That which is called and taught as science has its errors, and fallacies, and partial statements, and pitiful special pleading, like other departments of knowledge. The poet who clothes human thought in beautiful and elevated language, and gives best utterance to our highest aspirations; the preacher who inculcates self-renunciation and brotherly kindness; the painter or artist who preserves in form or color a loved human countenance or the vanishing splendor of a summer sunset; and the musician who glides into our inner being with melody or song, and fills us with sweet unspoken rapture, are equal interpreters of the truth with the scientific discoverer.

Ideality is not the observing faculty, but it co-ordinates facts and gives them expression.

The highest results of scientific study are *subjective*, not objective; they consist in developing the possibilities of observation and expression of the student, rather than in the many new objects he may discover.

The lecture was illustrated by microscopical preparations and living objects, among which were the jelly glands of *Brasenia* and the lately discovered rotatoria *Melicerta Emalii*.

MOULD AS AN INSECT DESTROYER.

By C. G. SIEWERS.

THE perplexing problem: How shall we check the excessive increase of noxious insects that imperil our crops? has been put in a fair way of solution by the researches of Dr. Bain, a Prussian savant, as recorded by Dr. Hagen, of Cambridge, Mass., in the June number of the *Canadian Entomologist*.

When Pasteur, employed by the French Government to investigate the fatal malady that had attacked the silkworm, made the discovery that the disease was caused by a fungous growth which he styled *muscardine*, that it could be imparted to healthy larvae simply by crushing infected ones on their food, and that the disease could be detected, by means of a lens, in the egg itself, and thus the good eggs separated from the bad, he saved from utter ruin thousands of French families whose main support depended on this industry. But he did more. Though he carried his researches no farther, others took up the investigation where he abandoned it, and the result of Dr. Bain's experiments, continued for twelve years, seem to have established the following facts:

That the mould of the mash tub, known as yeast, the mould that infects flies and fastens them to our walls and windows, the common mould of cellars and damp places, and the mould that attacks certain water plants, are but different developments of allied species of fungi, and alike fatal to certain species of insects that are brought into contact with it; and that the disease was developed in France by moist food, lack of ventilation and cleanliness, is probable, and though many were able to pass through all stages, their infected eggs spread the disease through the land, and in this way became epidemic.

I have just had an unpleasant experience of the effect of mould in the loss of a full-grown imperial walnut larva that I had reared from its first moult. Its food was inserted in wet sand in a covered tub, and before I was aware its droppings and food were covered with mould. Fresh food, a sun bath, and change of quarters were of no avail; it refused food for four days, then dropped from its perch a moist discolored mass.

In an article in the *Canadian Entomologist* (1877) I gave an account of a large colony of *Callimorpha* larvae, a species by no means common generally, and of my failure to bring one larva in two hundred to the pupa state. They were all taken at maturity, like the French silkworms, with a purging of whitish serum. The weeds on which they fed in the woods were also covered with their dried skins. The next year they were as rare as ever.

In the spring of 1874, the shade trees of our town, Newport, Ky., were attacked by legions of small gray caterpillars, spinning up and destroying the foliage, and invading doorways in such multitudes that the house broom was in constant requisition. Fine shade trees were hewn down, or fearfully lopped of their branches to abate the nuisance. They attacked the silver poplar in preference to all others, a tree singularly free from caterpillars heretofore. I found a small tree in my yard badly infested, and promised two small boys one cent a nest for all they got down with not less than twenty-five in a brood, and burning them as they were brought me, paid them ninety-seven cents for their hour's work. What was to be expected the next year but the total ruin of every shade tree; but my payment to the same boys was but forty cents, and the next year not one was to be found, and they have never returned to vex us. Continuous wet and cloudy weather may be sufficient to infect with fungus the food these caterpillars eat, but wherever we turn our eyes we find the provisions of nature ample to repress surplus life on this globe, and in no case more so than in our own species, where the half that survive infancy are winnowed out by sword, pestilence, and famine, till but a corporal's guard can be rallied at our allotted term of three-score years and ten.

The cases I have described are by internal poisoning; I will add one where the poison fungus acted externally. My first attempt to carry through the winter that hibernating larva, the black bear (*Espanthera*), proved a total failure, as I put them away in the cellar where they were attacked and covered with mould, and though I washed and brushed them apparently clean, dried them in the sun, and kept them out of doors the rest of the winter, they all died in the spring, refusing all food. Put away the next winter in leaves and brush, in the open air, I lost but one in ten. Exposed all winter to snow, frost, and rain, under chips and wet leaves, coming out in the spring to feed, distended with moisture, they are perfectly healthy, for no fungus spores have been able to fasten upon them. That prolific oak larva, *Anisota senatoria*, is also a badly infected species, which makes it rather lucky for oak trees, for but few of them ever come to maturity.

