by an interval of about 0.18 second. It is caused by the contraction of the auricle. In some tracings the *a* wave is very prominent, greatly overshadowing the succeeding *c* wave. This was noted particularly in patients with more or less decompensation, though it is not pathognomonic of such conditions.

The *c* wave occurs almost simultaneously with the carotid pulse and in some instances it is caused by a transmitted arterial pulsation. The earlier writers, especially Francois Franck, Fredericq and Gerhardt regarded the *c* wave as a true venous wave, but Mackenzie and Wenckebach believe that it is always a carotid pulse. Recent investigations, however, tend to show the correctness of the earlier views; for, (1) the *c* wave can often be recognized by inspection as being present in the veins themselves, (2) it often precedes the carotid pulse by about 0.02 second, (3) it has a different form, (4) it can occasionally be demonstrated on liver tracings, and (5) in pathologic venous tracings, especially from cases of auricular paralysis, the *c* wave on the jugular differs in size from the radial pulse, often being largest when the radial is smallest. In most tracings, therefore, the *c* wave is of venous origin; when of arterial origin, this is generally indicated by its form.

The venous *c* wave is probably to be referred back to the momentary increase in intra-auricular pressure which occurs at the onset of ventricular systole. This wave of increased pressure appears somewhat later in the neck on account of the slow transmission of venous waves.

The negative wave following the *a* wave is undoubtedly due to auricular diastole. That following the *c* wave may also be explained in part by auricular diastole; but it is evident (1) from heart block tracings and (2) from tracings of auricular paralysis from man and from animals that ventricular systole alone is capable of causing a negative wave in the venous pulse just after the *c* wave. This is caused by the descent of the ventricular base during systole, which opens up the auricle on its attachments to the great veins.

Tracings from a patient with palpitation showed a very marked *c* wave and a very marked depression immediately following. As other venous waves were merely indicated on the tracing, it seems probable that the earlier movements of the ventricle during systole were executed with unusual speed.

The *v* wave appears in the neck just after the time of the dicrotic notch on the arterial pulse. Owing, however, to the slow transmission of venous waves the *v* wave begins in the heart at a somewhat earlier period, probably in late systole, and it is terminated there by the opening of the tricuspid valves. It is probably due partly to a replacement of the base of the ventricle toward the auricle at the onset of diastole. It is also due in part to the accumulation of blood in the auricle during the closing of the tricuspid valves. The *v* wave is accentuated in conditions of auricular stasis especially in tricuspid insufficiency and auricular paralysis.

The negative wave following the *v* wave is due to the opening of the tricuspid valves and the consequent flow of blood toward the ventricle. It is especially pronounced in conditions of auricular stasis. In slowly acting hearts this negative wave is often followed by a shoulder on the venous tracing which seems to be due to a recoil from the rapid filling of the ventricle.

William J. Gies,
Secretary

Societies and Academies

The Washington Academy of Sciences

Dr. Alfred G. Mayer, of the Carnegie Institution of Washington, delivered an address before the Washington Academy of Sciences Tuesday evening, February 23, on "The Tortugas Marine Laboratory, its Scope and Aims." Dr. Mayer kindly furnished the following abstract of his address:

"The lecturer called attention to the fact that this laboratory is the only permanent marine station within the American tropics, and that the generous support accorded to it by the Carnegie Institution of Washington had enabled it to develop into the best equipped marine laboratory in the tropical world.

"The seven Tortugas Islands are out in the Gulf of Mexico, seventy miles west of Key West, and consist of coarse wave-washed and wind-blown fragments of marine shells, which afford no soil suitable for the growth of mangroves; and thus the laboratory is unique in being the only place on the seaboard of Florida which is free from endemic mosquitoes in summer.

"Along the mainland coast of southern Florida the winds cause the waters over the coral flats to be churned into a silky mass of suspended silt, which is fatal to pelagic life, but at Tortugas, owing to the great area of deep ocean water in their neighborhood and the small size of the coral

plateau around them, this is not the case. The islands lie on the leeward side of the Gulf Stream, and the rich pelagic life of the great tropical current is constantly drifted upon their shores.

