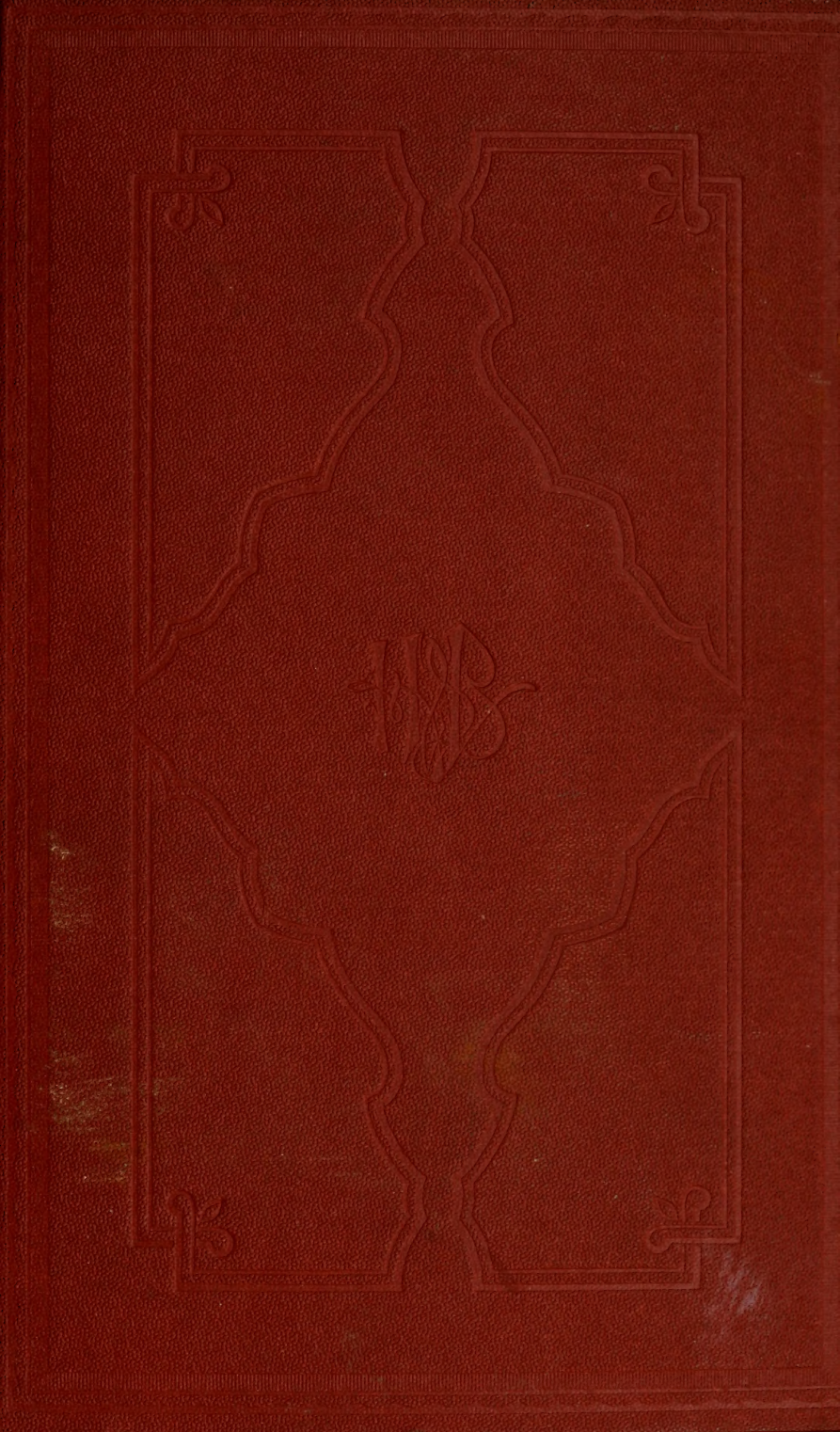

2

ANNUAL RECORD

OF

SCIENCE AND INDUSTRY

FOR 1878

EDITED BY

SPENCER F. BAIRD

WITH THE ASSISTANCE OF EMINENT MEN OF SCIENCE

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PREFACE.

The present volume is the eighth of a series commenced in 1871, and which, although entirely unconnected with a work having somewhat the same object—the "Annual of Scientific Discovery"—took up the record of scientific and industrial progress where the latter left it off, after having been published since 1850.

A modification of the original plan of the "Annual Record" was commenced in the volume for 1877. Previous to that it consisted of two parts—first, a general summary of progress in the various branches of science; and, secondly, a series of abstracts of special papers, credited to the work in which they were published. These abstracts, although prepared by several specialists, were without indication of their authorship. The experience of several years showed that in attempting to give abstracts of anything like the most important announcements of the year, more space was required than could be spared for the purpose; and it was therefore determined to enlarge the scope of the first division, and make it include a greater amount of detail, each summary to be prepared by some eminent specialist, and to be headed by his name.

This plan was found to give entire satisfaction to the patrons of the "Annual Record," and it has therefore been followed on the present occasion. In the table of contents will be found an analysis of the several articles, while a very minute alphabetical index will permit easy reference to any particular facts recorded.

Spencer F. Baird.

Smithsonian Institution, *March* 1, 1879.

TABLE OF CONTENTS.

ANNUAL RECORD

OF

SCIENCE AND INDUSTRY.

1878.

ASTRONOMY.

By EDWARD S. HOLDEN,
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INTRODUCTION.

By far the most important astronomical event of 1878 was the total eclipse of July 29. An appropriation of $8000 for observing this was liberally made by Congress, and was spent by the Naval Observatory in putting parties in the field. This Observatory not only sent six of its own observers, but paid, in part or entirely, the expenses of twenty-seven other persons selected from the astronomers of the country. Invitations were extended to every well-known astronomer in the United States, and the services of every one able to go were accepted. Many had, however, already made their arrangements to take the field under other auspices. An arrangement was made by the Naval Observatory with the Pennsylvania Railroad, by which foreign observers of the eclipse were transported to Denver and return at half-fare. Their instruments were also admitted duty-free by the Treasury Department.

As in the case of the transit of *Mercury*, instruments were

lent by the Observatory to various astronomers, who submitted reports of the work done. The excellent results reached have been a gratifying proof of the heartiness of the co-operation on both sides.

The detailed account of these results is given in the sections on Solar Eclipses and on the Transit of *Mercury*. These and other subjects are spoken of briefly under their appropriate heads. It must be remembered that the accounts here given are necessarily the barest summaries, and are intended mainly to call attention to work which has been done, in order that a reference may be made to the original sources if desired. At the same time, it is clearly impossible to give references to all the memoirs consulted. For such bibliographical information the reader is referred to Darboux et Houël's *Bulletin des Sciences Mathématiques et Astronomiques* (monthly, Paris), to *Nature* (weekly, London), to the *Observatory* (monthly, London), and other journals. Free use has been made of reviews by writers in these and other periodicals.

An important feature of the Astronomical Summary for 1877–78 are the reports from American observatories (p. 46), furnished by the directors themselves in answer to a circular letter. It is hoped that by means of these replies accurate knowledge of the activity of our observatories may be had, and it is intended to continue these in the future. A similar series of reports for European observatories is yearly made to the German Astronomical Society. These have been translated and condensed, and are given here (p. 76).

An abstract of an official report on the observatories of Italy, by M. Rayet (of the Observatory of Marseilles), is also given (p. 76).

The various important communications of Professor Watson on the subject of the discovery of *Vulcan* are given under that heading.

NEBULÆ AND CLUSTERS; NEBULAR HYPOTHESIS; CONSTRUCTION OF THE HEAVENS.

In the journal of the Italian Spectroscopic Society for November, 1877, Professor Celoria has a paper on the general distribution of the stars in space. In this paper he combines the gauges of Herschel, the results of the *Durchmusterung*

and of the *Uranometria Nova*, and of a zone examined by himself at Milan from 0° to +6° (δ), and deduces the relative distances of (1) the lucid stars; (2) the *Durchmusterung* stars of 7.5, 8.0, and 9.5 magnitude; (3) the stars of the Milan zone; and (4) those of Herschel's sweeps. This paper is an abstract of a longer memoir published by the Milan Observatory. The principal conclusion of M. Celoria is as to the existence of two rings which together make up the Milky Way. The two absolute maxima of star-density are in 6^h 50^m and 19^h 20^m R. A., and in the first region there is a maximum of lucid stars. If it is admitted, as has been shown by Gyldén, that the different brightness of stars is in general a function of their different distance, the conclusion follows that towards 6^h R. A. the stars nearest us are accumulated, and that towards 19^h the stars farthest away are situated. In the curves of star-density two maxima are shown in the Milky Way, the first being smaller than the second; and it follows that the branch of the Milky Way which comes first to the meridian contains the stars nearest us. "The Milky Way is thus formed of two rings whose planes are inclined about 20° to each other, which cross each other; and the sun is situated a little outside of their planes." Data for a review of this kind have been collected from the star-maps of Dr. C. H. F. Peters, of Clinton, by Professor Holden, of Washington, who has counted the number of stars per square degree in all of Dr. Peters's star-maps, and in many of Chacornac's charts, which have been completed by Dr. Peters by filling in the small stars. In this way statistics of the distribution of stars of the first fourteen magnitudes over the ecliptic regions have been collected.

The *Monthly Notices*, R. A. S., for January, 1878, contains the following papers: Señor Ventoza, of Madrid, has a note on the real motion of the stars in space, which is an abstract of a larger work to appear shortly. Mr. S. Waters, to whom we owe several charts of the same kind, has given a chart of the southern sky, on which the results of Sir John Herschel's star-gauges are plotted, and it serves to give a rough idea of the distribution of the southern stars.

Professor Winnecke, of Strasburg, brings evidence to show that the nebula H ii. 278 (G. C. 551) has *periodically* varied. From 1785–1827 it was p B; 1856–65 it was v F

or v v F; from 1868–77 it was again p B. It deserves attention.

In Vol. III. of the Moscow Observations, Professor Bredichin has given his observations to determine the parallax of the nebula H iv. 37. The series extended over sixty-five nights, and comprised eight measures of $\Delta\delta$ on each night. The observations are grouped into twelve groups. The parallax resulting is $0.065'' \pm 0.040''$. This includes the temperature correction of the screw. If the mean value of the screw be used without such correction, the parallax results as $0.009'' \pm 0.041''$. Thus this nebula appears to be at the same distance as the (single) comparison star.

Dr. Dreyer has published his supplement to the "General Catalogue of Nebulæ and Clusters of Stars" (Herschel). It contains, first, notes and corrections to the catalogue; and, second, a continuation of this. The numbering is continued from 5079 (Herschel's highest number) to 6251. Of course this sum includes errors, duplicates, possible comets, etc., and on this account it has been doubted whether the time for the systematic catalogue of Herschel had come in 1864. The immense convenience of it as a printed working-list quite overbears any possible want of logical arrangement; and Dr. Dreyer's work is a much-needed supplement, and is edited with great care.

Dr. Doberck has given in *Nature* (February 14, 1878) an abstract of D'Arrest's *Undersogelse* on spectra of nebulous stars, which will be valuable to English readers, the original paper being almost unknown. About 6000 nebulæ were known in 1872; of these 150 have been examined with the spectroscope—only one-fortieth part. Of these about three fourths give the continuous spectrum, while only one fourth are true gaseous nebulæ. Gaseous nebulæ are, with few exceptions, characterized by greenish-blue light, sharply defined circular or elliptic disks, and often have bright condensations within, almost stellar in appearance. A few are, however, large, irregular, and complicated, like *nebula Orionis*, for example. The ray-like elongated nebulæ are, so far, always characterized by a continuous spectrum. The characteristic lines of a gaseous nebula have the wave-lengths, according to D'Arrest, (A) 5004.0, (B) 4956.6, and (C) 4860.6, with a fourth line occasionally present. From a great number of

observations, Bredichin gives these: (A) 5003.9 ± 1.2, (B) 4957.9±11.4, (C) 4859.2±3.1.

Professor Holden has made a determination of the relative brightness of the different parts of the nebula of *Orion*, and for this purpose has used a photometer devised by Dr. Hastings, of the Johns-Hopkins University. These photometric determinations show that this instrument is capable of giving excellent results.

