THE DIFFERENCES BETWEEN MALARIAL AND NON-MALARIAL MOSQUITOES.

BY L. O. HOWARD, PH.D.

The attention of the medical world is now focused on the mosquitoes of the genus Anopheles owing to the fact that the species of this genus have been shown to be carriers and transmitters of micro-organisms of human malaria. The more abundant mosquitoes of the genus Culex have not been found to be able to transmit malaria germs. The biology of Culex has been known since the 17th century, but that of Anopheles has never been described, so far as the writer knows. So many physicians are taking up the study of the mosquito-malaria relation under local conditions in different parts of the country that it is highly important that they should be able to distinguish at once between Anopheles and Culex in any stage of growth. During the present spring the writer has worked out the life history of *Anopheles quadrimaculatus* at Washington and has carefully figured all stages. It is strikingly different from Culex in every stage from the egg to the adult, as a glance at the figures accompanying this article will readily show. It also differs in habits. The two species contrasted in this article are *Culex pungens* and *Anopheles quadrimaculatus.*

THE ADULT.—The main structural difference between Culex and Anopheles in the adult condition is that the palpi of Anopheles are nearly as long as the sucking beak, whereas in Culex they are very short. Anopheles, as a rule, has spotted wings, while the wings of Culex are as a rule not spotted. The males of both genera are readily distinguished from the females by the fact that the antennæ and palpi are feathery in the male, and not feathery in the female.

Resting Position.—A member of the English Malarial Expedition to Sierra Leone made a rough field sketch, which was published in The British Medical Journal, and which is here reproduced, which indicates that in resting the adult of Anopheles hold its body nearly at right angles to the surface upon which it stands, whereas in Culex the body is nearly parallel to this surface. Observations at Washington showed that this difference holds when the mosquito is resting upon a ceiling or any other horizontal wall, but not when it is resting upon a perpendicular side wall. In the latter case Anopheles frequently holds its body nearly parallel with the wall. A uniform difference, however, is seen in the fact that in Anopheles the body and beak are always held in about the same plane, whereas in Culex the head and beak form an angle with the rest of the body.

Note of the Female.—The peculiar hum of the mosquito is well known. There is a distinct difference between the hum of *Anopheles quadrimaculatus* and that of the common species of Culex in that the former is noticeably lower in pitch. The note of Culex as it approaches the ear is high in pitch while that of Anopheles is certainly several tones lower and of not so clear a character. In quality it is something between the buzzing of a house-fly and the note of Culex.