Experiments with diluted yeast should be tried on the potato bug, tobacco, army, and cotton worm, and on the grasshoppers of old pastures and clover fields. The proper policy is not to kill, but simply to infect them that they may disseminate the poison. But while we fill the air with fungus spores let us have a care to discriminate between the just and the unjust; in slaughtering the Colorado bug and grasshopper, let us not also lay violent hands on our honey bee, on our harmless and beautiful butterflies, and on the various insects that sport in the sun and enliven the face of nature. The bugs and the worms that annoy us can easily be kept in check, as I have shown, by paid handpickers.—*American Naturalist*.

ZINC VEINS AND WORKS OF LEHIGH VALLEY.

ZINC ore was first discovered in Pennsylvania on the site now occupied by the small village of Friedensville (Village of Peace), in Lehigh County, in 1845. The village stands at the head of the beautiful Saucon Valley, rich in an agricultural sense, and doubly so in minerals—iron and zinc. In 1847 William Theodore Reeeper, a resident of Bethlehem, and later Professor of Mineralogy in Lehigh University, from a pure love of science wandered over the spur of the South Mountain, that separates the Saucon Valley from Bethlehem, and was shown by a farmer (Ueberoth) a mineral that had puzzled the local mineralogists to classify. He pronounced it to be "calamine," or native carbonate of zinc. This haphazard discovery led to the development of the apparently inexhaustible mines that have for more than a quarter of a century supplied the large works of the Lehigh Zinc Company at this place. The works were erected by Maj. Samuel Wetherill, now of Philadelphia, in 1853, for the production of zinc oxide, in furnaces, by a process of Maj. Wetherill's invention. The works cost \$85,000, and on October 13, 1853, they produced the first zinc-white ever made in America. Maj. Wetherill commenced his experiments as early as 1850, believing that it was possible to substitute the oxide of zinc for white lead for paints. In 1852 he successfully invented his "furnace process." This, combined with the "bag process" of Richard Jones, Esq., made the matter possible. Before completion the works were blown down by a tornado, but immediately rebuilt, Charles J. Gilbert, Esq., of New York, being Maj. Wetherill's partner. The works had an annual capacity of 2,000 tons. Up to 1857, when Messrs. Gilbert & Wetherill sold out to "the Pennsylvania and Lehigh Zinc Company," the product had been 4,775 tons of oxide. This company was composed of New York capitalists, with a capital of \$1,000,000, and Thomas Andrews, of New York, was the first president. Maj. Wetherill continued in the superintendence of the works until 1857, when he was succeeded by Mr. Joseph Wharton, of Philadelphia. The latter leased the works, and his financial ability and his means and credit floated the concern through the financial storm of 1857. In 1860 the title of the company was changed to the Lehigh Zinc Company, and it is now a strictly Philadelphia company.

These works produced the first *metallic zinc* made in America. Maj. Wetherill had made many experiments looking to the production of metallic zinc, but had been only partially successful. In 1859 Mr. Wharton contracted for the erection of spelter works, and their erection was entrusted to Mr. Louis De Gee, of the firm of De Gee, Gerant et Cie, of Ougree, Belgium, who had been induced to come to the United States for this purpose. These works were put in successful operation, and produced the first metallic zinc in July, 1859. The operatives in this department were at that time imported from Belgium, and importation of Belgian experts and workmen have been frequent since. These spelter works have been in active operation from that time, and during the Franco-Prussian and Turko-Russian war the European demand upon the works was very large for the manufacture of cartridge cases.

In all that pertains to the original in the application of zinc these works seem to lead. The first sheet zinc, as well as the first spelter, was here made. Under the superintendence of B. C. Webster, Esq., then and since 1863 president of the company, a mill for the rolling of sheet zinc was erected in 1864 and 1865. Alex. Trippel, who had been sent to Europe to acquaint himself with the production of sheet zinc, had supervision of the erection. The first sheet zinc in America was rolled in these works in April, 1865.

