$5. The cost per year of chemicals and of apparatus to provide for breakage should not exceed $6. A class of twenty-five students can be accommodated in a room 20′ by 27′, and the expense of a complete equipment should not exceed $700. For smaller classes the cost should be proportionally less. These estimates are based on the results of extended experience in the construction and arrangement of several laboratories, which it has been my fortune to superintend.

The second obstacle mentioned above has reference to the large teaching force which would apparently be required in such instruction, but it would seem that it is rather a result of a want of knowledge of the best methods of teaching physical science, both on the part of executive boards and of many teachers themselves. From the results of my own experience in similar grades, as well as in more advanced instruction, I am convinced that this difficulty is only apparent. In a high-school course of three or four years, physics should be taught during the junior year and chemistry in the senior year.

In chemistry, two hours a week should be devoted to lecture demonstration, with two afternoons, of two hours each, to laboratory work, and one hour to a recitation on the subjects of the lectures and laboratory practice. The same method should be adopted in the physics of the third year, although from the nature of this subject perhaps a text-book may be used more freely.

The same laboratory will serve for both physics and chemis ry, and in physics the same apparatus will serve for different students. Hitherto the chief difficulty in teaching experimental physics has been the high cost of the apparatus; but suggestions concerning inexpensive forms of apparatus have recently been given for the benefit of the secondary schools by professors of physics, especially by the professors at the Jefferson Physical Laboratory of Harvard University, and such apparatus is for sale by the dealers at a small cost. The same instructor may have charge of physics and chemistry, and the success of such teaching would depend upon his particular qualifications. He should be allowed at least eight hours a week to prepare for class-room and laboratory exercises, with some aid from the janitor or other servant. He should still have considerable time which could be devoted to such other teaching as might seem expedient, perhaps in some other branches of science. In the high schools outside of the larger cities the annual salary of an instructor should be between $600 and $1,500, depending upon the size of the school. One instructor can easily teach a class of thirty members; in the larger schools, laboratory assistants would be necessary; lady teachers with suitable preparation are very successful in laboratory teaching, and this service could be combined with other duties.

I am aware that excellent training in elementary physical science is given in some of the high schools in the larger cities; but, notably throughout the West, such teaching, when it is given at all, is usually confined to routine text-book methods, with little, if any, experimental illustration, at least by the students themselves. Such a system as the one herein described requires certain small expenditures, but the efficiency of the high-school instruction would thereby be greatly improved, and the public would soon appreciate the importance of sustaining efforts leading to broader and more practical training.[1]

If at first the governing boards of high schools should feel the need of suggestions in the preparation of plans and estimates for equipment of laboratory rooms, I am sure that professors in charge of laboratories would gladly render such assistance. The success of this system requires a knowledge of special methods, which many teachers do not possess, but they are enabled to acquire it in laboratories which are open during a part of the summer vacation. The chemical laboratory of Harvard University was first opened during the summer of 1873 for the benefit of teachers, and many now have charge of responsible teaching through the knowledge acquired by continuous attendance during successive vacations.

[1] Every citizen is directly interested in the welfare of the public schools, and all parents will heartily support any endeavor looking towards the attainment of the greatest amount of useful knowledge, as well as the best mental development for their children.

What has been said about physical science in the secondary schools may apply in a different sense and on a higher plain to the condition of scientific training in many colleges. The increasing demand for the admission of college graduates to advanced standing in schools of science should be encouraged, since the discipline of a collegiate course is an excellent foundation for advanced scientific study, provided it includes thorough instruction in the elementary branches of science. A college course should offer, as a part of its required work, comprehensive training in general and descriptive chemistry and descriptive physics with extensive laboratory practice in both subjects. Most colleges can also give elective instruction in qualitative chemical analysis, with some additional study in quantitative analysis Graduates from such courses, which should also include French and German, are well qualified to enter the junior year in the best scientific schools. Unfortunately, at present, not all colleges give a sufficiently thorough drill in elementary physical science, in consequence of which many graduates who desire to enter schools of science labor under a serious disadvantage from a want of the more elementary knowledge. Most colleges, doubtless, feel that they devote as much attention to scientific subjects as is consistent with the thorough general training that is expected in a college course. While this may be true in part, it must be admitted that thorough training in physical science should now have as important a place in a college course as mathematics or the ancient languages. It is not to be expected that the college can provide the expensive equipment for the study of science that is the foundation of the school of science. But every college can afford the small expenditure that will thoroughly equip and maintain working rooms for the use of elementary physics and chemistry, with sufficient instruction to render this study interesting and profitable. The feeling of mutual interest and dependence between the secondary schools and the scientific schools, and perhaps in a less degree between the college and the scientific school as a professional school, should be promoted and encouraged; and whatever aid it is possible to render in either direction should be cheerfully granted.