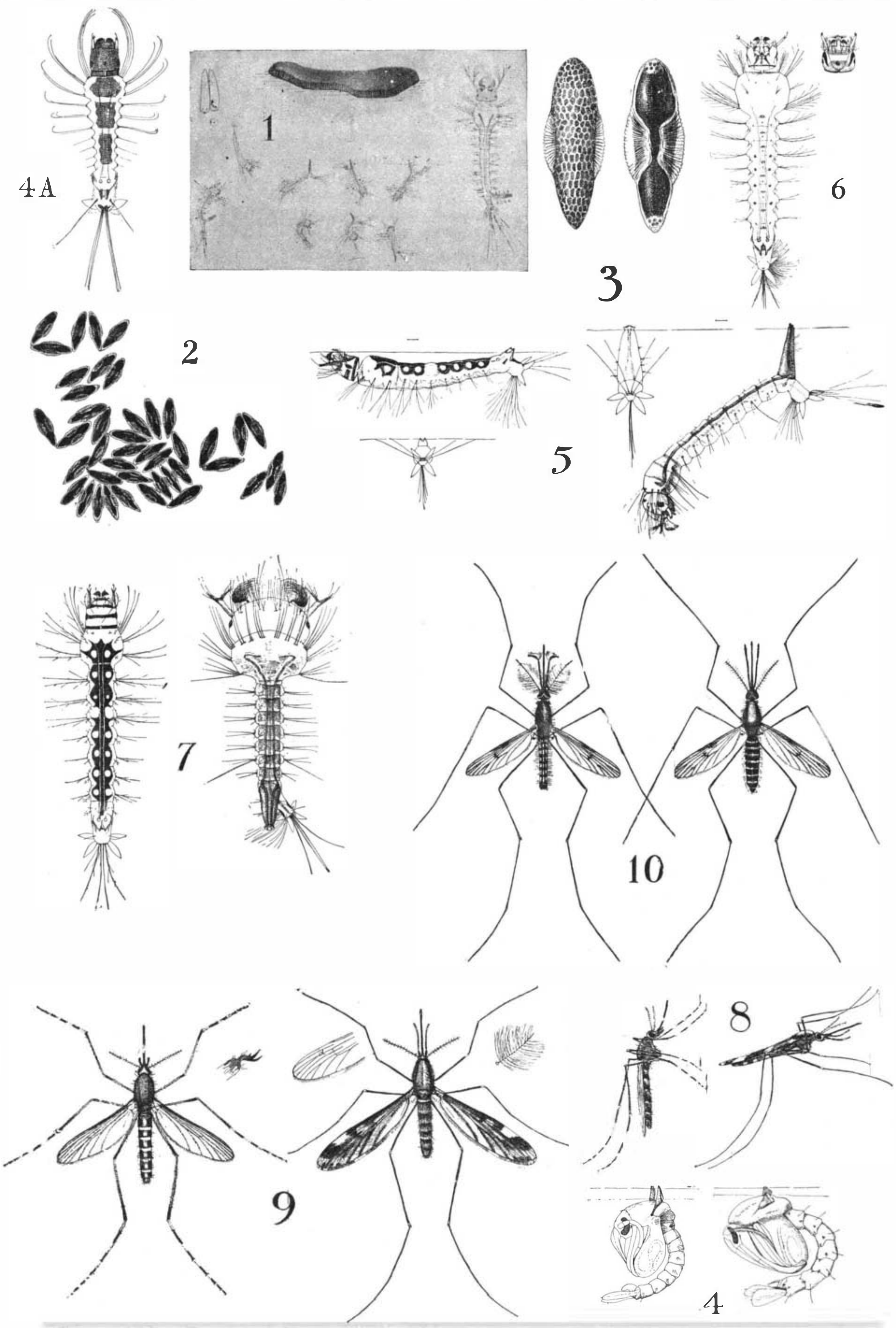
THE EGGS.—The eggs of Culex, as is well known, are placed perpendicularly on the surface of the water closely joined together into a boat-shaped or raft-like mass. Those of Anopheles, however, are radically different. With *Anopheles quadrimaculatus* the eggs are laid loosely on the surface of the water, each egg lying upon its side instead of being placed upon its end as with Culex. They are not attached to one another except that they naturally float closely to one another, and there are about 40 to 100 eggs in each lot. The individual egg is of a rather regular elliptical shape, strongly convex below and plane above. Its characteristic appearance is shown in the accompanying figure. It is 0·57 mm. long. The eggs are laid at night, as with Culex, and hatch in from three to four days in May.