Before describing the mines that supply all these works, and which are a wonder in their way, a brief description of the buildings and the process of manufacture will not be without interest. The old oxide works include about two acres of buildings, furnaces, tower, dry room, bag room, and packing houses. The ore for this purpose is ground fine by a stone crusher, and then carefully mixed with coal known as "buckwheat," next in grade to "pea." It is then transferred to the furnaces, of which there are fifty-four, with 1,390 feet of grate surface. Within these the mixed coal and ore is reduced by the direct action of heat and the cold blast upon a furnace bed having a multiplicity of small holes, each producing the reducing flame of the blowpipe. The zinc oxide rises, passes through a huge combustion flue to a large circular tower, 50 feet high, in which the oxide and ashes separate. The ashes being heavier than the oxide, the velocity of the fans which impel the product forward lifts the oxide to the top, and the ashes drop to the bottom. The oxide is forced onward through a cooling room, size 80 by 40 feet, and heated to from 400° to 700° Fahrenheit. Thence the oxide is blown through large flues into the "bag" room. This is a huge building, devoid of furniture, excepting long bags of muslin, 45 feet long, in which the oxide is deposited. It is now white as snow, and, after being kiln-dried and bolted, it is placed in bags, and by heavy pressure reduced in bulk, barreled, and is ready for shipment.

The spelter furnaces cover a space about one-half that occupied by the oxide department, taken up by rooms for storing ore, grinding rooms, dry room for retorts, pottery, reverberatory furnaces, and spelter furnaces. Of the latter there are thirty-two. The ore, having been ground and mixed with coal, passes through the reverberatory furnaces. In calcinating it changes from a blue blende to a deep yellow. The sides of the furnaces bristle with retorts. These are charged with the calcined blende, the mouth of each being covered with a fire-clay condenser. A intense heat is maintained by fires beneath, and condensation takes place within the cones. The metal is then drawn out into ladles, poured into iron moulds, forming ingots about 1½ inches deep and 7 by 22 inches in size. When cooled the metal is ready for the sheet mill or the market.

The rolling mill is a brick structure 103 by 64 feet. The sheets are heated in ordinary annealing furnaces, and are rolled by ordinary two-high sheet rolls. The secret of polishing the plates consists in rolling numbers of them at a time and changing their position in the "pile," the friction doing the work. As early as 1857 Maj. Wetherill had sent some metal to the sheet-iron mills of the Messrs. Wood, which was successfully rolled and showed the malleability of the metal. The polish was wanting. When Maj. Wetherill first saw the simple process by which the metal was polished—and considered how much thought, time, labor, and money he had spent in trying to find the secret—he relieved his mind with a cavalry man's expletive and walked away. The sheets are cut into any size desired, and a recent invention enables the company to cut circular plates for stoves, of which there is a large demand. The American sheet zinc supplies not alone the home market now, but much of it is sent abroad. It is fully up to the standard of the popular "La

Vieille Montaigne" of France, and because of its freedom from arsenic and iron is often preferred.

The capacity of these works is as follows: For oxide of zinc, 3,000 tons per year; for metallic zinc, 3,600 tons per year; for sheet zinc, 3,000 casks, or 1,800 tons, or about one-half the annual consumption of the country. From 300 to 500 men are employed by the company, and 40,000 tons of coal are annually consumed.

All this has grown up from Prof. Reeeper's discovery in the Saucon Valley, and it is worth while returning to this point. The mines are four miles away from the works, and all the ore is hauled by heavy teams over the rough mountain roads. The consumption of ore taken from these mines has reached the enormous quantity of 19,000 tons in a single year, including rich blende, which has been developed in the progress of mining. The main shaft is 250 feet deep, and the valley is arched and tunneled and cut away to a great depth and in a perfect network to get at the seams of the veins.

All about are evidences of a violent upheaval in the long ago, and in the crevices between the rocks the calamine or blende is found, with veins of iron ore at times mixed with the zinc veins. The veins are followed under, over, and around huge rocks, which are carefully propped up, and the leads are a perfect labyrinth of rocky-begirt aisles, a wonder to behold, and a rare study for the geologist, the metallurgist, and the engineer. But the curiosity of the mines is the monster engine—believed to be the largest and most powerful in the world, and, in honor of the efficient President of the company, happily named "Webster's Unabridged." At an early day, and at a shallow depth, water was encountered in working these mines. It was overcome by a small pump, worked by a single horse power. Later this was followed by a donkey pump, still used for dressed ores. Then, as the mines went downward, came a Burdon engine of 30 horse power. This was followed in 1863 by a Corliss engine of 100 horse power, working a series of centrifugal pumps, which found their limit at a depth of 65 feet, with 1,500 gallons of water per minute. But the water came faster than the pumps could remove, and the company decided to make some lasting provision for controlling it, by establishing power to raise 4,000 gallons per minute from a depth of 150 feet, if so much should be found, and to this end they erected and started, in 1865, an engine of 32 inch cylinder and nine feet stroke, working two 22 inch lifting pumps, to which a third 22 inch lift was soon added, with 17 strokes per minute, and the shaft carried down to 122 feet, in 1866, when it encountered and raised 5,600 gallons, and there found the limit of its capacity.