Dr. Vogel, of the Potsdam Observatory, has published the results of measures on the cluster χ *Persei*, made in 1867–70 by means of the 8-inch refractor at Leipsic, with the object of fixing the relative positions (and magnitudes) of the stars of this cluster, so that any future change may not pass undetected. 176 stars, in all, have been fixed in position by the filar micrometer. The field was bright, and a magnifying power of 145 diameters was employed throughout. The various sections of this work of 36 quarto pages treat of the following subjects:

§ 1. *The position of the instrument; the determination of the parallel.*

§ 2 contains an *investigation of the position-circle*, and of the *value of the revolution of the micrometer.* The zero of the micrometer is dependent upon the position of the instrument, and also upon the kind of illumination of the thread. The value of the revolution is found from transits on twenty nights, from November, 1867, to May, 1870. During all this time the reticle was left at the same distance from the objective, and the thermometric coefficient resulted $+0.001581'' \, t^\circ$ in Réaumur's scale. The magnitude and the *sign* of this Dr. Vogel explains by the fact that the focal point was not determined each night (as he says is usual), and he correctly points out the necessity of leaving the focus unchanged for such observations, and for determining the value of the screw during the series itself.

§ 3 deals with *the methods of observation and reduction.* The brighter stars less than 10 magnitude were determined from measures of p and s with four selected stars of the group. These four were connected by measures of p and s and also $\Delta\alpha$ and $\Delta\delta$; and they were further connected with two stars of the cluster *h Persei*, which had been observed with the Bonn meridian-circle. For each pair of the brighter

stars at least four nights' observations were made. The reductions are complete, and the observations are reduced to 1870.0.

The fainter stars (10–12 mag.) were observed by $\Delta\alpha$ and $\Delta\delta$ with other stars at least on two nights for each star.

§ 4 deals with the *accuracy of the observations*, and first, for the brighter stars, the probable error of a single observation in s is found to be $\pm$ 0.228″, in p (reduced) $\pm$ 0.306″. The probable errors for the mean of each night are more important, and result as follows (no dependence of the probable errors on the distance or the position-angles being evident): probable error of one night in s, $\pm$0.190″, in p (reduced) $\pm$0.165″. For the final position (at least four nights) these become, in s, $\pm$0.092″; in p, 0.080″. For the $\Delta\alpha$ and $\Delta\delta$ of the brighter stars these are $\pm$0.097″ in R. A., $\pm$.089″ in N. P. D. The positions for the fainter stars are determined within less than 1″ in each co-ordinate, which Dr. Vogel considers sufficient for his purpose.

§ 5 treats of the *determinations of the brightness of the stars of this cluster*. The 176 stars of the cluster range between the 6.5 and 13 magnitudes.

Each one of the fainter stars (higher than 10 mag.) was determined by eye estimates of magnitude at least five times; the probable error of the mean is $\pm$0.14 magnitude. The brighter stars were determined on several evenings by the eye, and on two nights each was compared by a Zollner photometer with one of the standard stars. A table (p. 12) gives the magnitudes of the brighter stars, 1st, by eye (Vogel); 2d, by eye (Argelander); 3d, photometric magnitude, assuming the light ratio $\frac{1}{2}\cdot\frac{1}{519}$, or 0.397. The agreement is remarkable, but the table shows (what was already known) that Argelander's magnitudes higher than 9.0^{m} make the stars too bright.

§ 6 gives the *observations of the stars* (in tabular form), *and the results*. A difference between the spring and autumn observations, in *both* $\Delta\alpha$ and $\Delta\delta$, of one of the stars indicates possibly a parallax of about 0.3″.

§ 7 gives the *observations of the fundamental stars, and catalogue of the 30 brightest stars*. The observations are of relative $\Delta\alpha$ and $\Delta\delta$ of the four fundamental stars, and of two of Argelander's stars in *h Persei*, and also meridian observa-

tions. These last also indicate a parallax to the star *b*. None of the stars appear to have a large proper motion.

§ 8 deals in the same way with *observations of the fainter stars, and catalogue of all the stars of the cluster.* This is followed by two charts, one of the brighter stars and the plan of triangulation, the other of the whole cluster.

This brief analysis will give an idea of the contents of this extremely thorough paper, which will take its place beside the other researches of the author in the same field. They are all models of what such investigations should be, and leave nothing to be desired in methods of observation or reduction, in the accuracy of the final results reached (which are always adequate to the purpose in hand), and, finally, are excellent examples of the literary style and clearness appropriate to such memoirs.

NEW STARS; VARIABLE STARS; RED STARS; PROPER MOTIONS, ETC.

Dr. Fearnley, Director of the Christiania Observatory, states that a ninth-magnitude star, $\alpha = 11^h\ 13^m\ 31^s$, $\delta = +66°\ 31'\ 25''$ (1875), has a proper motion of 3.04″ in a great circle, as shown by a comparison of his observations with the Bonn observations of 1855. This star is 60° distant from the solar apex, and the direction of its motion is such as to indicate that we have really to do with a star near to us, and therefore suitable for observation for parallax.

"The Red Stars: Observations and Catalogue," is the title of a work by J. Birmingham, published in the *Transactions* of the Royal Irish Academy, Vol. XXVI., Part 7. It includes all known red or yellowish-red stars, 658 in number, with the positions given for 1880. The catalogue gives the magnitudes (mostly from Argelander) and details concerning the color, brightness, and variability, together with an account of spectroscopic observations. Birmingham's observations have been made with a telescope of 4.5 inches aperture, with a power of 53 diameters; and with this instrument stars to the tenth magnitude can be observed, and their color determined. Such an aperture has for its *minimum visibile* 12.5 magnitude on Argelander's scale. The observations lead to the conclusion that for variable red stars the red color in general is increased with a decreasing magnitude. His explana-

tion of this is that the star may be surrounded by a rotating nebulous ring of different thickness at various parts, so that variations of both color and intensity are the results of absorption.

DOUBLE, BINARY, AND MULTIPLE STARS.

Mr. Burnham, of Chicago, has published his ninth catalogue of new double stars discovered with the 6-inch refractor. It comprises the discoveries of 1876 and the first part of 1877. It contains Nos. 453–482, i. e. thirty stars; of these, eighteen are closer than 2.11″.

No. 4 of the publications of the Cincinnati Observatory for 1877 has been received. It gives the measures of 517 double stars. The introduction contains an account of the methods of observing. Positions are measured by placing the objects between parallel wires, and with both forward and backward motions of the tangent screw and distances, so as to eliminate the zero and to make the bisections symmetrical. The three observers were found to have a personal equation in position-angle, which Professor Stone refers primarily to the position of the observer's head. The observations are compared with older series, and the probable errors determined. The colors are noted on a new plan, by using numbers, which allow them to be expressed briefly.

This publication of the detailed observations is followed by a volume of *Mean Results*, which is a summary of the preceding work. It is in octavo form, sixty stars on a page, and contains observations on 517 such pairs of stars. On the average, about two observations have been made on each pair, both in position and distance. The various columns have for caption, "Number," "Name," "Epoch," "Position-Angle," "Distance," and "No. of Obs." Many close pairs have been measured, and also many neglected stars are to be found in the list.

The *Rendiconti* of the (Italian) Royal Academy of Sciences for May, 1877, contains a memoir by Signor A. Nobile on the trapezium of *Orion* (Σ 748). The instrument employed was a refractor of 0.14^{m} (5.51 inches) aperture. The method of observation employed was that invented by Nobile, and previously described by him. We possess previous determinations of the relative positions of these stars by W. Struve

and by Liaponoff. A comparison of the previous measures of *distance* with Nobile's indicates no motion. From the comparison of angles he concludes a probable revolution of stars B, C, and D about A, so as to increase the angle. From this it is inferred that the four stars of the trapezium are physically connected with each other.

Professor Hall, of Washington, has observed the six stars in the trapezium of *Orion* during two years, the different combinations of the angles and distances of these stars being measured first with bright wires in a dark field, and again with dark wires in a bright field. Each angle and distance has been measured on at least six nights by each method. Professor Holden has made a discussion and an adjustment of these measurements by the method of least squares, from which it appears that these six stars are probably physically connected, as supposed by Nobile and others.

Observations of the double stars, selected by Mr. Otto Struve, Director of the Imperial Observatory at Pulkova, for determining the personal errors of various astronomers, have been made by Professor Hall, at Washington. This list contains thirty stars, and on an average each star has been observed on six nights. Professor Stone, of Cincinnati, is also observing this list, as well as Professor Winnecke, of Strasburg, Baron Dembowski, etc.

Mr. Burnham, of Chicago, quotes Struve's measures of Σ 547, which are (1831) $p=344.3°$, $s=4.25''$, and notes measures of his own (1878)—$p=9.7°$, $s=2.46''$. This appears to be in rapid motion.

Mr. Burnham has just sent to the Royal Astronomical Society, for publication, his double-star observations of 1877–78. These comprise: I. A catalogue of 251 new double stars, with measures; II. Micrometrical measures of 500 double stars. Of the 251 new double stars, 75 pairs are less than 1″ distant, and 59 pairs are distant from 1″ to 2″. Over 1400 micrometrical measures have been made, each of 5 angles of position and 3 measures of double distance. This great labor was entirely one of love, and the observations were all made after a day spent in business occupations. Considered in this way, the number of measures becomes as remarkable as their excellence.

STAR CATALOGUES AND MAPS.

At the Stockholm meeting of the German Astronomical Society, reports of the progress of the zone observations were received. The *Fundamental Catalogue*, which is based on Pulkova observations (1861–72), will appear during 1878. The observations on which it is founded will first be printed, and the *Catalogue* will follow.

In the Nikolaief zone (−2° to +1°) 1015 observations have been made. The Leipsic zone (10°–15°) is approaching completion. The zone (25°–30°) undertaken at Cambridge (England) reports:

Total No. of stars to be observed	10,299
" " " " still unobserved	2,253
" " " " observed once	2,317
" " " " " twice	2,173
" " " " " three or more times	3,556

The reductions are in a forward state. The observations of the Leyden zone (30°–35°) are finished, except about 150 observations, to complete imperfect positions. There were 4300 observations printed in the *Leyden Observations*, Vol. V.; 2250 more are completely reduced; for 2400 the reduction is begun, and only 900 were untouched.

The Bonn zone (40°–50°). Up to the present time 29,939 stars have been observed by three observers.

The Harvard College zone (50°–55°) contains 8317 stars, of which 2014 have not yet been twice observed. Many of these have been observed once.

The Helsingfors zone (55°–65°) will be continued by Dr. Krüger, at Gotha, with the same instrument as before, which has been lent for the purpose by the Helsingfors University.

The Christiania zone (65°–70°) contains 3880 stars, of which 10,744 observations have been made. Two thirds of the observations are completely reduced. The printing was begun during 1878.

In the Dorpat zone (70° – 75°) 2180 stars have been observed twice, and 312 once, since August, 1876. The right ascensions are nearly completely reduced.

Dr. C. Powalky has reduced all of Lacaille's observations of stars (about 400 in number) taken with the altitude instruments both at the Cape of Good Hope and at Paris. By introducing new values of the latitude, refraction, and cor-

rections for the division errors of the instruments, he has been able to bring about excellent agreement between the Paris and Cape observations with both sextant and sector. The results appear to be comparable in precision with Bradley's observations. The epoch chosen is 1750.0.

Dr. Schrader, of the O'Gyalla Observatory, Hungary, has published a list and maps of all stars visible in northern latitudes from the first to the fifth magnitude. There are five charts in all—one polar chart and four others, equatorial charts—so divided that in each season of the year (as spring, etc.), only one of these, or at the most two, will be needed. This is a convenience in observations of meteors, and in other ways. The maps have a peculiarity which is new, we believe. The sizes of the circles which represent stars of the various magnitudes are proportioned to the absolute amount of light received by the eye from the stars themselves. 1840 stars are mapped. An appendix gives the method of computing the orbit of a meteor swarm from observations with tables.

A catalogue of the mean places of 750 stars for 1870.0, from observations made at Kremsmünster by P. G. Strasser in 1864–74, has recently appeared. In Vol. XII. of the *Memoirs* of the R. A. S. (1838), a catalogue of 208 stars observed at Kremsmünster appeared; and a series of 560 stars, observed about 1840, has been reduced by Reslhuber, but not yet published.

The maps to the uranometry of the southern heavens, made by Gould and his assistants at Cordoba, have been prepared at Bien & Co.'s, in New York. They are lithographed, and each map will be about half the size of the maps to the *Durchmusterung*.