THE LARVÆ.—The larva of Anopheles is quite as unlike that of Culex as is the egg. It differs in structure, in its food habits, and in its customary position so markedly that it can at once be distinguished with the utmost ease. The larva of Culex comes to the surface of the water to breathe, thrusting its long breathing tube through the surface layer and holding its body at an angle of about 45° with the surface of the water. It descends at frequent intervals toward the bottom, to feed, returning to surface every minute or two. Its specific gravity seems to be greater than that of water so that it reaches the surface only by an effort and when it is enfeebled for any cause and is not able to wriggle up to the surface it drowns. The larva of Anopheles, however, until it becomes nearly full-grown, habitually remains at the surface of the water. Its breathing-tube is much shorter than that of Culex, and its body is held not at an angle to the surface, but practically parallel to the surface and immediately below the surface film. Its head rotates upon its neck, and it feeds with the underside of the head upward, the venter of the rest of the body being below. In this customary resting position the mouth parts work violently, the long fringes causing a constant current toward the mouth of particles floating on the surface of the water which eventually enter the alimentary canal. The spores of algæ, bits of dust and everything which floats follow this coarse and can be seen to pass through the head down into the alimentary canal. The color of the young Anopheles larva is dark, nearly black, while that of Culex is light gray or faintly yellowish. Since the Anopheles larva feeds only upon these light floating particles its specific gravity is nearly that of the water itself, and it supports this horizontal position just beneath the surface film with ease. It requires an effort for it to descend which it apparently never does, up to the period of the final larval stage, except when alarmed. The structural differences are very marked, the great size of the head and thorax of Culex as contrasted with the small head and thorax of Anopheles being shown plainly in the illustration. The arrangement of the hairs is entirely different, as the figure indicates, and the compound hairs of Anopheles contrast strongly with the simple hairs of Culex. As already pointed out, the very long breathing-tube of Culex is entirely different from the very short one of Anopheles. The larvæ of Anopheles feed with avidity upon the spores of algæ which seem to be their proper food. Those studied were in jars in which occurred algæ of the genera Oedogonium, Cladophora, Spirogyra and Oscillaria. They reached the last molt in 10 days, considerable cold weather, however, having intervened, and remained in the last larval stage, 6 days, transforming the pupæ 16 days after hatching.

THE PUPÆ.—The differences in this stage between Culex and Anopheles are not so marked as in the larval stages. The structural differences are shown in the accompanying illustration. The difference in resting position is rather marked, the pupa of Culex resting in a more perpendicular attitude than that of Anopheles, and there is a marked difference in the shape of the respiratory siphons, which now issue from the thorax instead of from the anal end of the abdomen. The pupa of Anopheles is quite as active when disturbed as that of Culex. If one touches the nearby surface of the water the pupa at once wriggles violently downward, returning shortly to the surface for air.

The extreme activity of both larvæ and pupæ of mosquitoes is a necessary factor in their struggle for existence, since stagnant pools of water swarm with predatory animal life. The larva of one of the water beetles of the family Hydrophylidæ, for example, eats hundreds of other aquatic insects in the course of its existence, and the larvæ of mosquitoes do not escape entirely, although by their extreme activity they stand a better chance than do other more sluggish species.

The duration of the pupa stage of Anopheles varies



1. Egg mass of Culex, with newly hatched larvæ. 2. Egg mass of Anopheles quadrimaculatus. 3. Greatly enlarged eggs of Anopheles, showing structure (from below at left, from above at right). 4. Pupa of Culex pungens (at left), and of Anopheles quadrimaculatus (at right). 4a. Newly hatched larva of Anopheles. 5. Half-grown larva of Anopheles (at left), and Culex pungens (at right), showing position with reference to the water surface. 6. Full-grown larva of Anopheles; dorsal view; head reversed in feeding position; dorsal surface of head at right. 7. Half-grown larva of Anopheles (at left), and of Culex (at right). 8. Resting position of Anopheles (at right), and of Culex (at left), redrawn from British Medical Journal. 9. Adults of Culex tæniorhynchus (at left), and Anopheles punctipennis (at right), showing structural differences between the two genera. 10. Anopheles quadrimaculatus, adults; male at left, female at right.

THE MALARIAL (ANOPHELES) AND THE NON-MALARIAL (CULEX) MOSQUITO.

according to the weather. Five days was the minimum observed during June, although several specimens remained in this stage for 10 days. The entire life-round, therefore, of *Anopheles quadrimaculatus* is as follows: Egg stage, 3 days; larval stage, 16 days; pupal stage, 5 days; making a total for the early stages of 24 days. It should be stated, however, that during the early larval existence in May there occurred nearly a week of cool weather, so that it is certain that in the hot season of July and August the growth and transformation will be more rapid. In 1895 the writer traced one entire generation of *Culex pungens* in June in 10 days.