"Expeditions have for generations brought tons of preserved specimens of tropical forms home to our museums and colleges, where they have been studied and named, but as yet we know sadly little of the *living* animals of the tropics, their habits, development and physiology. The laboratory, therefore, aims chiefly to encourage research in these new fields, and to this end many of our leading investigators and most promising young workers in research have been invited to pursue their studies at Tortugas.

"The laboratory is now entering upon its fifth year. Two volumes of its researches have been published by the Carnegie Institution, and ten other papers have been published in various scientific journals, and the amount of research work now in press greatly exceeds that yet published.

"The lecturer then reviewed some of the more generally interesting, although not necessarily the most important, researches, as follows: The late Professor William K. Brooks, of Johns Hopkins University, carried out interesting studies of the pelagic *Solfœ* of the Tortugas, his papers being excellently illustrated by the drawings made by Mr. Carl Kellner. Brooks and McGlove find that the lung of the prosobranchiate gasteropod *Ampullaria* is developed out of a thickening, or ridge, of the epithelium of the mantle, and arises simultaneously with the gill and osphradium, all three being homologous organs. There is probably no phylogenetic relationship between the lung of *Ampullaria* and that of the pulmonates. *Ampullaria* is a large brown snail which lives in the fresh water of the Everglades, and lays eggs in pearl-like clusters on the stems of grasses above the water-line.

"Mr. Frank M. Chapman, of the American Museum of Natural History, describes the nesting habits of the booby (*Sula leucogastra*) and of the frigate bird (*Fregata aquila*) upon the isolated rocky island of Cay Verde in the Bahamas. Permission to study these birds was generously granted by his excellency, Sir William Grey-Wilson, in his official capacity as governor-in-council of the Bahamas. Specimens for a 'group' of the frigate birds were collected and these are now beautifully displayed in the American Museum in New York. Mr. Chapman found the nesting season of both boobies and frigate birds to be at its height early in April, the birds having apparently come to the island to nest in February. He found that the boobies always lay two eggs, but rear only one young bird.

"Professor Edwin G. Conklin, of Princeton University, studied the structure of the egg of the 'thimble jellyfish,' *Linerges mercurius*, which appears in vast breeding swarms upon the surface in the spring at Tortugas, and the Bahamas. He discovered that these medusæ always spin in an anti-clockwise direction as they progress through the water if viewed from the oral pole. The eggs consist of three easily distinguished substances. A peripheral layer of clear protoplasm which becomes the peripheral layer of the embryo and gives rise to the cilia, an intermediate layer of closely crowded yolk spherules which constitute the principal parts of all of the cells of the gastrula and blastula, and an inner mass of dissolved yolk which is poured into the cleavage-cavity and probably serves as a source of nourishment.

"Dr. R. P. Cowles, of Johns Hopkins, made an elaborate study of the habits of the 'ghost crab,' *Ocypoda arenaria*, and finds that it probably can not distinguish color as such but detects simply a difference between light and shadow. It can form simple associations and displays memory. It has apparently no sense of hearing, but its otocysts are organs of equilibration. It changes color under the influence of light and temperature, but this change does not occur if the crab's eyes be blackened.

"Dr. H. E. Jordan, of the University of Virginia, carried out a very elaborate series of studies upon the histological structure of the eggs of echinoderms and of the walking-stick-insect, *Aplopus*. The germinal spot in echinoderm eggs appears to be in part at least a storehouse of material which is to contribute in the formation of the chromosomes. He finds in *Asterias* and *Hipponoë* that the chromosomes do not arise out of the nucleolus, but the latter contribute nutritive substance to them. In the walking-stick-insect, *Aplopus*, he finds that half of the spermatozoa have eighteen, and half seventeen chromosomes, and the accessory chromosome is large and U-shaped and probably determines the female sex.