Dr. Loewy, of Paris, has presented to the French Academy of Sciences a catalogue of 521 moon-culminating stars. The places of these depend upon observations made at the observatory of the Bureau of Longitudes with portable instruments. The Bureau has just completed the determination of the telegraphic longitudes of Neuchâtel, Geneva, and Lyons. It will shortly undertake the determination of the longitude of Lisbon, in aid of the American determination of the longitude of Rio Janeiro just completed by Lieut.-Commander Green, U.S.N.

The Hydrographic Office has published "An Observing List of Stars Selected for the Determination of Time in the Southern Hemisphere." This is a list of 408 polar and clock stars, nearly equally distributed throughout the twenty-four hours. The approximate right ascensions and declinations are given (right ascension to the nearest second, declination to nearest 0.1′), with a reference to one authority for each place. It is for use in the longitude expedition under Lieut.-Commander Green, U.S.N.

THE SUN.

Dr. Dreyer calls attention, in *Nature*, to a probable observation of the solar corona A.D. 1030, August 31, and to the fact that Plutarch noticed the faint light round the sun during a total eclipse.

Colonel Tennant, R.E., has published two accounts of astronomical expeditions in India. The first is a "Report on the Observations of the Total Eclipse of the Sun December 11–12, 1871;" the second, "Report on the Preparations for and Observations of the Transit of Venus as seen at Rourkee and Lahore December 8, 1874."

The Report of Messrs. Lockyer and Schuster on the Total Solar Eclipse of 1875 has just been published in the *Philosophical Transactions* of the Royal Society. Bad weather prevented some of the most important plans from being carried out.

Mr. Downing, of Greenwich, has a note on the probable errors in transit observations of the sun, discriminating the results for the two limbs. He comes to the conclusion that for experienced observers the probable accidental error for the two limbs is the same, while for inexperienced observers the second limb is more uniformly observed.

An observer of experience has been sent by the English government to India to arrange for the founding of an observatory for the purpose of taking daily photographs of the sun. This is on account of the recent famine in India, and the supposititious connection between sun-spots and famines, which the government seems to consider of sufficient interest to go to some expense in order to test it. This is in some sense a reversion to Sir William Herschel's supposed connection between sun-spot frequency and the price of wheat.

The chief signal-officer of the army has proposed to the various observatories of this country, both public and private, to co-operate in physical observations of the sun. Every phenomenon of interest should be registered, whether relating to spots, faculæ, or protuberances, etc. Each observatory that is willing to take up any special field, or that already occupies such a field, is requested to give its results, or such part of them as it is willing to give, to the Signal Bureau for record in its *Monthly Weather Review*. Thus a prompt publication is secured. In response to this invitation, a record of the number of spots daily observed on the sun's disk is prepared by Mr. D. P. Todd, of Washington. It is to be hoped that a regular series of photographic records of sun-spots can be made by some one or more observatories in the East, and by at least one on the western coast. In order to render such observations of the sun complete, the establishment of these stations and one in Japan is required.

Sun-spots continue to be observed photographically at Greenwich, Paris, Moscow, Toulouse, Kasan, Vassar College, and are observed visually at Madrid, Oxford, Berlin, Zurich, Leipsic, and Potsdam.

Protuberances are observed at Palermo, Rome, Greenwich, Moscow, O'Gyalla, Potsdam, etc.

Professor Langley, of Allegheny Observatory, and Dr. Huggins, of London, some years ago described the granular surface of the sun's photosphere. Their division of the brighter aggregations of the surface was (successively as to size), first, cloud-like forms, perceptible to telescopes of ordinary power; second, "rice-grains," or nodules, of which such forms are composed, the rice-grains being perceptible with higher powers and good definition; third, granules composing the rice-grains. The discovery of the granules has been independently made by the photographic researches of M. Janssen, who has succeeded in obtaining photographs of the sun with only $\frac{1}{3000}$ of a second exposure. These were procured with lenses of long focus, and a slow development of the image. The "willow-leaves" or "rice-grains" of previous observers appear in these photographs only as occasional aggregations. The main feature is an abundant granulation. The forms of the granules are sufficiently defined

for study. They appear to be generally of a spherical shape, and it is noticeable that larger grains seemed to be formed of aggregations of smaller ones, the lesser grains being most evidently spherical. An interesting account of one of Janssen's largest positives has been contributed to the *American Journal of Science* for April, 1878, by Professor Langley.

In the *Annuaire* of the Bureau of Longitude for 1878 (p. 689), M. Janssen gives a detailed account of his discovery of the reticulated arrangement of the solar photosphere. The paper is accompanied by a photograph of the appearances described, which is enlarged threefold. M. Janssen says that photographs less than 4 inches in diameter cannot satisfactorily show such details. The chief obstacle to the production of photographs of the sun which should show the details of the photosphere has hitherto been the photographic irradiation. As the granulations of the solar surface are in general not greatly larger than 1″ or 2″, the irradiation, which sometimes is 20″ or more, may completely obscure their characteristics. This difficulty M. Janssen has overcome by enlarging the image and shortening the time of exposure. In this way the irradiation is diminished as the diameters increase, the dimensions of the details are increased, and "the imperfections of the sensitive plate have less relative importance." [This last advantage certainly holds good only between limits.]

Again, M. Janssen has noted that in short exposures the photographic spectrum is almost monochromatic. In this way it differs greatly from the visible spectrum, and to the advantage of the former for this special purpose. The purely photographic difficulties are immensely augmented, however; but these have been surmounted by the care and perseverance of M. Janssen and his assistant M. Anents. The diameters of the solar photograms have since 1874 been successively increased to 4.7, 5.9, 7.9, and 11.8 inches. The focal adjustment varies greatly with the season, and even with the time of day. The exposure is equal over all parts of the surface. In summer this exposure for the largest photograms is less than 0.0005″. The development of the pictures is very slow. These pictures show that "the solar surface is covered with a fine granulation. The forms and the dimensions of these elements are very various. They vary in size

from 0.3″ or 0.4″ to 3″ or 4″. Their forms are generally circles or ellipses, but these forms are sometimes greatly altered. This granulation is apparently spread equally all over the disk. The brilliancy of these points is very variable, and they appear to be situated at different depths below the photosphere: the most luminous particles, those to which the solar light is chiefly due, occupy only a small fraction of the solar surface." The most remarkable feature, however, is "the reticulated arrangement of the parts of the photosphere." "The photograms show that the constitution of the photosphere is not uniform throughout, but that it is divided in a series of figures more or less distant from each other, and having each a special constitution. These figures have, in general, rounded contours, but these are often almost rectilinear, thus forming polygons. The dimensions of these figures are very variable; some are even 1′ in diameter (over 25,000 miles)." "Between these figures the grains are sharply defined, but in their interior they are almost effaced, and run together as if by some force." These phenomena can be best understood by a reference to the figures of M. Janssen.

SOLAR ECLIPSES.

The best general account of the principal results of the total eclipse of July 29, 1878, which has yet appeared, was written by Professor C. A. Young in the New York *Times* of August 16. A portion of this is given below:

"As regards the physics of the sun and the corona, the principal and most important result of all the observations bearing upon this subject is to demonstrate a decided sympathy and connection between the condition of the sun's visible surface, as indicated by the number and character of the sun's spots, and the constitution of the corona.

"At the present time the sun's spots are at their minimum; whole months have passed without the appearance of a single one. The chromosphere, or colored envelope of hydrogen and other gases which immediately surrounds the sun, has also been correspondently quiescent, and the so-called 'prominences' have been few and small. Of course, it was a question of interest whether the corona also would show a corresponding difference of condition from that indicated in 1869 and the later eclipses, when the sun's surface

was in full activity, and the question has received an emphatic and affirmative answer.

"As to the brightness of the corona at the recent eclipse, there is considerable difference of opinion. The writer, with, he thinks, a large majority of those who also saw the eclipse of 1869, is strongly of the impression that in 1869 the corona, though perhaps less extensive, was many times more brilliant, while the corona in 1870 seemed to him intermediate between those of 1869 and 1878. Some of the best observers, however, are of quite the contrary opinion.

"While, however, there may be room to question the conclusion that the corona this year was uncommonly faint, there can be no question that its spectrum was profoundly modified.

"The bright lines which come from its gaseous constituents were conspicuous in 1869 and in all the subsequent eclipses until the present one; but this year they were so faint as to be seen by only a few of the observers, while the great majority missed them entirely, seeing only a continuous spectrum. This was especially remarkable in the case of the green corona line (known as '1474' from its position upon Kirchhoff's map of the solar spectrum). Many observers saw it plainly just at the beginning and end of totality, but during the middle of the eclipse nearly all entirely lost sight of it. That it was really present all the time, however, though faint, is proved by the observations of Professor Eastman, Mr. Thomas, and the writer, the first of whom traced it all around the sun to a distance of from 10′ to 20′, going twice over the ground, and keeping it in sight all the time. With the hydrogen lines the case was similar; the writer had one or other of them in the field continually, and they never quite disappeared, though at times very faint.

"Of course, the slitless spectroscopes, both ocular and photographic, from which so much had been expected, failed to give any satisfactory results. In 1871, when the instruments were first used, the observers saw a series of colored images of the corona. Mr. Lockyer, for instance, saw four such images—one red, one green, one blue, and one violet. This year nothing of the kind appeared. At the moment, indeed, when totality began, there was an exquisite exhibition, first of the darkness of the solar spectrum, and then for an instant of a multitude of bright-colored segments—the spectrum of the

chromosphere; but when the moon had covered the chromosphere, there was only a disappointing continuous band of color, unmarked by rings of any kind.

"Those, also, who were looking for new bright lines in the corona spectrum were equally unsuccessful, whether they employed the ordinary spectroscope or worked by photography. Some of the observers, the writer among others, used a so-called 'fluorescent eye-piece,' which brings the otherwise invisible light beyond the extreme violet end of the spectrum within the range of the human eye by the action of a film of fluorescent liquid (æsculia solution) enclosed between thin plates of glass. But, although before totality the apparatus worked perfectly, disclosing to the eye dark lines innumerable in the portion of the spectrum invisible without its aid, after the darkness came on it failed to show a single bright line. The most carefully prepared and sensitive photographic apparatus succeeded no better, except that Dr. Draper, Mr. Lockyer, and one or two others perhaps, did obtain, by means of a slitless spectroscope, an impression of a faint continuous spectrum in the ultra violet, without rings or markings of any kind. Evidently no lines existed to see or photograph on this occasion.

"One or two observations were made of some interest in their relation to previous work. Professor Rockwood, of the Princeton party, using a double-barrelled slitless spectroscope, observed at the beginning of totality a bright-red line in the chromosphere spectrum very near to B. This explains an observation of Mr. Pogson in 1868, who then insisted that he saw B reversed in the spectrum of a prominence; but as all the other observers had C instead of B, his record was generally regarded as a mistake.

"The line is probably one well known to solar spectroscopists as 534 of Kirchhoff's scale—a line exceedingly difficult to see in the spectrum of the chromosphere under ordinary circumstances, but still invariably present. Its conspicuousness in Professor Rockwood's instrument is a matter of some surprise; but there could be no mistake, as C was even more brilliantly conspicuous at the same time. What the substance which causes it may be is quite unknown. Like the so-called D_3 line, it has no corresponding dark line in the solar spectrum.

"The same observer, and the writer also, saw both H lines (calcium) brightly reversed in the spectrum of the chromosphere; thus confirming observations made six years ago at Sherman, but never corroborated since, except by the photographic spectrum obtained by the Siam expedition in 1875.

"The exquisite reversal of the dark Fraunhofer lines at the moment of totality was seen by many of the observers. One observer, at least (and we believe some others), Professor Barker, at Rawlins, was able to confirm Janssen's observation in 1871 by seeing the principal dark Fraunhofer lines in the corona spectrum, thus showing that a considerable percentage of the coronal radiance is mere reflected sunlight. The dark lines were, however, so faint as to be seen by very few, and this shows equally clearly, we think, that the particles which reflected the sunlight are themselves also self-luminous, as, of course, they ought to be so near the sun.

"A great deal of attention has been paid to the polarization of the coronal light in past eclipses, and while on the whole there has been an overwhelming weight of evidence in favor of radial polarization, yet at every eclipse some observer of reputation has obtained anomalous results quite at variance with all the others. This year Dr. Hastings, of Baltimore, comes out with strong tangential polarization as his result. The rest of the observers—Wright, Ranyard, Harkness, and others—are emphatic and clear in their contrary conclusion.