The writer is frequently asked as to the duration of the adult stage of mosquitoes, but beyond the statement that the adults hibernate, living in this condition from November to April in the latitude of Washington, D. C., he has been unable to give a satisfactory answer. They die rather quickly in confinement in the summer. Anopheles hibernates in the adult condition, and the writer has had living specimens in confinement in breeding jars for 8 days, all dying at the expiration of that time. This, however, is not a fair indication of the length of free individuals, and as the specimens in question were all captured specimens, they had lived an unknown number of days before capture. There are two genera of large mosquitoes found rather commonly in our Southern States—Megarrhinus and Psorophora, which Southern investigators should study as to their possible function as carriers of the malaria plasmodium. Neither of these forms has been studied in this connection, and it seems to the writer that from their large size and blood-sucking propensities their possibilities as transmitters of blood-inhabiting micro-organisms are great.

THE WHEAT CROP OF CALIFORNIA.

Cultivation of wheat in California will long continue to be one of the greatest sources of wealth to that surprisingly fertile State. The history of the industry is perfectly well defined. Introduced by the fathers of the missions, in 1769, from seed brought from Mexico, the adaptability of the country for the growth of cereals was quickly demonstrated, and the object accomplished of rendering the country independent of Mexico for its breadstuffs. During the supremacy of the missions enough wheat was raised to more than supply the scanty population of the period, and this condition of affairs continued until the confiscation of church property in 1824, after which the cultivation of wheat declined. In 1847, but little wheat was produced and that of a very inferior quality. The era of gold mining interrupted agricultural pursuits for several years, but, by 1854, the local crop began to appear upon the market in increasing quantities and to gradually displace importations from South America and the East.

The exportation of California wheat to English ports, probably as ballast, has been followed by ever increasing shipments until now a hundred of the finest sailing vessels of the world's fleet are employed in the traffic.

The new era, beginning with the American occupation of the country, was due to the great influx of a highly intelligent class who came in search of gold. Probably not five per cent of these people contemplated a permanent stay. They knew little about the agricultural possibilities of this new land, and never suspected that the riches of the gulches were actually secondary to the wealth that lay dormant in the soil. Unsuccessful in the quest of gold, and with resources greatly impaired, these men were obliged to return to their familiar occupations as agriculturists and of necessity to the cultivation of crops requiring the least labor to mature, and to such as would find the promptest market at remunerative prices. Hence, the early attention given to raising wheat. The bay and river system of the country gave access to the most fertile valleys of the world in every direction. Acres and acres of virgin land only required the scratch of the plow to yield abundantly. In six months crops could be gathered and brought to market and sold at prices that meant riches. Hence, in 1854, the crop of wheat amounted to enough to supply the country and allow a small quantity for export.

The acreage devoted to wheat continued to increase until 1899, when it amounted to 3,300,000, with a crop of 18,723,680 centals. Since then the acreage has gradually become less. In 1899–1900 there was (estimated) 2,750,000 acres in wheat with a crop (estimated) of 20,000,000 centals.

The conditions insuring a large wheat crop in California cannot be said to depend upon the quantity so much as the timeliness of the rainfall. The great crop of 1880 was produced with a rainfall of but 16·74 inches (in San Francisco), at least 10 inches below the annual average.

Lands devoted to wheat in California include those reclaimed from the beds of rivers by embankments, which have been under water for ages and never produced anything but rank growths of vegetation. Once protected from overflows, the crops of fruit, vegetables or cereals grown upon these lands are surprising. Instances of 40 sacks of wheat, averaging 130 pounds, as the product per acre of a reclaimed farm, multiply; and knowing their exceeding fertility and witnessing the rank, powerful growths of the stalk before harvest time, such a yield ceases to astonish. Wheat grown upon these soils, however, does not rank in quality with the best.