"Dr. Charles R. Stockard, of the Cornell Medical College, and Dr. Charles Zelemy, of Indiana University, found, working independently, that in the scyphomedusa *Cassiopeia xamochana* removing a greater number of the mouth-arms causes each and every arm to regenerate faster. Stockard finds also that although regeneration of each and

every arm is more rapid the greater the number of arms removed yet this regeneration is carried on at the expense of the normal body tissues which shrink while the arms grow, thus recalling the case of cancerous growths which, having more ability to absorb nutriment than the normal body tissues, grow at the expense of the body itself. Stockard finds also that the nearer the cut surface is to the center of the disk of the medusa the more rapid the regeneration. He finds that regeneration is somewhat retarded by a slight excess of NaCl, very much retarded by $CaCl_2$, but not appreciably affected by Mg. A slight excess of KCl accelerates, and a strong excess retards regeneration. Zeleny, working upon the gulf-weed crab, *Portunus sayi*, finds that successive removals of appendages neither increase nor decrease the rate of regeneration of the successively removed part.

"An interesting series of observations were carried on by Dr. Stoddard in which he shows that the habits of the walking-stick-insect, *Aplopus*, accord perfectly with the general resemblance of the animal to a stick. He discovered that the males will mate with the cut-off terminal part of the female's abdomen if this be mounted upon a stick.

"Professor Jacob Reighard, of Michigan University, investigated the problem of 'warning coloration' in so far as it affects the brilliantly colored reef fishes and their enemies, and he shows conclusively that these brightly colored fishes are at once greedily devoured if they leave the shelter of the coral reefs. The commonest predatory fish of the Tortugas, the gray snapper, *Lutianus griseus*, can, however, be *taught* to avoid a fish rendered artificially distasteful, and will remember its experience and still avoid the possible prey for at least twenty days after it has had the evil experience of attempting to devour such a fish. The coral-reef fishes are, therefore, *not* warningly colored, yet warning color *could* exist, but apparently it does not in nature; at least in so far as the reef fishes experimented with are concerned.

"Professor John B. Watson, of Johns Hopkins University, remained for three months upon Bird Key, Tortugas, studying the reactions of the noddy (*Anodus stolidus*) and sooty (*Sterna fuliginosa*) terns. This work was conducted under conditions of great inconvenience, for the temperature of the air under the bushes is commonly 123° F. at noon. Professor Watson found about 1,400 noddies, and 18,800 sooties nesting upon this little island not a quarter of a mile wide. While the noddy is building its nest in the bushes early in May it is very shy, but as soon as the egg is laid its habits change and it will remain and defend the egg. If, however, an egg be artificially placed in an unfinished nest the habits of the birds at once change and they settle down upon the egg and defend it. They do not recognize their own eggs, and will sit upon hens' eggs, sooty terns' eggs, their own eggs painted red, green or black, or an artificially egg-shaped piece of magnesium sulphate. The sooty tern, however, will not usually accept colored, or strange-looking eggs. The noddies relieve each other on the nest at intervals of about two hours, the new-coming bird crowding the sitting mate off the nest.

"The sooty tern makes its nest upon the ground. It is greatly confused and may lay a new egg if the egg be moved twenty-two inches horizontally from the original place, but the egg may be raised or lowered many feet in a vertical direction and the bird alights upon it at once apparently undisturbed.

"The young birds of both species can be taught to go through a labyrinth for their food; and the old sooties can learn to go through a maze to their egg, or to open a cage to obtain access to the egg. Neither of these birds is in the habit of going more than about seventeen miles from the island for their supply of fish, yet when they were taken away in the holds of vessels and liberated at Key West, Havana and Cape Hatteras they returned to the island. In the case of the sooties, the return from Cape Hatteras to Bird Key was made in five days, the straight-line distance being 850 and the 'along-shore' route 1,081 statute miles. There are many other important observations recorded in Professor Watson's paper.

"The lecturer expressed regret that limitations of time prevented his presenting before the academy the results of other interesting studies which had been conducted by investigators at Tortugas, but would refer his audience to the papers of Jennings, Linton, Perkins and others who had published accounts of their researches at the laboratory."