OUR VACANT PUBLIC LANDS.

BY F. H. NEWELL, WASHINGTON, D.C.

THE total area of the public lands vacant in 1892 has been estimated by the Commissioner of the General Land Office at, in round numbers, less that 568,000,000 acres, these being located in 25 states and territories. Of this total by far the greater part, as is generally known, is in the western half of the United States and mainly west of the 100th meridian. Taking therefore the Dakotas, Nebraska, Kansas and Texas, and the states and territories to the west of these, numbering in all 16, these contained nearly 542,000,000 acres, or about 95 per cent of the vacant public lands. The remaining 26,000,000 acres in the nine political divisions to the east of the states named may be considered as of little value, at least for homesteads. A great part of this is in the swamps of Florida and Louisiana or in what are generally considered non-agricultural regions of Arkansas, Michigan, Minnesota and Wisconsin. The very fact that these lands have not been taken up, although open to settlement for many years, testifies as to the doubts or failures of would-be settlers.

The rate at which the public lands are being sold is also should in the reports of the officer above mentioned, from which the following figures have been culled:

Disposal of Public Lands.

1890	12,798,837	acres
1891	10,477,700	"
1892	13,664,019	"

During the year 1892, the disposal of lands has been abnormal in quantity, owing doubtless to several causes, but mainly from the legislative or official side rather than from increase of settlement. As a rule it may be said that the sales of public lands have been steadily decreasing year by year until 1892, when they suddenly rose far above the average. This is shown by the following brief statement of the original homestead entries:

Comparison of Original Homestead Entries.

1888..........	6,676,616	acres, a decrease of 917,734
1889..........	6.029,230	" " " " 647,386
1890..........	5,531,679	" " " " 497,551
1891..........	5,040 394	" " " " 491,285
1892..........	7,716,062	" an increase of 2,675,668

Taking the average annual disposal of the public lands at 12,000,000 acres, and assuming all the vacant land susceptible re-entry, it would be entirely taken up in less than 50 years. As a matter of fact, however, only a small portion of this vast area can be acquired under the operations of the present laws or is suitable for homestead purposes. A great part consists of high mountains or deeply-eroded plateaus, of sterile lava-covered plains, or is too rough to be valuable for agricultural purposes. What may be considered as the choicest portions of this vacant public land, where the soil is deep and rich and can be readily tilled, are at present almost valueless on account of the aridity of the climate. While on the one hand mountains, canyons and lava plains cannot be removed, yet on the other the aridity, or at least its effects, can be modified to a certain extent, and lands with fertile soil now useless can be added to the producing farm areas of the country. This aggregate area, however, is relatively small, and at the present rate of disposal of public lands it is a question of only a few years when every available acre will be taken.

Under the operation of existing laws, the rate of disposal of vacant public lands must naturally be constantly diminishing, and it follows, that the probable time of disposal of the lands must be indefinitely prolonged. This decrease in sales or number of homestead entries is, of course, not due to diminution of the demand, for each year this is growing greater and greater, but is the result of scarcity of supply. As previously stated, the more available lands have been taken, and each year the choice is more limited, and men are compelled, by circumstances, to enter upon lands which a few years ago they would not have considered worth taking up. In this state of affairs public interest is being turned to questions bearing upon the reclaiming of portions of the remaining public lands, and greater eagerness is shown in developing all the resources by which these may become valuable.