"Experiments with the tasimeter, or new heat-measurer, of Mr. Edison showed, as was ascertained many years ago, that the heat of the corona is quite sensible. With a thermopile attached to a peculiarly arranged spectroscope, Mr. Anderson, of the Princeton party, obtained a doubtful result, which may indicate a bright heat-line in that part of the chromosphere spectrum below the red.

"It has been represented that the results of this eclipse require a fundamental reconstruction of the theories hitherto held regarding the constitution of the corona. This is, however, an entire misapprehension. The same constituents appear in the corona as hitherto, only in altered proportions, as might have been, and was, expected by students of solar physics. In 1869, 1870, and 1871 the gaseous elements of the corona—the hydrogen and '1474 stuff,' whatever that

may be—were in such quantity and condition, and rose so high above the solar surface that their lines were conspicuous in the coronal spectrum, and attracted the attention of observers far more forcibly than the feeble continuous spectrum of the light emitted from, and reflected by, the minute solid or liquid particles which also constitute an essential element of the corona. At present the condition is reversed. The gases are either too small in quantity or too cool to be conspicuous. The lesson, and it is an important one, is simply, as has been said, that, to a certain extent, the corona sympathizes with the sun-spots.

"It certainly looks probable, also, that while the gaseous elements of the corona are strictly solar, the non-gaseous matter—the coronal dust or haze—is of extraneous and very likely meteoric origin. At any rate, the extent of the corona was certainly not less than on former occasions, whatever may have been the case with its brightness. In fact, it has never been traced quite so far from the sun before, as this time by Langley and Newcomb, who followed it out for 6° along the ecliptic, a success partly, of course, due to the clearness of the air at their elevated stations. Now, this is quite consistent with the theory that meteor streams furnish the hazy matter of the coronal envelope, since, so far as we can judge, they have nothing to do with sun-spots.

"A very interesting problem relates to the effect of solar forces upon this meteoric matter, if such it really be, and the material for the study is furnished in rich abundance by the numerous drawings made by Langley, Abbe, Penrose, Boss, and others, and by the photographs, which in excellence and number excel those obtained on any previous occasion. Among the best which we have seen are the magnificent series made by Rogers at La Junta, those of Draper at Rawlins, and those of the Princeton party at Denver; undoubtedly there are others of at least equal excellence.

"To sum up: the eclipse of 1878 has probably added a new planet to the system, and has rendered it likely that the unknown cause, whatever it may be, which produces the periodical sun-spots at intervals of about eleven years, also affects the coronal atmosphere of the sun.

"The result of the late eclipse goes to show such a periodical change in the state of the solar atmosphere as might

very possibly produce a sensible effect upon the earth; whether it does or not is a question which can be settled only by a careful and systematic investigation of the facts."

The detailed reports of the various parties sent out by the Naval Observatory have not yet been printed. The following abstract of their principal work is taken from the Report of the Secretary of the Navy for 1878.

It was seen that in order to obtain thoroughly satisfactory photographs of the corona, it would be necessary to use far more powerful apparatus than had been employed heretofore, and it was proposed by Professor Harkness to construct two equatorial cameras of six inches aperture and thirty-six inches focus. This plan was adopted, the objectives being furnished by Dallmeyer, of London. Two of the Transit-of-Venus 5-inch telescopes were removed from their equatorial mountings, and the cameras were substituted in their places. In this way two very serviceable instruments were obtained which were subsequently used by the parties of Professors Hall and Harkness. It was finally decided to adopt dry plates, and Mr. Jos. A. Rogers kindly furnished the observatory with some of his own manufacture. The results subsequently obtained with them upon the corona prove that there is every reason to be thankful that his generous offer was accepted.

As the liberal appropriation made by Congress enabled the observatory to fit out quite a number of parties, the co-operation of all the best-known astronomers in the country was solicited, and they responded heartily. While the observatory was able to assist them both pecuniarily and by the loan of instruments, they were left entirely free to plan their own observations; thus securing a wide range of investigation. The final arrangement of the parties, and the work accomplished by each, were briefly as follows:

The party under charge of Professor Hall was stationed at La Junta, Col. The principal results of the work of this party were:

1. Professor Hall made an unsuccessful search for *Vulcan* with a 5-inch Clark equatorial, magnifying power one hundred and fifty diameters. The space south of and following the sun was swept over, keeping near the ecliptic and sweeping about 10° east of the sun.

2. Mr. Wheeler made an unsuccessful search for *Vulcan* with a 5-inch Clark telescope, magnifying one hundred and fifty diameters, and mounted as an alt-azimuth. The space swept over was below and preceding the sun, where Professors Watson and Swift discovered *Vulcan.*

3. Mr. J. A. Rogers made five photographs of the corona. The exposures were 3, 5, 10, 60, and 20 seconds. The image of the moon was $\frac{36}{100}$ of an inch in diameter. As the exposures were increased, more and more of the corona was shown, and the longest exposure gave a corona twenty minutes of arc in extent each side of the sun.

These photographs show a great amount of detail, and in connection with those of other parties will probably give more information in regard to the minute structure and extent of the corona than has yet been obtained from photographs.

Professor A. W. Wright determined the plane of polarization of the corona, and the percentage of polarized light present, and took two photographs.

Dr. Thorpe determined the magnetic elements of La Junta, and photographed the corona.

The party under direction of Professor Harkness was stationed at Creston, Wyoming Territory.

Professor Harkness, assisted by Lieutenant E. W. Sturdy, searched the violet and ultra-violet portions of the coronal spectrum for bright lines, but found none.

Mr. Alvan G. Clark and Mr. A. N. Skinner managed the equatorial camera, and obtained six photographs of the corona, which are thought to be at least as extensive and as rich in detail as any ever taken. The exposures were, respectively, 3, 15, 30, 60, 8, and 5 seconds.

Professor Otis H. Robinson used the polariscopic camera, and obtained four photographs which distinctly show the polarization of the corona. They are now in the hands of Professor A. W. Wright, who is making a special study of that subject.

The party under direction of Professor Eastman selected as an observing-station the town of West Las Animas, Col.

Professor Eastman observed contacts, and, with a single-prism spectroscope attached to a 5-inch equatorial, traced the limit of the substance in the corona which gives the

bright line "1474" in the green portion of the spectrum, on the north, east, south, and west limbs of the sun. The existence of this line was demonstrated to a distance from the sun's limb equal to about four tenths of the solar diameter, and the limit was about the same in the four different directions.

Professor Boss determined the latitude and longitude of the station, observed contacts, and during totality devoted himself to the study of the details of the structure of the corona.

Professor Pritchett observed contacts, and during totality devoted a portion of his time to an unsuccessful search for *Vulcan*, and the remainder to a study of the solar prominences, and one or two portions of the corona.

Assistant Paul observed contacts, and during totality sketched the outline of the corona projected on a finely ground glass plate in the focus of a telescope of 48.5-inch focus, with an objective of 3.5 inches.

Mr. H. S. Pritchett observed contacts, and during totality pointed the telescope which carried Professor Eastman's spectroscope.

The party under Professor Holden was stationed at Central City, Col. The work done was as follows:

Professor Holden made an unsuccessful search for *Vulcan*, and a sketch of the corona.

Dr. C. S. Hastings made six independent determinations of the plane of polarization of the coronal light.

Professor E. W. Bass made a minute examination of one half of the corona, and observed the four contacts.

Lieutenant S. W. Very, U.S.N., determined the latitude and longitude of Central City, and assisted Dr. Hastings during totality by pointing his telescope.

Mr. J. E. Keeler made a crayon drawing of the corona.

Mr. C. H. Rockwell made a sketch of the corona, and noted time for Professor Bass.

Mr. Peers, of Central City, took a photograph of the corona. This photograph is noteworthy, as it gives more of the outer corona than any other, and is a valuable supplement to the photographs of Professors Hall and Harkness, which give so much detail in the inner corona. (The outer corona is shown over 60′ on each side of the sun.)

The party under Professor S. Newcomb was stationed at Separation, Wyoming.

This party observed contacts and exposed a large number of (dry) photographic plates in a photoheliograph. When these plates came to be developed, no image of the sun was seen. The plates were certainly sensitive, and the cause of the failure is unknown.

Commander W. T. Sampson, U.S.N., who observed the eclipse at Separation with Professor Newcomb, describes briefly his examination of the spectrum of the corona in *The American Journal of Science* for November. The result he sums up as follows: "The conclusion forces itself upon my mind that the light of the corona is not all reflected light. Several considerations lead to this conclusion. Until this eclipse, no observer has ever seen the dark lines in the spectrum of the corona except M. Janssen, who reported dark lines, notably D, in 1871, but much more difficult to see than the bright lines. Several observers during the recent eclipse failed to see the dark lines, though they looked for them carefully. While I do not question the results of observers who report the presence of dark lines, I think all the observations taken together show that the continuous spectrum of the corona is not the spectrum of the sun. Aside from this, Professor Arthur W. Wright made measurements of the polarization of the light of the corona—the first time, I think, it has been attempted—and has found the polarization to be but a small percentage of the whole light emitted. Although all reflected light does not reach us as polarized light, yet I think the small percentage of polarization, taken with the faintness of the dark lines, indicates that the corona is to a considerable extent self-luminous. The meteoric dust not only reflects the sun's light, but it is continually showering upon the sun, and in its passage through its atmosphere is rendered incandescent. No photographs of the spectrum of the corona can probably throw any light upon the matter."

A party consisting of Professors S. P. and J. W. Langley occupied the summit of Pike's Peak. They were engaged in photometric determinations of the light of the corona, etc., and secured valuable drawings; and Professor S. P. Langley was able to trace the corona for several degrees on

each side of the sun, and to see it after the reappearance of the sun.

Mr. G. W. Hill made a drawing of the corona at Denver, Col.

Professor O. Stone and Mr. W. Upton observed the eclipse a few miles east of Denver. Contact and other observations were secured.

Messrs. L. and G. H. Trouvelot observed at Creston, and a fine pastel drawing of the corona has been received from them.

Mr. D. P. Todd, of the *Nautical Almanac* Office, was stationed at Dallas, Texas, and, in spite of cloudy weather, observed contacts. He also secured a number of observations of the duration of totality from volunteer observers stationed near the limits of total eclipse.

The discovery of *Vulcan* by Professor Watson is mentioned elsewhere.

TRANSIT OF MERCURY, MAY 6, 1878.

The transit of *Mercury* was observed by Professor Hall at Washington. Seventy-two photographs of the planet, when on the disk of the sun, were made at Washington by Mr. Joseph A. Rogers with one of the photoheliographs used in photographing the transit of *Venus* in December, 1874.

Professor Harkness went to Austin, Texas, to observe this transit. Although the first half of the transit was lost in clouds, he was favored with a clear sky and a steady atmosphere during the latter half, and succeeded in making twenty-five measures of the polar diameter of *Mercury*, the same number of measures of its equatorial diameter, excellent determinations of the instants of third and fourth contact, and a very satisfactory observation of the physical phenomena attending these contacts.

The transit was observed by Professor Eastman with the 9.6-inch equatorial at the Naval Observatory; and by Assistant Astronomers Frisby and Skinner with smaller equatorials. Professor Eastman observed the second, third, and fourth contacts, made several series of measures of the diameter of *Mercury*, and made a careful study of the physical phenomena at the time of contacts. Assistant Astronomers Frisby and Skinner observed contacts.

Professor Holden, in connection with Dr. Draper at Hastings-on-the-Hudson, observed the third and fourth contacts, and secured nineteen good photographs.

Assistant H. M. Paul observed the transit at Hanover, N. H.

Professor James C. Watson and Professor E. C. Pickering photographed the transit of *Mercury* with instruments furnished them by the Naval Observatory. Professor Watson exposed seventy-two plates, but, owing to bad weather, Professor Pickering exposed successfully only twenty-six. The plates were returned to the Naval Observatory and there developed.

The London *Academy*, May 18, states that cloudy weather prevailed over England during the transit of *Mercury* on May 6, but that Scotch observers were more successful.

From the *Observatory* the following is extracted: "In addition to the observations given in the report of the meeting of the R. A. S., reports have been received from a number of observers abroad. M. Janssen, at Meudon, was able to see *Mercury* outside the sun's disk before external contact; and by means of the spectroscope he succeeded in establishing the existence of an atmosphere round the planet, and its constitution. He also obtained some photographs, of which two are excellent. Captain Mouchez and MM. Henry at the Paris Observatory observed internal contact, though the observation was bad, owing to cloud, as was also the case at Algiers and Bordeaux.

