was, however, one tremendously encouraging feature of my first visit, which was made at the invitation of the Mexican government, for no less than 366 elephant seals were counted as they lay basking on the ancestral beach—by far the largest number that had ever been recorded. The following year (1924) I was again invited to make a census of the elephant seals and found only 124 animals. Reduction of the number does not, however, necessarily indicate a corresponding diminution of the herd, as there was a difference of six weeks in the time of year when the count was made—July 16 in 1923, and August 30 in 1924—and our knowledge of the movements and life history of the elephant seal is still too meager to warrant the drawing of definite conclusions.

On the other hand, a keen look-out during both years for a single possible remaining fur seal proved fruitless. In 1923 complete circumnavigation of the island failed to reveal the slightest trace of these animals, although the polished rocks of the rookeries and even the tiny wooden pegs used a hundred years ago by the seal-hunters to stretch out the skins to dry, could still be found in place on the old killing grounds. It is known that in the more recent raids upon the fur seals their pelts were preserved by salting and not by drying.

What, then, from a naturalist's standpoint, does this former "paradise" hold in the way of hope for the future? Surely nothing of its former wealth of plant and bird life. These are gone forever. From now on the fame of Guadalupe must lie in the fact that it harbors the only known herd of northern elephant seals on earth. Even for them a new and modern type of persecution has lately arisen in the form of disturbance by curious or mercenary photographers and "movie" men. To the lasting credit of Mexico let it be said that she is fully awake to the unique interest of her "elefantes marinos" and has now created Guadalupe Island a federal reservation, protected by a permanent garrison of soldiers. As a result of this wise action, it is within the realm of possibility that these strange animals will have oppor-

tunity to increase until they once more inhabit their ancient haunts up and down the coasts of the two Californias.

LAURENCE M. HUEY
NATURAL HISTORY MUSEUM,
SAN DIEGO, CALIFORNIA

ROGER FREDERIC BRUNEL[1]

IT has been my good fortune to come in close contact with the scientific work of Dr. Brunel from a number of points of view, and I consider it a privilege to have the opportunity to endeavor to make clear in a non-technical way the value and significance of his contributions to the science of chemistry.

My interest in Brunel's work was aroused by his first publication because I was working in the same general field of chemistry and because of the fact that we were graduates of the same university. The thesis presented by him in connection with his work for the doctorate gave a clear indication of his skill in experimentation, and an insight into the kind of a problem that aroused his interest. In contrast to many researches in organic chemistry which have as their aim the preparation of a series of new compounds lacking theoretical interest, the problem under study had to do with the more fundamental properties of molecules. Chemistry is concerned primarily with the study of the transformation of one kind of molecules into another kind. Only recently has attention been paid to what may be called the mechanism of such transformations—that is, the manner in which reaction takes place between the chemical units. Research of this kind involves the development of new methods and a high order of scientific imagination. It is more difficult and less likely to yield a wealth of new facts suitable for publication. It requires quantitative measurement and the point of view of the physicist.

The fact that Brunel began his research work in this special field of organic chemistry, no doubt, was the determining factor in his subsequent activities. All his published work has to do with the study of the most fundamental things of the science. The reputations of many chemists are based upon the fact that they have added perhaps hundreds of new substances to the long list of known organic compounds—Brunel was attracted by the more profoundly important problems of how molecules interact and the nature of chemical affinity itself.

His association with Professor Arthur Michael, immediately upon graduation, was most fortunate, because he came in the closest contact with the leading investigator in organic chemistry in America, and a man of international reputation on account of his leadership in what I may call the philosophy of the science. Michael was studying chemical affinity from the standpoint of energy, and the work of the two investigators led to results of great value.

When I was asked to review Brunel's work I wrote to Profesor Michael to tell him of the action taken by the authorities of Bryn Mawr, as I knew he would be pleased at this recognition of the services of his former co-worker. I have just received a reply to my letter from Professor Michael from Bermuda. He writes:

> The sudden death of Dr. Brunel was a shock to me, as it must have been to his other friends, who, like myself, know his fine personal character. He worked two years with me, so I had ample opportunity to appreciate his acute, rare mentality, and his unusual skill in experimentation. I have always considered Dr. Brunel one of our ablest investigators in organic chemistry, who already had made notable contributions to the science and of whom much might have been expected.

The work done with Michael had for its object the study of variations in chemical affinity brought about as the result of the change in the arrangement of the atoms in molecules of the same composition. In these researches the quantitative point of view, which is not considered in so much work in organic chemistry, was stressed as before—the results obtained were of great scientific value. It may be interesting to point out here that these results have been found useful in connection with certain industrial developments based upon the compounds studied.

One of the outstanding contributions of Brunel was the paper published in collaboration with Marguerite Willcox. This investigation centered around the study of the relative chemical affinities of certain important groups of atoms. The concept of chemical affinity was that derived from modern physics and physical chemistry, and quantitative measurements were made. The mode of attack of the problem and the detailed plan were both most ingenious. The research is a model that could well be followed in investigating further chemical affinity, and this study is, to my mind, the most important problem before chemists to-day.

Another paper published by Brunel, in collaboration with Crenshaw and Elsie Tobin, illustrates a second type of research in which he was a master. In this paper are recorded the properties of certain alcohols. The materials upon which measurements were made with a high degree of accuracy were first obtained in an unusually pure condition. The work showed great attention to details, and the results are taken as standards by organic chemists.

A short time ago one of my own students was preparing a sample of an alcohol and I questioned him as to the purity of his product. He replied with a

[1] Address at the meeting in memory of Dr. Brunel held at Bryn Mawr College on February 5, 1925.