The results of the eleventh census of the United States, as they have been published, cast light upon some points hitherto obscure, bringing out the condition of development of the western part of the United States, as well as of the whole country. Among other facts, the enumeration has shown that the area irrigated in 1889 was 3,631,381 acres. The scattered patches which go to make up this amount were located from points west of the 100th meridian to the Pacific coast, with the exception of the western part of Oregon and Washington. The total land surface of this area, deducting the 36 counties of western Oregon and Washington, is 1,380,175 square miles, or 883,312,000 acres. The area irrigated thus formed about four-tenths of one per cent of this vast country, which contains nearly all possible combinations of soil and climate, ranging from the smooth, almost arren plains, with scanty vegetation to the high, rough mountains, whose peaks are covered with snow throughout the year, and whose slopes have been clothed with thick forests.

Looking at this vast extent of arid and sub-humid land in a broad way, it is possible to distinguish four great classes, according to the amount of moisture received, or the water supply available, as shown by the character of the vegetation, viz., desert, pasture, fire-wood and timber lands. These may be defined as follows: The desert land is that within which the water supply is so scanty that cattle cannot obtain sufficient for drinking purposes, and the vegetation so ephemeral that it has little value for pasturage. The soil, however, is often rich, and when watered, produces large crops. These desert areas of the United States are, however, rarely without vegetation, and the large amount and variety of plant life are often matters of astonishment to the traveller.

The second class, the pasture land, may be said to embrase all of the Great Plain region which, on account of prevailing aridity, is useful mainly as pasturage. The localities at which agriculture is possible are relatively of insignificant size, although of great importance in a grazing country. It also includes the valley lands within the Rocky Mountain region and the rolling hills on which native grasses grow.

The fire-wood land may be defined as that fringing the timbered areas, and intermediate in character between the pasture land and the high, rough, forested slopes or plateaus. It includes also precipitous hillsides found at an elevation too low to receive a large or constant supply of the moisture which falls upon the more heavily timbered areas.

The fourth class embraces the forested areas upon the high mountains where the conditions are such that trees have been able to attain a size suitable for timber. With this understanding, the following table is given:

	Acres.
Desert land..........................	64,000,000
Pasture land..........................	620,912,000
Fire-wood land..........................	115,200,000
Timber land..........................	83,200,000
Total..........................	883,312,000

Of this total, as above stated, less than 568,000,000 acres still belong to the general government.

The irrigated and irrigable lands are mainly included within those divisions which in their natural state have been considered as desert or pasture land. In a general way, it may be stated that fully nine-tenths of this area is covered with a fertile, arable soil which only lacks sufficient moisture in order to be of value for agriculture. If this proves to be the fact, then out of this total of, in round numbers, 616,000,000 acres of arable lands less than six-tenths of one per cent was irrigated in the census year. As to the reclaimability of a large portion of this area, the question of water supply obviously must first be discussed.

CONTRIBUTIONS FROM THE LABORATORY OF THE YORK COLLEGIATE INSTITUTE.

BY C. H. EHRENFELD, YORK, PA.

Effect of Burning on the Volume of Limestone,

In the York, Pa., courts recently, a case was tried which involved the question whether limestone shrinks by being burned. The matter was submitted to me to be tested. On consulting authorities I found the statement given that no shrinkage occurs; but no method was given for making the test. Hence I devised methods as follows: Several pieces of limestone of varying firmness of texture were taken, and permanent marks made upon them. The distance between these marks was accurately measured. The pieces were then burned in a gas furnace at a high heat for about seven hours. After cooling, the distances were again measured, and were found to be unaltered. The pieces were then slaked with water, to ascertain if the burning was complete. Another test was made in the following manner: The pieces of stone were dipped into melted paraffin and quickly removed in order to coat them with a very thin layer of paraffin, sufficient to render them impervious to water, but not enough to add materially to their volume. Their volumes were then determined accurately by lowering them into a graduated vessel partly filled with water. After being burned, the pieces of stone were again dipped into melted paraffin and the volume determined as before. It was found that no change whatever had taken place.

Water in the Spheroidal State.

While carrying on a piece of work recently which involved the use of a common Liebig condenser, it was noticed that where the stream of waste water fell into the water-trough, the bottom of which was rough, small globules of water were formed, which darted out on all sides and ran on the surface of the water to the sides of the trough, eight or ten inches distant. Frequently