"At Toulouse M. Perrotin observed internal contact through cloud so dense that a dark glass was not used. Under these circumstances, he remarked a *dark* aureole or penumbra round the planet, but this disappeared when the light became too bright.

"The French expedition to Ogden, Utah, was perfectly successful, seventy-eight photographs of the transit having been taken by MM. André and Angot, as well as observations of contact. Satisfactory observations and photographs were also taken at the observatory of West Point, N. Y.

"The transit was also observed in Spain, at San Fernando and Cadiz. At the latter place M. Arcimis records that no arc of light was seen before internal contact, either outside the sun or round the part of the planet's limb on the sun. At internal contact the planet assumed a balloon or pear shape, and

for a long time after no ring was seen round the planet. About an hour and a half after ingress, however, a dark ring, not so black as the planet, and about 8″ or 10″ broad, was seen, the sky being then quite clear."

Mr. Talmage, of Leyton, observed a luminous ring about *Mercury*, which was very well defined. He had, however, only a few seconds of clear weather. In this country it was extensively observed, and many photographs were made. These are now being measured at the Naval Observatory, Washington.

Professor Langley, at Pittsburgh, observed the transit of *Mercury* under favorable conditions. The planet was seen outside the sun about half a minute *before* first contact, the whole disk being seen. Haze prevented similar observations at egress. No bright point or annulus was seen. The darkest part of the planet was the centre, the edges being less gray, but the planet was certainly not black. Photometric measures of the absolute amount of light from *Mercury* were attempted, but Professor Langley interprets the results as measures of the minimum effect to be assigned to the earth's atmosphere in inflecting the solar light.

The observations of contact published up to the present time agree closely with the predicted times based on Leverrier's tables, the general accuracy of which is thus supported.

TRANSIT OF VENUS AND SOLAR PARALLAX.

The publication of the results of the French Transit-of-Venus reductions has been delayed through the illness of the editor, M. Puiseaux. The results of the eye observations have been deduced, however, and harmonize well, being between 8.82″ and 8.88″ from pairs of stations, and the general result will not be far from 8.85″. The difference between this and the English result, 8.77″, is marked. The French photographic results are not yet published.

A somewhat unexpected result is obtained by the reductions of the British observations on the last transit of *Venus*. The data used are the eye observations (telescopic) in Egypt, Honolulu, New Zealand, Rodriguez, and Kerguelen. The photographic observations, of course, were not combined with these, and there are also eye observations taken in India and Australia that may be utilized; but it is not believed that any

great change in the result will be effected by the figures obtained from the latter source. The new British calculations give for the value of the sun's parallax 8.76″, with a probable error of 0.013″. This corresponds to a distance for the sun of 93,300,000 miles, with a probable error of 140,000 miles. The British photographs of the transit of *Venus* have been twice measured, and are discussed by Captain Tupman. His conclusions are that the English method was fundamentally wrong (as, indeed, was predicted), and the two results (8.25″ and 8.08″) are of no value, and must be rejected.

Lord Lindsay has published the second volume of the *Annals* of the Dun-Echt Observatory—a quarto volume of 212 pages. It contains the determination of the solar parallax by observations of *Juno*, and a description (with plates) of the heliometer employed. The method employed is the determination of the diurnal parallax, and this experiment was tried to determine the advantages or disadvantages of the method. The authors (Lord Lindsay and Mr. D. Gill) think that this method has been shown to be one of the very best, and the resulting solar parallax 8.77″±0.041″ is regarded as a close approximation, to be subsequently corrected by similar observations of *Mars* and asteroids which have been made by Mr. Gill at Ascension Island. The description of the heliometer, with the investigation of its constants, is very full, and will serve as a manual for similar investigations. It is concluded that it is possible with this instrument to determine the distance of a minor planet relative to two stars with a probable error of less than 0.1″.

THE DISCOVERY OF VULCAN.

The reports of Professor James C. Watson, of Ann Arbor, Mich., and Mr. Lewis Swift, of Rochester, on their discovery of a new star or stars during the eclipse are given below in the form of letters to the Superintendent of the Naval Observatory, Washington. Subsequent letters give changes in matters of detail, but the most important facts are given below. Professor Watson says:

"I am now able to give you more precise information in reference to my observations of a supposed new planet during the recent total eclipse of the sun. . . . Before the commencement of the eclipse, the adjustment of the equatorial

had been attended to, so that the error to be feared on this account will be very small. A few minutes before the total phase, I swept over regions east and west of the sun from eight to fifteen degrees distant; but I did not see any star. Immediately after the totality, I began sweeps east and west, extending about eight degrees from the sun. The first sweeps were towards the east. On the fifth sweep I found between the sun and *Theta Cancri*, and farther south, a star of the 4½ magnitude, as estimated at the instant, which immediately attracted my attention on account of its general appearance. I had committed to memory the relative positions of the stars in the neighborhood of the sun, and I had placed the chart of the region conveniently before me for ready reference whenever required. There was a fainter star west and north of *Theta Cancri*, as shown on the chart, and I could not be sure of the place without an actual measurement. The object which I had in the field shone with an intensely ruddy light, and it certainly had a disk larger than the spurious disk of a star. . . . Having made the record, I placed my eye again at the telescope, and saw that there had been no disturbance of its position. I noticed, further, that the object in the field did not present any elongation, such as might be expected if it were a comet in that position. The sweeps were then continued, and I finally brought into the field what I supposed to be *Gamma Cancri*, although it appeared very much brighter than *Delta Cancri*, which I had seen near the sun at the commencement of the search during the totality. I proceeded to record its position on the circles. Before this was completed the total phase had ended, and I ran across to where Professor Newcomb was observing, in hopes of being able to direct his larger telescope, with graduated circles, upon the object first seen before the sunlight would interfere; but he was reading his circles for an object which he had in the field, and his telescope could not be disturbed. Thereupon I returned to my own telescope; but the sunlight had already become so bright that further observations were impossible, and hence I could not assure myself that a gust of wind had not disturbed the instrument before I had marked the last pointing. . . . The places of the sun were again recorded and verified at suitable intervals, so that the position of the star (which I believe to be an intra-Mercurial planet) can be de-

termined relatively to the sun. . . . In the brief time allotted it was not practicable to change the eye-piece and observe the star in question under a higher power. Its light was quite red, and, so far as my recollection of its appearance in the telescope will enable me to determine, I am of the opinion that it was situated beyond the sun. . . .

"In regard to the star B, which I consider to be the planet sought, there is no uncertainty whatever, beyond the unavoidable errors of the record as made. I consider the place given to be trustworthy. . . . I have further observations of contacts, and also some sketches of the corona made by members of my party, which I will send you in due season. Meanwhile, I doubt not that you will agree with me that the observations above detailed establish the existence of one new star in the vicinity of the sun, and point possibly to the existence of two."

Professor Watson is now inclined to believe that *both* of the new objects seen by him are planets.

Mr. Swift's observations were made at Denver. He says: "About one minute after totality I observed two stars, by estimation three degrees southwest of the sun, pointing towards the sun, of about the fifth magnitude, or what I estimated at the time, as bright through the telescope as *Polaris* is to the naked eye. How much allowance ought to be made in estimating magnitudes so close to a totally eclipsed sun I do not know. I saw them three times, and attempted, at the last moment, to get another observation; but at the critical moment a little cloud passed over the sun, and I hastened to observe again the sun for the third contact and attending phenomena. At each of the observations, by careful comparison, they appeared exactly of the same magnitude, and both as red as *Mars*. I looked closely for twinkling, but they were as free from it as the planet *Saturn*. They both, at the time, seemed to my eye and mind to have a small round disk about like the planet *Uranus*. Whether the disks were imaginary or real I cannot tell, but every time I saw them (the stars) the disks attracted my attention."

Professor Pliny E. Chase writes to the Smithsonian Institution that "Gaillot's orbit for Watson's second intra-Mercurial planet represents his tenth *subsidence-node* [$\frac{2}{3}$ *Jupiter*

$\div(2n-1)$], and gives the ninth verification to his harmonic prediction. Gaillot 0.1803; Chase 0.1826."

THE PLANETS AND SATELLITES.

Mercury.—The principal observations of *Mercury* are spoken of under the heading *Transits of Mercury.*

Venus.—M. Boutigny has called the attention of the French Academy to the fact that Varro (31 B.C.) spoke of changes in the diameter, color, figure, and path of *Venus.* The passage referred to is quoted in a work of St. Augustine. *Venus* has been observed during the last year with the 26-inch Washington equatorial. No markings on the disk were seen, but the illumination of the dark hemisphere was frequently noted by several observers.

Mars.—From the recent discussion by Professor Hall of his observations of the satellites of *Mars*, we extract the following: "The planes of the orbits of both satellites are very nearly coincident with the equator of *Mars.* The elements of these orbits are determined with tolerable accuracy, excepting the periodic times, for an accurate determination of which we must wait until the satellites have been observed in another opposition. The times that have now been found will serve to carry forward an ephemeris to 1879. In the orbit of *Deimos*, the value of the eccentricity being small, the position of the line of apsides is of course uncertain. This eccentricity is so small that circular elements of this satellite may be considered as sufficient for the observations. In the case of *Phobos*, the eccentricity of its orbit has, I think, a real existence. It will be noticed that in the comparison of the observations of *Phobos* with the assumed circular elements, every comparison of distance confirms the existence of an eccentricity. It is true that the observations of this satellite were always difficult on account of its closeness to the planet, and also because of the brightness of the planet; and it may be suspected that some systematic error has influenced the result. Such an error would indeed have more influence on the eccentricity of the orbit of the inner satellite than on that of the outer one. But the resulting eccentricity is too large, I think, to be explained in this manner, and I conclude that the orbit of *Phobos* is really eccentric."

The mass of *Mars* can be determined from the motion of

these satellites. "Expressing the mass of the planet in the common unit, we have, from the above values of the elements, the following results:

$$\text{Deimos: Mass of Mars} = \frac{1}{3095313 \pm 3485};$$

$$\text{Phobos: Mass of Mars} = \frac{1}{3078456 \pm 10104}.$$

"These results agree so nearly within the limits of their probable errors that I have taken the mean by weights as the final result from the Washington observations. In this way we have

$$\text{Mass of Mars} = \frac{1}{3093500 \pm 3295}."$$

The recent report of Professor Pickering, Director of Harvard College Observatory, states that it has been decided to devote the large refractor chiefly to photometry. In this way a field is taken up which has too long been unoccupied. Besides a great number of photometric observations on double stars, asteroids, and satellites of the outer planets, the satellites of *Mars* have been studied. Assuming the *albedo*, or intrinsic reflecting power of these bodies, to be the same as that of *Mars*, it is concluded that the diameters are for *Deimos* (outer satellite) about 6 miles, and for *Phobos* (inner) about 6.5 miles.

Following are some previous values of the mass of *Mars* which are interesting for comparison with Professor Hall's results: Laplace assumed the mass of *Mars* to be $\frac{1}{1846082}$. Delambre reduced this estimate to $\frac{1}{2546320}$. Burckhardt, in 1816, diminished this still further to $\frac{1}{2680337}$. By Hansen and Olufsen, of Sweden, in their solar tables, the estimate is $\frac{1}{3200900}$. Leverrier got $\frac{1}{2994790}$.

The spectrum of *Mars* has been photographed by Dr. Huggins.

Professor Hall, of Washington, made, during the last opposition of *Mars*, a large number of measures (thirty-two nights) of the position of the south polar spot of *Mars*. From all of these he finds for the angle of position of this spot for 1877, September 17.0 G. M. T., 166° 22′, and for the same epoch the radius of the small circle described by the spot is 5° 11′. The various determinations of the south polar dis-

tance of the spot are: Herschel (1783), 8° 8′; Bessel (1830), 8° 6′; Mädler (1837), 12° 0′; Secchi (1857), 17° 42′; Linsser (1862), 20° 0′; Kaiser (1862), 4° 16′; Hall (1877), 5° 11′. A similar work has been done by Professor Schiaparelli at Milan, and he finds for 1877, September 27.0, $\lambda = 6° 15'$, Hall's result for this epoch being 5° 18′. Professor Hall's observations were of the angle of position of the spot, while Schiaparelli made his own by placing the micrometer wire tangent to the limb of the planet at the middle of the spot. A series of the same kind (as yet unpublished) was made at the Dudley Observatory by Professor Boss.