Lands which are protected from overflow by artificial levees, of which there are hundreds of thousands of acres along the banks of the Sacramento and San Joaquin Rivers, are the finest wheat lands of the State, and the most valuable. Lying low, they are independent of drought, and their natural fertility has been augmented by deposits brought down by overflows before the levees were constructed. The Yalo basin on the Sacramento River, in time of harvest, is a sight beyond description. The wide, level valley, stretching on both sides of the river, is a golden sea of vegetation. The great Glenn ranch of 60,000 acres, all in wheat, is situated here. The high lands, located above the influence of river floods, and dependent upon rainfall for moisture, extend in these valleys to where the foothills begin. They are of vast extent, and produce the finest, deepest and weightiest wheat grown in the world. They average, perhaps, six sacks, of 150 pounds each, per acre.

After persistent cultivation the reclaimed and leveed lands show no signs of exhaustion. No fertilizers have ever been added to these fields other than the charred straw burned after each harvest. The high lands, some after fifty years of continuous planting to wheat, upon which no fertilizers have ever been spread, do show the effects of wear, though these lands are quickly restored to their old fertility by deep plowing and a change of crops. Alfalfa substituted for wheat for a few years, and then a change back to wheat, has shown as fine crops on these soils as were ever raised.

These high lands are all capable of irrigation. In Merced County, where thousands of acres of wheat are planted under the superb irrigating system there established, crops never fail and are always of huge dimensions.

The fortunes so rapidly acquired by the early wheat growers naturally influenced others to follow their example; but the scarcity of laborers became a serious problem when the wheat area increased to hundreds of thousands of acres. Then it was that mechanical ingenuity supplied the means for plowing, cultivating, seeding, and harvesting the enormous wheat crops.

To California mechanics is due the distinction of instituting steam for hand labor in manipulating cereals in the fields. Huge 50-horse power traction engines, of the "Best" type shown in our illustrations, with driving wheels 60 inches in diameter, and flanges 60 inches in width, drawing over the fields sixteen 10-inch plows, four 6-foot harrows, and a press drill to match, plowing, harrowing, and seeding from 45 to 75 acres at one operation each day, explains why the vast crop of California, covering millions of acres, can be planted and cultivated in a country where the supply of labor is not great enough to plant a crop one-tenth part as large. In the harvest time, by the aid of one of those enormous harvesters, whose cutters are 26 feet wide, the wheat is at once headed, thrashed, cleaned, and sacked, ready for market, the machine in one day gathering the crop of seventy-five acres.

To observe one of these enormous machines traveling over the uneven surface of these fields, crossing wide ditches, or crawling along the side hills, surmounting every obstacle with the most perfect ease, and automatically gathering in the ripened grain, sacked ready for market, is a sight of the rarest description.

These mechanical prodigies are adapted only for countries like California, with seasons of wet and dry, well defined, where cereals ripened by hot suns easily fall from the husks. For the moist lands of the great North these harvesters have not proved an entire success.

Preparing the ground for the coming wheat crop in California differs little from the methods used in other countries, though "deep" plowing is not common. On the higher lands the furrow is never over 6 inches in depth, and rarely over 5 inches. Deeper plowing is thought to dry out the land too fast and is avoided on that account. Summer fallowing is on the increase, and to allow absolute rest in alternate years is more and more encouraged. Five crops in ten years aggregate, it is found by experience, as much as yearly crops would do. In summer fallowing, plowing during the late spring rains is the custom. The land lies undisturbed, with the exception of running over a weeder during the season. On the first rain the cultivator is run over the ground, which is seeded at the same time, and then cultivation is over. No further attention is required until the maturity of the crop.

The marketing of California wheat bears no resemblance to the methods of the great Northwest. Wheat in bulk is unmarketable. Shippers and exporters refuse to handle it. A cargo in bulk was once sent to Liverpool; the ship was never heard from. Since that time shipments in sacks only are permitted. Otherwise no insurance can be effected.