The paper was discussed at considerable length by C. Hart Merriam, Austin H. Clark and T. S. Palmer, who heartily commended the work of the Tortugas laboratory, and referred to similar laboratories and their work in various parts of the world.

J. S. Diller,
Recording Secretary

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

THE 661st meeting was held on February 27, 1909, Vice-president Abbot in the chair. The following papers were read:

The Relation between Sky Polarization and the General Atmospheric Absorption: Mr. H. H. KIMBALL.

Rayleigh has shown that sky polarization may be attributed to the presence of particles in the atmosphere whose diameters are small as compared with the wave-length of light, and the researches of Barus indicate that such particles must be "an integrant part of the air" and "could scarcely be separated from it except by filtration." We can not, therefore, expect marked fluctuations in the intensity of the polarized component of sky light.

On the other hand, the intensity of the unpolarized component will vary with the amount of light scattered by particles in the atmosphere whose diameters are large as compared with the wave-length of light, and with the amount reflected from the surface of the earth and from clouds.

Eliminating reflection from clouds, and allowing for variations in the reflection from the earth's surface, there remains as a variable factor the scattering of light by large particles in the atmosphere.

The intensity of the unpolarized component of sky light should, therefore, be a function of the number of such particles present, and consequently of the general absorption or diffusion of light by the atmosphere.

From observations with an Angström pyrheliometer and a Pickering polarimeter at the Central Office of the Weather Bureau, an empirical equation has been developed showing the relation between sky polarization and the general atmospheric absorption. By means of this equation polarimeter observations are now employed to check the computations of the value of the solar constant from readings of the pyrheliometer and the psychrometer by a method shown in Bulletin of the Mt. Weather Observatory, Pt. 4, Vol. 1. The results indicate a close relation between sky polarization and the general atmospheric absorption.

The Principles of Machines for Liquefying Gases: Dr. EDGAR BUCKINGHAM.

The speaker discussed the principles involved in the action of simple liquefying machines as distinguished from cascade processes with one or more precooling stages. The total cold available depends only on the pressures between which expansion takes place and the initial temperature of the gas; and with the ordinary type of liquefier is quite independent of the internal arrangement of the apparatus. The fraction of the gas that can be liquefied may be computed from its thermal and mechanical properties, if these are known; and the computed values agree very closely with those found by experiment. The increase in yield attainable by avoiding part of the dissipation within the liquefier may also be computed, and is very considerable. Methods for obtaining this improved yield were discussed briefly.

R. L. FARIS,
Secretary

THE ACADEMY OF SCIENCE OF ST. LOUIS

THE regular meeting was held on Monday, February 1, 1909, at the academy building, 3817 Olive Street, the program of the evening having been especially arranged in celebration of the centenary of the birth (February 2, 1809) of Dr. George Engelmann, one of the founders of the academy, and its first president. Standing not only among the leading medical practitioners of the last generation, Dr. Engelmann was also one of the foremost botanists of his day; for, during the many years of an active, useful life, most of which was spent in St. Louis, he found sufficient time, in the leisure hours of his practise, to devote to a series of most valuable scientific investigations. And, moreover, in addition to his professional and botanical labors, he was a zealous meteorological observer, keeping observations pertaining to atmospheric phenomena for over forty years.

Dr. Baumgarten opened the program of the evening with a very interesting paper, entitled "The Personality of Engelmann." And Dr. Baumgarten, having been a personal friend of the physician and botanist, was peculiarly well fitted to handle this subject, which he treated in a reminiscent way, making characterizations of a personal rather than mere biographical nature. This tribute of Dr. Baumgarten to the memory of his friend was one that bespoke only the most sincere friendship for Dr. Engelmann, and the highest appreciation of his character and achievements.