Jupiter.—The conclusions of Mr. Neison upon the atmosphere of *Jupiter* are that it may be regarded as certain that it is physically impossible for *Jupiter* to have an atmosphere of great depth, unless the temperature of the planet be supposed to be many million times hotter than a white heat, or unless the atmosphere is constituted of some substance unknown to us, and widely different from substances familiar to us.

Saturn.—In the *Astronomische Nachrichten*, Mr. Marth continues his very complete ephemeris of the five inner satellites of *Saturn.* He notes the desirability of observations of the conjunctions of *Mimas* with the ends of the ring, but has overlooked the fact that no satisfactory observations of these phenomena have ever been made. From his own observations at Malta, and the experience at Washington, it is even doubtful if they ever can be made. It may be worth while to note in this place the times of *sidereal revolution* of the five inner satellites adopted by Marth. They are, *Mimas*, 0 d. 22 h. 37 m. 8.26 s.; *Enceladus*, 1 d. 8 h. 53 m. 6.86 s.; *Tethys*, 1 d. 21 h. 18 m. 25.96 s.; *Dione*, 2 d. 17 h. 41 m. 9.33 s.; *Rhea*, 4 d. 12 h. 25 m. 11.87 s.

M. Tisserand continues in the *Comptes Rendus* his researches on the system of Saturn, and has published the motions of the perisaturnium of each of the five inner satellites. For *Mimas* this motion is 349° per annum. Tisserand further shows how the mass of the ring itself may be determined, as well as the oblateness of the ball. For this, continued observations of *Mimas* and *Titan* are necessary.

"The appearance of the ring of Saturn was carefully observed at Washington during the whole opposition, and it

was followed until February 11, 1878. The disappearance of the ring occurred about February 6. The angle of position of the major axis of the ring was observed on thirty-six nights by Professor Hall, and on twenty-two nights by Professor Holden. Although at the time of the disappearance of the ring the planet was too near the sun for good observations, yet the whole of these observations indicate that Bessel's elements of the ring are very nearly correct."

Professor Hall, of Washington, has an investigation of the outline of the shadow of a planet projected on any plane—first, for the case where the luminous and opaque bodies are both spherical; and, second, where the opaque body is supposed to be an ellipsoid of revolution. The conclusion is that, even in the case of *Saturn*, which has the most eccentric figure of any of the planets, the outline of the geometric shadow on the plane of the ring is sensibly a right line. The apparent convexity of the bounding line of this shadow towards the centre of *Saturn* has then to be explained from conditions other than geometrical.

M. Souillart, known by his researches on the theory of *Jupiter's* satellites, has a paper in the *Astronomische Nachrichten* on the shape of the shadow of a planet, and comes to essentially the same conclusions as previously given by Professor Hall in the same journal.

M. Tisserand, of Toulouse, who has lately occupied himself with the system of *Saturn*, has an important note in *Comptes Rendus* on the nature of the ring. Laplace proved in 1787 that even if observation did not show that the ring of *Saturn* was composed of two or more concentric rings, the theory of gravitation would require this. Tisserand, as the result of the re-examination of the problem, comes to the conclusion that a continuous ring of the dimensions of the real ring cannot exist in equilibrium. Hence it is divided. In fact, the ring of *Saturn* has been seen (by Bond, De la Rue, Dawes, etc.) divided into numerous fine concentric rings, just as this condition requires.

Uranus and Neptune.—The satellites of these planets are followed at the Naval Observatory, Washington.

MINOR PLANETS DISCOVERED IN 1878.

Date.	No.	Name.	Discovered by	Dis.'s No.	Observatory of
Jan. 29	180	Garumna	Perrotin	5	Toulouse.
Feb. 2	181	Eucharis	Cottenot	1	Paris.
Feb. 7	182	?	Palisa	12	Pola.
Feb. 8	183	?	Palisa	13	Pola.
Feb. 28	184	Diopeia	Palisa	14	Pola.
?	185	Eunike	Peters	28	Clinton.
April 10	186	Celuta	Henry	?	Paris.
April 11	187	?	Coggia	2	Marseilles.
July 7	188	Menippe	Peters	29	Clinton.
Sept. 17	189	Phthia	Peters	30	Clinton.
Sept. 22	190	Ismene	Peters	31	Clinton.
Sept.	191	Kolga	Peters	32	Clinton.

THE MOON.

"Lohrmann's Map of the Moon consists of 25 sections on the scale of 37.5 inches to the moon's diameter, or the same scale as Beer and Mädler's 'Mappa Selenographia.' They have been engraved at different times on copper-plate, and are in every respect perfectly analogous to the four original sections which were issued in 1824. They have been carefully edited by the well-known selenographer Herr Julius Schmidt, of the Observatory at Athens, and are a faithful reproduction of the original ink maps of Lohrmann, so that in the present map we have an exact representation of the surface of the moon as it appeared to Lohrmann during the period 1821–27. On this account, therefore, the map will form a most valuable contribution to selenography. In his capacity of editor, Schmidt has added to the map all the standard names of Beer and Mädler. He has also named a number of additional points."

Schmidt's great map of the moon has not reached this country, so far as we know.

Professor Newcomb, of Washington, has an important note in *Silliman's Journal* (November) on the mean motion of the moon. It is an abstract of the researches which have been published in full in *Wash. Ast. Obs.*, 1875.

He has made a discussion of all trustworthy recorded observations of the moon before 1750—eclipses and occultations. These materials are:

1. Ancient eclipses (total) of the sun, such as the celebrated ones of Larissa, etc. Professor Newcomb comes to the con-

clusion that the accounts which remain to us are in no one case sufficient to connect the eclipses computed back from modern data with the phenomenon recorded by the historian. In many cases it is not even certain that this phenomenon was an eclipse at all.

2. The nineteen eclipses of the "Almagest" give data which are at the best uncertain.

3. The eclipses of the Arabian astronomers, which are now for the first time utilized.

4, 5, 6. The observations of Tycho Brahe, etc., of Gassendus and Hevelius, are not valuable for this purpose, as they were taken without the aid of telescopes, and are not of sufficiently ancient date.

7. The observations of De la Hire, De l'Isle, and others, from 1672 to 1750, are now discussed for the first time, and prove to be most valuable material. From 1750 to 1860 or 1865, Hansen's tables represent the observations well. The whole series is represented by omitting the empirical terms of Hansen depending on eight times the mean motion of *Venus*. The value of the acceleration from observation alone is 8.8″, Hansen's adopted value being 12.17″. This value 8.8″, however, requires to be changed by $-0.9''$ in a century to satisfy observations, and there are several ways in which this may be effected. The rotation of the earth may not be uniform, the analytical theory may not be complete, or other and undiscovered bodies may enter in. A term expressing the total correction to Hansen's tables is deduced and provisionally adopted. Its theoretic basis requires further investigation. Dr. Haughton has considered these ancient eclipses in a memoir read to the British Association. Dr. Weiler has also a series of papers on the theory of the secular acceleration in the *Astronomische Nachrichten*, No. 2060 *et seq.*

In 1787 Sir William Herschel announced that he had observed three volcanoes in active operation in different parts of the moon, the diameter of the principal crater being about three miles. In May, 1877, Dr. H. J. Klein, of Cologne, while examining the moon, noticed a great black crater on the Mare Vaporum, and a little to the northwest of the well-known crater Hyginus. He describes it as being nearly as large as Hyginus (or about three miles in diameter), as being

deep and full of shadow, and as forming a conspicuous object on the dark gray Mare Vaporum. Having frequently observed this region during the last twelve years, Dr. Klein felt certain that no such crater existed there at the time of his previous examinations. He communicated his observations to Dr. Schmidt, of Athens, who assured him that this crater was absent from all his numerous drawings of this part of the lunar surface: neither is it shown by Schröter, Lohrmann, or Mädler. Dr. Klein made his discoveries known generally, and they seem to have been partially confirmed by other observers. The Mare Vaporum, in which the new crater is situated, lies close to the centre of the visible surface of the moon, so that objects in this region are very slightly affected by the lunar librations. It is also a part of the moon which has been most carefully studied. Had this new crater of Dr. Klein's appeared in a less well known region, much more doubt would have been felt as to whether it had previously existed or not.

COMETS; METEOR STREAMS.

The comets of 1878 have been—

Comet I., discovered July 7, by Lewis Swift, of Rochester, N. Y. This comet was only observed in America by Dr. C. H. F. Peters, the majority of American observers being in the West on eclipse expeditions. It is probably identical with a comet discovered by P. Ferrari at Rome in July. On July 20, Tempel's periodic comet was found by Winnecke, quite away from its ephemeris place.

Orbit of Comet IV., 1873.*—M. Raoul Gautier, of Leipsic, has discussed all accessible observations of this comet, extending from August 20 to September 20, and, though the period of visibility was not long, the data make it tolerably certain that the orbit is elliptic, the sum of the squares of the residuals being reduced from 81.18 on the hypothesis of a parabola to 2.14 on that of an ellipse, while the probable error of an observation is reduced from 6.04″ to 1.14″. The eccentricity of the ellipse is, however, very large, corresponding to a period of revolution which may perhaps range from 3000 to 3600 years, so that this comet is to be classed among those of very long period.

* *Astronomische Nachrichten*, No. 2164.

One of the most important papers of the year is by Professor Newton, of Yale, on the "Origin of Comets." It is impossible to give here an abstract of this paper, which is itself a series of propositions, each in a condensed form, and each closely connected with every other. We can only refer to this as a body of doctrine which will become the *Principia* of this subject.

In the *Monthly Notices*, R. A. S. (1878, May, p. 369), Professor A. S. Herschel has a "List of Known Accordances between Comets and Observed Meteor Showers," which will be useful. Seventy-one such are noted.

Encke's comet was found on August 3, by Mr. Tebbutt, of Windsor, N. S. W., with a 4½-inch telescope. The comet was 2′ in diameter, and pretty bright.

ZODIACAL LIGHT; METEORITES.

The "Results of Observations of Shooting-Stars from 1833 to 1875," by the late Dr. Heis, of Münster, has been published. It comprises Dr. Heis's own observations for forty-three years at the observatory of which he was director. According to *Nature*, it gives the times of occurrence and the points of first and last appearance of 13,000 meteors, followed by a partial discussion of the results, and catalogues of radiant points.

The zodiacal light continues to be observed by Mr. Henry C. Lewis, of Germantown, Pa.

NEW OBSERVATORIES, NEW INSTRUMENTS, ETC.

Accounts of European and American observatories are given elsewhere.

A new private observatory has been founded in Providence, R. I., by Mr. George A. Seagrave. The building is of brick, with a wooden dome. The principal instrument is an equatorial refractor of eight inches aperture, from the workshops of Alvan Clark & Sons. The tube of the telescope is made of sheets of steel riveted together so as to form two conical halves, to insure rigidity. The mounting is unusually heavy for an instrument of this size. The circles for indicating the position of a heavenly body in space are conveniently graduated on their outer edges for roughly finding an object. The declination circle reads by its verniers to 15″, and the hour

circle reads to 2″ for locating it. The telescope is provided with a position micrometer by the Clarks, and a double-image micrometer by Browning, of London, for the purpose of exact measurements. There are two spectroscopes by Browning and Grunow. The observers are Mr. Seagrave and Mr. L. Waldo, of Harvard College Observatory. From an account of the observatory it is learned that the observers contemplate prosecuting two plans of work. "One of these researches is the measurement of such of the close double stars discovered by our distinguished fellow-countryman S. W. Burnham, Esq., of Chicago, as we can reach with our optical means. The second research is the continuous and exhaustive measurement of one or two stars which have shown unusually large annual motions in the heavens, to determine, if possible, their parallax."

In the list of papers read to the Scientific Association of the Johns-Hopkins University, and as yet unpublished, the only one relating to astronomy is by Dr. C. S. Hastings, "On a True Criterion for Color-Correction in the Astronomical Objective." The formulæ arrived at have been put to a practical test by Dr. Hastings in the making of a 4-inch object-glass.

A commission appointed by the French Chamber of Deputies has reported favorably on the erection of a large observatory at Meudon. The credit given is 690,000 francs ($138,000), of which $78,000 are for the purchase of a large refractor. M. Janssen will be, as before, the director.