San Francisco, Port Costa and Stockton are the great tidewater markets for wheat. The latter city is the great manufacturing center of the coast. Its great flour mills turn out 8,000 barrels every day. It is at the head of navigation of the San Joaquin River system and an important station of two transcontinental roads. Its warehouses have a capacity for 120,000 tons. Its flour is known the world over. The flour mills of the State have a capacity of 20,000 barrels daily. San Francisco has a warehouse capacity of 120,000 tons, under the control of its Produce Exchange. All foreign shipments are arranged at this port, and every question of values, insurance, or exchange adjudicated. The operations of the Produce Exchange are enormous in their volume, and it enjoys the unlimited confidence of merchants, foreign and at home.

Port Costa, forty miles north of San Francisco, on the bay, has warehouse facilities for 290,000 tons. The great storehouses extend for miles along the water front, and at these docks ships from all over the world find the best facilities for prompt loading. This point is the head of deep water navigation on San Francisco Bay, and there have been seen forty vessels at the docks at one time, all waiting for cargoes for foreign countries.

California wheat and flour find a market in Europe, Mexico, Central and South America, Australia, China, and Japan. The islands of the Pacific are taking increased quantities. Siberia is becoming an active customer, and South Africa, until war interrupted, consumed large amounts. Flour as well as wheat is handled only in sacks.

The future of California wheat is dependent upon price. At a rate remunerative to the grower the quantity now raised could be greatly exceeded. With a plentiful supply of moisture, such as an intelligent conservation of the resources of streams now going to waste would assure, the wheat crop of the State could be quadrupled.

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Formation of Selenide of Zinc.

At a recent meeting of the Académie des Sciences, M. Forizes-Diacon describes a series of experiments in which he obtains the selenide of zinc in two different crystalline forms. By causing the vapors of selenium to react upon zinc at a high temperature, M. Margottet obtained an amorphous selenide of zinc which, when strongly heated in a current of hydrogen, gave rise to long needles, yellow by reflection and red by transparence; these crystals derive from the cubical system. As sulphide of zinc crystallizes, according to circumstances, in the hexagonal or the cubical system, the experimenter wished to prepare a hexagonal form of the selenide of zinc, which would thus show a similar dimorphism. By reacting upon chloride of zinc in vapor with a mixture of nitrogen and hydrogen selenide, he obtained fine crystals, yellow by reflection and greenish by transparence; these took the form of long needles which carried laterally hexagonal prisms, acting strongly upon polarized light. The crystals correspond to the formula Zn Se, and belong, like the mineral würtzite, to the hexagonal series. The experimenter also tried to prepare the selenide of zinc at the temperature of the electric furnace by heating in a tube a mixture of seleniate of zinc and carbon. The walls of the tube were lined with amorphous selenide, which presents crystalline masses of an indistinct character. The next experiment was made by heating precipitated selenide of zinc in a carbon crucible placed above the electric arc for 10 minutes; after the operation, the crucible contained a melted mass, crystalline at the surface, showing parts of a gold-yellow color; these crystals are not sufficiently distinct to determine their system, but they have no action upon polarized light; their density, 5·42 at 15° C., is very near that of the crystals obtained by M. Margottet. By reducing seleniate of zinc by hydrogen in a porcelain tube at a white heat, clusters of selenide of zinc are obtained in the form of long needles of a greenish color; these seem to be elongated rhomboids. The crystalline selenide of zinc dissolves in fuming hydrochloric acid, giving off hydrogen selenide; gaseous hydrochloric acid is almost without action upon it, even at high temperatures. Chlorine decomposes it by displacing the selenium. It burns in oxygen, giving a basic selenite and selenious anhydride, which is sublimed. By a similar method, the experimenter has obtained a selenide of cadmium in crystals of the hexagonal system.

THE Empire State Sugar Company, which is building a large beet sugar plant at Lyons, N. Y., has ordered ten auto-trucks of five tons capacity, which are to be used to cart sugar beets from farms to the refinery. The company has 5,500 acres of land contracted for. Three electric omnibuses have also been ordered to run between Lyons and Sodus Point, on Lake Ontario, a summer resort, to compete with the steam railroad.