Professor H. A. Wheeler presented a paper on "Engelmann's Contributions to Geognosy." For Engelmann's reputation extended beyond the borders of his master work in botany and his devotion to local meteorology; although his influence in geognosy is perhaps due less to actual work done in that field than to the stimulation

he inspired in specialists of that department. In 1859 he published a paper that concerned itself with the elevation of St. Louis above sea level, which, aside from its general interest and scientific value, was especially important in that St. Louis was then the point upon which were based the computations for determining the altitudes of such places in the far west as were visited by the early exploring expeditions of Nicollet, Fremont, Owen and Emery. Engelmann, after a series of barometric observations in 1853, determined a directrix of 404.9 feet for the city of St. Louis—a figure which differed by only 7.8 feet from the later 412.7 feet mark as determined by precise leveling of government deparments, and by only 2.2 feet from the original 410.5 of Nicollet which was made in 1841 by barometric determinations based upon data furnished by Engelmann himself. While the contributions of Engelmann seem slight when compared with his masterly work in botany and meteorology, they are, nevertheless, a valuable index of the breadth of the man, of the keen interest he took in the natural sciences, and of his mental caliber and scientific training.

Professor Nipher, of Washington University, in a paper, "Engelmann's Work in Meteorology," told how Engelmann began his meteorological observations when he first settled in St. Louis, and how he continued them for nearly fifty years. Dr. Nipher explained how this long series of observations enables us to determine the normal rainfall and temperature for St. Louis, and how they, in turn, are useful in fixing extremes of temperature and rainfall. In 1861, Engelmann published the results of his rainfall observations, which show that June is by far the month of greatest precipitation; and he pointed out that the June rise in the Mississippi is not due to the melting of snows in the mountains, but to heavy and wide-spread spring rains. The fact that Engelmann gave attention to the rate of rainfall is noteworthy because that is a quantity which must be considered in the design of bridges and other structures that are to carry flood water. After remarking that Engelmann made an early study of the differences of temperatures and humidity in the city and in Shaw's Garden (which was, he said, on an open prairie three miles from the city), Dr. Nipher concluded with the statements that Engelmann was continuously in cooperation with the weather service in charge of the Smithsonian Institution, and that in many ways his aid was solicited by government officials in charge of work in the far west.

Dr. Trelease, of the Missouri Botanical Garden, which possesses Engelmann's invaluable collections, concluded the program of the evening with a paper on "Engelmann as a Biologist." He showed a number of drawings which exhibited Engelmann's skill in picturing details of plant structure, among them those made for his thesis, which was published in 1832, as well as the large quarto volume in which his botanical publications were reprinted at the expense of Henry Shaw in 1887, under the editorial direction of the great botanist Asa Gray, of Harvard University. To these were joined specimens of the beautiful prairie flower named *Engelmannia* in his honor, and of the blue spruce of Colorado which also bears his name. Tersely epitomizing Engelmann's work, and analyzing the economy of time and directness of purpose which enabled him to accomplish in the leisure hours of a busy physician's life more than the average achievement of a botanist whose whole effort is directed to his specialty, Mr. Trelease closed by quoting from Engelmann's gifted biographer, Professor Sargent, of Harvard University, the prediction that "the western plains will still be bright with the yellow rays of *Engelmannia*, and that the splendid spruce will still cover with noble forests the highest slopes of the Rocky Mountains, recalling to men, as long as the study of botany will occupy their thought, the memory of a pure, upright, laborious and stimulating life."

At the conclusion of the memorial session, the members and guests of the Academy were invited to pass into another room, where were displayed a number of interesting objects connected with or commemorative of Engelmann's life and work. Under the guidance of Mr. H. C. Irish and Mr. Chas. H. Thompson, who explained the several objects, an interesting half hour was spent in the inspection of this exhibit, which included the manuscript and original sketches for Engelmann's thesis as well as the publication itself in a copy with partly colored plates; several volumes of his many thousands of unpublished notes and sketches; the simple dissecting microscope and the elaborate compound microscope made by Hachet; the jubilee medal struck by the academy in 1906, bearing Engelmann's portrait; an illustration of the Colorado Engelmann spruce; and specimens and original descriptions of the three genera of plants that have been dedicated to his memory in the name *Engelmannia*.

W. E. McCourt,
Recording Secretary