Mr. John West, the engineer of the company, had already matured a plan of engine, pumps, and shafts, for raising 12,000 gallons per minute from a depth of *three hundred feet*, and in December, 1868, the company contracted with the Messrs. Merrick, of Philadelphia, for this new engine, and a year later with Messrs. I. P. Morris & Co. for the pumps, boilers, and mountings. The timber for shaft and pump-rods was brought from Georgia. This engine and its pumping apparatus were set in motion January 19, 1872, in the presence of a large concourse of people, and amid interesting ceremonies. A technical description of the engine is not wanted, but the following particulars will not be uninteresting: The engine has a pumping capacity of 17,000 gallons per minute (and has run to 19,000 per minute in an emergency), raising water from a depth of 350 feet. The engine alone weighs 650 tons, and including the pumps and boilers, the total weight of the machinery is 1,000 tons. The cylinder is 110¼ inches in diameter; length of stroke, 10 feet. The heaviest pieces of iron in the engine are the sections of beams, which weigh 24 tons each. The fly-wheels, of which there are two, weigh 75 tons each; crank pins, 1 ton each. The piston rod is 14 inches in diameter. The cross-head weighs 8 tons. The connecting rods have 9 inch necks, are 15 inches in the middle, 41 feet 2½ inches long, and weigh 11 tons each. There are two air pumps, 50 inches in diameter each. The engine drives four plunger pumps, each 30 inches in diameter by 10 feet stroke, and four lifting pumps, each 31½ inches in diameter by 10 feet stroke, the plunger pumps being uppermost and stationary. The lifting pumps are in the bottom, and are movable, so as to go down as the shaft is sunk. To handle these pumps a steam capstan capable of lifting 50 tons vertically is used.

The foundation that holds this moving mass of iron—and it moves without a jar, is a marvel. The bob-wall of solid masonry, 9 feet thick, was commenced on a plant of solid rock 114 feet below the surface. The foundation for the engine is 32 feet deep below the bedplate. The engine is estimated at 3,500 horse power. The engine is conceded to be the largest fixed single engine in the world, that at Haarlem Meer being a compound engine, with one cylinder within the other. She works comfortably at 12 strokes per minute. Altogether, this engine is a marvel of mechanical skill, and it has attracted visitors from all sections of the world.

This monster is now standing idle. Recently the company discovered a new vein of blende, which they are now working without any interference from water. This vein is not only very rich, but has some very peculiar and desirable characteristics, being available, when worked with brass or copper, for purposes unknown to ordinary zinc—among others, that of making metallic cartridges. The cost of running the large engine was so great that for a time it was feared these works would have to close up. An advantageous contract and the discovery of the new vein have averted this calamity to South Bethlehem. The works occupy ten acres of ground, and their cost has been as follows: Oxide works, \$125,000; spelter works, \$100,000; rolling mill, \$51,000. Total, \$276,000.—*Public Ledger*.

THE PROGRESS OF IRON AND STEEL AS CONSTRUCTIVE MATERIALS.*

By MR. J. A. PICTON, F.S.A., Liverpool.

THE working and employment of metals have from the earliest ages exercised a most important influence on the progress of the human race. The ancient poets celebrated in song the golden and silver ages, typifying what was supposed to be the primitive state of innocence and purity of our early fathers; but the real advantage and progress of humanity commenced with the use of iron. It would be hardly possible to exaggerate its importance in the economy of human affairs. The employment of iron is a crucial test of the civilization of any people at any period of history. Without it art and science are comparatively unknown, and progress, except to a very limited extent, is impossible. With the free use of iron commenced the dawn of the arts of life. Every invention which contributes to material comfort, every pursuit which tends to elevate humanity, is

* Read before the Iron and Steel Institute.