Mr. Lockyer has published in *Nature* a series of articles on the "Modern Telescope," which gives a useful and convenient popular summary of the principal defects and advantages of the telescopes now in use. The paper by Mr. Grubb on the same subject is taken as a basis, and some of the difficulties described by Mr. Grubb are considered.

Mr. Henry Bessemer, in considering these difficulties, has been led to propose (*Nature*, January 24, 1878) a plan for overcoming the difficulties in mounting and figuring large glass reflectors, according to which plan he is now making a 50¼-inch silvered glass reflector. First, as to support: a ribbed casting of iron 52½ inches in diameter and 13 inches thick, weighing 1400 pounds, is to be made and annealed in oil. Its face will be turned to a true plane, and a spiral groove one sixteenth of an inch deep and wide will be cut all over this

face, the channels being half an inch apart. The back surface of an ordinary rolled glass is turned to a plane and moistened with oil, and placed on the iron back and fastened round the edge to a projecting ring on this back with marine glue. The air is then exhausted from the channels in the cast-iron back through an orifice, and the glass and iron are thus fastened together. The figuring is to be done by a diamond point, which is mounted on a slide-rest, which cuts at the same time both a concave surface on the glass for the mirror, and a convex surface of the same radius on another glass or metal which is to serve as a grinding tool. The spherical surface to be thus obtained is to be turned into a paraboloid by mechanical means not described.

In Vol. III. of the Moscow *Observations*, M. Gromadski gives the results of his discussion of the division errors of the meridian circle of that observatory. It was made by Repsold, and a comparison of its division errors with those of the two Repsold circles at Pulkova has led M. Gromadski to the following important results:

1. The precision of the copies of the original graduation made by Repsold is far more exact than has been suspected till now.

2. The errors of the divisions of the original circle are applicable to all the copies, particularly when the abnormal errors of a few divisions are determined independently.

3. Since several of Repsold's circles are now in use, and since others will doubtless be made, it is of importance that the original circle should be carefully investigated.

As an illustration of 2, Gromadski gives in three columns the division errors of corresponding divisions of the two Pulkova circles and the Moscow circle. Considering the numbers in the three columns as comparable, the probable error of a single division is $\pm 0.11''$. This is the measure of the precision with which the original circle is copied. The probable error of the mean of all is $\pm 0.06''$. From the table it appears that the largest error is less than $1.2''$.

ASTRONOMICAL BIBLIOGRAPHY, ETC.

At a meeting held in London on October 26, 1877, it was resolved to found a society to be called the "Index Society," for the purpose—

1. Of forming indexes to standard works at present without them, and of enlarging and re-editing indexes already made.

2. Of compiling subject indexes of science, literature, and art.

3. Of accumulating materials for a general reference index.

The want of such an organization has been so generally felt for many years that the committee appeal with confidence for support to all classes of readers. In almost every department of knowledge the student finds it well-nigh impossible to keep himself acquainted even with the literature of his own subject; and on all sides the need of registration is painfully felt. It is to meet this difficulty that the Index Society is formed. Under the second head the programme is to form hand-lists of various departments of science and literature, containing notices of books and papers in journals, and transactions of societies (British and foreign); general subjects — such as astronomy, biology, mythology, anthropology, philology, etc.; eras of history; great men; great authors. It is intended that each of these hand-lists or reader's guides shall be drawn up by one who is thoroughly acquainted with the subject he undertakes, and therefore able to bring important communications to the front. No attempt will be made at a full bibliography; but while accuracy in details is strictly attended to, the titles will be reduced into a tabular form. Persons engaged in the formation of indexes are requested to communicate with H. B. Wheatley, Esq., Secretary, Burlington House, Piccadilly, London, W.

The Royal Society of London has printed Vol. VII. of its Catalogue of Scientific Papers. It includes the initials A–HYR (1864–73), and is on nearly the same plan as the earlier volumes. It is edited by Mr. Henry White.

Secchi has published "L'Astronomia in Roma nel Pontificato di Pio IX."—a pamphlet of fifty-one pages, with three plates. It is a sketch of the founding of the Observatory of the Roman College, and of its labors in many fields.

The Observatory of Harvard College has issued a pamphlet, prepared by Assistant Waldo, on "Standard Public Time," "for distribution among those interested in a common standard of public time throughout New England;" and also a circular to New England cities, etc., on the same sub-

ject. If the public really value an accurate standard time, they can now easily obtain it from the observatories of Harvard College, Albany, Washington, Pittsburgh, Cincinnati, Ann Arbor, etc., which are ready to furnish it at a moderate expense.

A very complete bibliography of books and memoirs on the "Method of Least Squares" (81 pp.) has just been published by Professor Merriman, of Yale College.

The publication of the *Bulletin* of the Arcetri Observatory, Florence, is to be renewed under the editorship of Herr Tempel.

In Vol. XIII. of the *Proceedings* of the American Academy, the only astronomical paper printed is one on the longitude of Waltham, Mass., by Mr. L. Waldo.

The fifth volume of André, Rayet, and Angot's "Astronomie Pratique" has reached this country. It treats of the observatories of Italy, and is essentially a report made by M. Rayet to the Minister of Public Instruction.

About a year ago, the Academy of Sciences of Paris decided to issue a complete edition of the works of Laplace. The preceding editions, which have become very rare, contained only seven volumes, but the new one will include six other volumes, comprising all the works which Laplace published in numerous academic and periodical collections, the scattered form of which has rendered their study difficult. Vols. I. and II. of the "Mécanique Céleste" are already out, and Vol. III. will be published in 1878. To the first three hundred subscribers the price of the five volumes which comprise the "Mécanique Céleste" varies from eighty francs to one hundred and twenty francs, according to paper and binding.

A critical study of the question, "Was Galileo tortured?" (*Ist Galileo gefoltert worden?*) has been published by Dr. E. Wohlwill. The conclusions he has reached indicate that the Inquisition certainly went so far as to subject him to the *territio realis*, which always involved the confronting of the prisoner with the rack in the torture-chamber at the very least. A very complete review of the case, by Sedley Taylor, is found in *Nature* for February 14, 1878.

A very complete and valuable Catalogue of the Library of the Leyden Observatory has been published by Dr. Van der Sande Bakhuysen.

In the Harvard College Library *Bulletin*, No. 9, October 1, 1878, is printed a list of books and memoirs on the transits of *Mercury* from 1631 to 1868 inclusive, with notes by Professor E. S. Holden. It has above one hundred and fifty authors' names.

The following astronomical publications are noteworthy, and mostly of popular interest:

André (C.), G. Rayet, et A. Angot.—L'Astronomie Pratique et les Observatoires en Europe et en Amérique depuis le Milieu du XVIIe Siècle jusqu'à nos Jours. Cinquième partie: Observatoires d'Italie, par G. Rayet. In-12. Gauthier-Villars. 4 fr. 50 c.

Atlas Coelestis Eclipticus Eduardi Heis D., etc. Octo continens tabulas ad delineandum Lumen Zodiacale. Long 4to. 1878. $2.20.

Hilfiker.—Ueber die Bestimmung der Constante der Sonnenparallaxe, etc. 8vo. Berne, 1878, pp. 91.

Hinrichs.—Vierteljahrs-Catalog aller neuen Erscheinungen im Felde der Literatur in Deutschland. Nach den Wissenschaften geordnet, mit Register. Leipzig (periodical).

——— Bulletino di Bibliografia e di Storia delle Scienze matematiche e fisiche. (Periodical.)

Kiefer.—Inhaltsverzeichniss zum Bibl. Kat. des Tiflis'schen Physik. Observ. Tiflis, 1874.

Laplace.—Œuvres Complètes, publiées sous les auspices de l'Académie des Sciences, par MM. les Secrétaires Perpétuels. Tomes I. et II. In-4. Gauthier-Villars. Chaque volume, 20 fr.

Cette nouvelle édition, publiée aux frais de la famille, formera 13 volumes, dont les 5 premiers contiendront le "Traité de Mécanique Céleste." Prix de souscription à ces 5 volumes, 80 fr.

Lohrmann's Mondkarte. 25 sections and text. 4to. 1878. $18.40.

Recension Von F. W. Bessel. 1878. Compiled by R. Engelmann. $2.60.

Secchi, Dir. P. A.—Die Sterne. Grundzüge der Astronomie der Fixsterne. Mit 78 Abbildungen in Holzschnitt und 9 Tafeln in Farbendruck, Lithographie und Stahlstich. Autorisirte Ausgabe (A. u. d. T.: Internationale wissenschaftliche Bibliothek. XXXIV. Band.). 8vo. Leipzig, 419 pp. $3.00.

Zöllner, Fr.—Wissenschaftliche Abhandlungen. II. Band. I. Theil. Mit den Bildnissen und Handschriften von Gauss, Wilhelm Weber und Riemann, nebst Tafel I.–X. Gr. 8. Leipzig, 489 pp. $4.40.

MISCELLANEOUS NOTES.

The Imperial Academy of Sciences of Vienna has resolved to renew the prizes (formerly proposed for three years) for

the discovery of *telescopic* comets. The prizes consist each of a gold medal, or of its money value of twenty Austrian ducats (about £9 10*s.*), and are awarded for the first eight successful discoveries in each year of comets invisible to the naked eye at the time of discovery, and the appearance of which could not have been predicted. The priority is to be decided by the epoch of the first position, and the discovery is to be made known to the Imperial Academy of Sciences *immediately, and without waiting for further observations*, by telegraph, where practicable, otherwise by earliest mail. The first notice must contain the position and motion of the comet, besides place and time of discovery, and it is to be supplemented at the *next* opportunity by later observations. If the comet should not have been verified by other observers, the prize will be awarded only when the observations of the discoverer are sufficient for determining the orbit. Application for the prize must be made within three months of the discovery.

The prizes (in astronomy) of the Paris Academy of Sciences have been awarded as follows: The *Lalande* prize to Professor A. Hall, for the discovery of the satellites of *Mars*. The *Valliant* prize to M. L. Schulhoff, for the analytic methods and ephemerides which have led to the re-discovery of three minor planets which had been lost fifteen and a half, eight and a half, and five years respectively. The report of the commission speaks in the highest terms of the mathematical excellence of the methods of M. Schulhoff. The *Valz* prize to the MM. Henry, for their series of (17) celestial charts.

The medal of the Royal Astronomical Society has been awarded by the council to Baron Dembowsky for his observations of double stars, communicated at various times during the past twenty years to the *Astronomische Nachrichten*. It has long been a matter of regret that this valuable series of observations has not been published in a collected form; and we trust that, as public attention is now directed to this vast accumulation of material, some means may be found of rendering it more readily accessible to all astronomers. The medal was presented at the meeting of the R. A. S., on February 8, by the President, Dr. Huggins.

Of the Government Grant Fund of £4000 administered by the Royal Society of London, the following sums have been

devoted to astronomical researches: David Gill, £250, for reduction, etc., of his observations of *Mars* for determining the solar parallax; J. Norman Lockyer, £200, for continuation of spectroscopic researches.

M. Tisserand, Director of the Observatory of Toulouse, has been elected to the French Academy of Sciences in the room of Leverrier. He is succeeded at the Toulouse Observatory by M. Baillot.

The *Monthly Notices*, R. A. S., for December, 1877, contains a note by Professor Zenger, of Prague, on what he calls a "new astrophotometrical method," which consists of determining the order in which the details of a planet's disk vanish as twilight comes on. This method was applied by G. P. Bond to determine the relative brightness of various parts of *nebula Orionis*, etc. (see *Annals* Harvard College Observatory, vol. v., p. 156), as early as 1859.

The Selenographical Society was formed in London in 1878, and is constituted for the purpose of promoting selenography by aiding those who are engaged in the study of the lunar surface, both by affording them information calculated to be of assistance to them in their observations, and by giving them opportunities of consulting the work of their fellow-laborers in the same branch of astronomy. Its founders hope that the society, by printing beforehand notes, diagrams, and other information on the objects to which the attention of the members may be from time to time directed; by occasionally publishing printed transactions embodying the results achieved by the society, and by circulating a volume containing the observations which have been made by the members, may foster and promote a steady and increasing interest in the study of the lunar surface. In time, it is trusted the society will be able to issue their transactions in half-yearly or quarterly volumes, so that they will constitute a record of the progress of selenography. It is proposed to issue a monthly bulletin, which will be rendered as valuable as possible to the members, by affording them data on which to base their observations and such other information as may assist them in their work. It is hoped that before long the society may be in a position to render their monthly bulletin a means of communication between working selenographers, and to all astronomers an interesting and authoritative jour-

nal of selenography. The society already numbers in its ranks W. R. Birt, Rev. T. W. Webb, G. Knott, Rev. W. J. B. Richards, A. A. Common, Herbert Sadler, Nath. E. Green, E. G. Loder, J. W. Durrad, E. Neison, and other well-known lunar observers.

Professor Newcomb, Superintendent of the *American Ephemeris*, has recently issued a circular to astronomers inviting their opinions upon the advisability of making certain changes in the form of the annual ephemeris, which changes are named in the circular. They are usually not radical in nature, and have for their object the attainment of greater uniformity throughout the work, as, for example, the proposal to give all the ephemerides of the planets and of the sun in Greenwich time, keeping only in the second part the ephemeris for time of Washington transit and omitting the ephemeris for Washington noon. Some additions are proposed, principally of data relating to the satellite systems and of more standard stars, with revised places for these. No radical change is suggested except the omission of the star constants A, B, C, D. A committee of the National Academy will report upon the plan.

The compilation and arrangement of the *American Ephemeris and Nautical Almanac* for 1881 differs in only a few minor respects from that of the volumes for the years immediately preceding. The principal change consists in the adoption of new positions, in both right ascension and declination, of all the standard stars whose apparent places are printed in the *Ephemeris*. The right ascensions of the time-stars have been corrected in accordance with a new and very complete investigation by Professor Newcomb; and all the declinations are adopted directly from a paper by Mr. Lewis Boss. Both these investigations are still unpublished. Ten fundamental time-stars have been added to the standard catalogue, as given in previous years, so that the complete list now numbers 208.

No change whatever has been made in that portion of the *Almanac* intended for the use of navigators, and computed for the meridian of Greenwich.

In the few pages devoted to eclipses, we note the lack of the elements for each eclipse. Complete data are, however, given for computing the eclipse for any place. The data for

the transit of *Mercury*, November 7, 1881, are presented in the usual form, including approximate formulæ for computing the times of the phases for any point on the surface of the earth.

The pages devoted to positions of observatories contain more complete and useful data than heretofore. The list has been considerably enlarged, and the longitudes have been corrected from the most recent available determinations. Additional columns of these pages give the longitudes referred to Greenwich, the reduction to geocentric latitude, and the logarithm of the distance from the centre of the earth.

The subsidiary tables heretofore given in the appendix for the corrections of apparent places of stars depending on moon-terms and small terms of nutation are to be omitted in the *Ephemeris* for 1881. The effect of these terms has been included in the computation of the apparent places of circumpolar stars, wherever of sufficient importance.

Extensive changes are to be made in the volume of the *American Ephemeris* for 1882, under the direction of the present superintendent, Professor Newcomb. Among the more important alterations proposed are these: The list of fundamental stars will be largely extended; the heliocentric longitude, latitude, and radius vector of all the planets, together with their distance from the earth, are to be given; also, the principal data for the moon's transit of the meridian of Washington; more complete data in regard to eclipses of the sun, and maps of the same on a larger scale; also, the means of readily identifying at any time the satellites of the outer planets, *Mars*, *Jupiter*, *Saturn*, *Uranus*, and *Neptune*.

REPORTS OF AMERICAN OBSERVATORIES.

For the purpose of rendering the summary of the progress and condition of astronomical science in 1878 fuller and more satisfactory, a circular was sent to the directors of the various public and private observatories of the United States, asking for information on the following points:

First, the *personnel* of the observatory;

Second, its principal instruments;

Third, the subjects of observation to which attention has been devoted during the past year;

Fourth, those which will be taken up during the coming year; and,

Fifth, the principal publications of the year.

It was intended that one such circular should reach every observatory, public or private, in the United States. If any have been omitted, it has been by inadvertence, and notice of such omissions is desired by the editor.

The various replies to this circular follow in the alphabetical order of cities, and are given *unchanged*, except that occasionally material elsewhere accessible has been omitted to gain space.

It is proposed to continue these summaries in the future, and it is hoped that the directors of the various institutions will be willing to furnish from year to year brief sketches of the activity of the observatories under their charge. In this way a record of current astronomical work in the United States will be kept up, which otherwise it is difficult to maintain in the absence of any American periodical specially devoted to astronomy.

Allegheny City, Pa.: Allegheny Observatory.

Professor S. P. LANGLEY, Director.

1st. The Allegheny Observatory is under the charge of the director, Professor S. P. LANGLEY, who is aided at the present time by Mr. F. W. VERY.

2d. Its principal instruments are an *Equatorial*, made by H. FITZ, of New York, the object-glass of which has been refigured by ALVAN CLARK & SONS, of Cambridge. It has an aperture of 13 inches, and is provided with hour circle, reading to seconds of time, and declination circle, reading to 10″ of arc; *Position Micrometer*, *Polarizing Eye-piece*, and spectroscopic attachments. One of the spectroscopes, constructed by H. GRUNOW, of New York, is provided with a special arrangement for reflecting light from two independent sources into the slit, which is so adjusted that the line of division between any two parallel spectra becomes nearly invisible. As an instance of its application, when the light from opposite ends of the sun's equatorial diameter is examined, the Fraunhofer lines of solar origin are seen to be discontinuous in the two spectra, when the terrestrial atmospheric lines are exactly prolonged from one spectrum into the other, and this affords a method of discriminating between solar and telluric lines which promises good results. There is a *Spectroscope* with two prisms, after HUGGINS's pattern, made by TROUGHTON & SIMMS; but the more powerful instruments are supplied with Mr. RUTHERFURD's gratings.

The lower end of the polar axis of the Equatorial carries an opti-

cally plane *Circular Mirror*, of 12 inches diameter, figured by CLARK, which by the ordinary clock-work of the Equatorial becomes a Fahrenheit heliostat, used with certain apparatus employed in recent solar physical investigations, and which is too heavy to be attached to the telescope. By the simple introduction of a change wheel in the clock, it is also used as an AUGUST heliostat, giving a fixed *horizontal* beam.

A *Transit Instrument*, by TROUGHTON & SIMMS, of London, is used in connection with a *Chronograph*, and with a *Sidereal Clock*, constructed by FRODSHAM, of London, for time determinations. Two *Clocks*, by HOWARD, of Boston, and two *Chronometers*, by FRODSHAM, are used to indicate mean solar time. The clocks and one of the chronometers have break-circuit electrical attachments, by which automatic time-signals may be sent over the telegraph lines. A THOMSON *Galvanometer*, a large variety of *Thermopiles*, and a Cassegrainian *Reflector*, of 6½ inches aperture, without clock-work, made by CALVER, are used for special investigations in heat.

3d. Daily star-observations for time are taken in order to furnish a standard for the use of several trunk-railway lines, the city of Pittsburgh, and various private parties. Though not the first observatory in this country to furnish time-signals, it seems proper that the statement should be made that the Allegheny Observatory was the first to introduce the system, and even the name, of public "Time-service" on the present extended and systematic scale, by which it is now distributing time daily to many thousand miles of railway (of which it is the official standard), as well as to cities and individuals, an example which is now being followed by others.

The daily direct telescopic study of the solar surface is one of the principal objects of this institution. It has been somewhat interrupted during the past year by the general absence of any noteworthy features at this period of minimum of sun-spots.

A considerable time has been devoted to spectroscopy, and particularly to the study of the less refrangible portion of the visible spectrum. The latter work was interrupted during a portion of July and August by the absence of the director, who observed, from the top of Pike's Peak, Col., the total solar eclipse of July 29.

4th. Investigations in solar physics form the special work of research of this observatory. During the ensuing year researches similar to the foregoing will be prosecuted. A portion of the fund bequeathed by Count Rumford for aiding investigations in radiant energy has been placed in the director's charge, as well as an appropriation from the Bache Fund, made at the instance of the late Professor Henry, and will be used during the coming year in furthering the study of the distribution of energy in the spectrum. In a portion of these researches it is proposed by the director to try the ex-

periment of converting the entire Equatorial into a large spectroscope. The eye-piece end will be pointed to the sun and furnished with a slit and a prism of total reflection for the diffracted rays, the telescope constituting a collimator of great focal length, and being used also, at the same time, as observing telescope for the spectrum, from a large grating attached to and moving with it. Preparations have been made for applying photography to the study of problems connected with the sun, and this department, which has been enforcedly neglected, will soon, it is hoped, be in operation.

5th. A popular account of "The Electric Time-service" appeared in the April number of *Harper's Monthly* for 1878.

An article on the "Transit of Mercury" was contributed to the *American Journal of Science and Arts*, vol. xv., June, 1878, and another on the same subject to the *Monthly Notices* of the R. A. S. for June, 1878.

Memoirs describing the principal scientific work of the year are shortly to appear, but are not yet printed.

Brooklyn, N. Y.: Private Observatory of Henry M. Parkhurst.

This consists of a two-story brick building, with revolving roof opening on both sides. The *Telescope* is nine inches clear aperture, by HENRY G. FITZ, mounted equatorially, with circles reading to minutes of space. It has been employed, during the few months of the year when it could be employed otherwise than in miscellaneous observation, in continuing an investigation of the law of the visibility of stars under illumination, chiefly by observations during the day and in the twilight.

Buffalo, N. Y.: Private Observatory of Henry Mills, Esq.

My principal instrument is a *Telescope* of 3-inch object-glass and 44-inch focus, which I use chiefly for the entertainment of my friends in viewing such celestial objects as come within range of such an instrument.

Besides a report made to the Naval Observatory on the transit of *Mercury* on May 5 and 6, I have no special work to record.

Cambridge, Mass.: Harvard College Observatory.

Professor E. C. PICKERING, Director.

1st. The observers and computers at present constantly employed at the observatory building are:

Edward C. Pickering, S.B., Phillips Professor of Astronomy and Director of the Observatory.

William A. Rogers, A.M., Assistant Professor of Astronomy.

Arthur Searle, A.M., Assistant.

Leonard Waldo, A.M., Assistant, in charge of the time-service.

Winslow Upton, A.M., Assistant.

Frank Waldo, S.B., Assistant.

Miss R. G. Saunders; employed in reductions of the observations made with the Meridian Circle.

Mr. Joseph F. McCormack; employed in assisting in the observations made with the Meridian Circle, and in reducing them.

There are other persons not immediately connected with the observatory who are customarily employed in performing computations for it.

2d. The principal instruments of the observatory are:

The *East Equatorial*, a refractor of 15 inches aperture and 22½ feet focal length, made by MERZ, of Munich, and mounted in 1847.

The *West Equatorial*, a refractor of 5¼ inches aperture and 7½ feet focal length, made by ALVAN CLARK & SONS, and mounted in 1869.

The *East Transit Circle*, made by TROUGHTON & SIMMS, and mounted in 1848. Aperture of telescope, 4¼ inches; focal length, 5 feet.

The *Meridian Circle*. The object-glasses of the instrument and of its collimators were made by ALVAN CLARK & SONS; the metal work mainly by TROUGHTON & SIMMS. The instrument was largely designed by the late director of the observatory, Professor Joseph Winlock, and has done great credit to his ingenuity. The aperture of the principal telescope is 8¼ inches, and its focal length 9 feet 4.4 inches. The aperture of each collimator is 8 inches, and its focal length the same as that of the chief telescope. The instrument was mounted in 1870.

The *Portable Transit Instrument*, made by HERBST, of Pulkova, and mounted in 1870. Aperture of telescope, 2¾ inches; focal length, 33 inches.

3d. The work done with the Equatorials has principally consisted of photometric observations of the brighter double stars (including, in the case of some colored stars, measurements of the variations of their light in different parts of the spectrum); of faint stars used as test-objects; of the satellites of the superior planets; and of the eclipses of *Jupiter's* satellites, thus determining the times of these eclipses more accurately than by the usual method. Among the miscellaneous observations made may be mentioned measurements of the diameter of *Mercury* during its transit, and determinations of the positions of asteroids.

The Meridian Circle has been employed, first, in completing the observation of the zone 50° to 55° north declination, undertaken by this observatory as its contribution to the work of determining the places of the stars of the ninth magnitude, or brighter, belonging to the northern hemisphere; secondly, in observing, at the request of

the Coast Survey, a list of the bright stars whose places have not recently been accurately determined; and, thirdly, in the determination of the observer's scale of magnitudes, by comparing the effects of different apertures upon estimates of brightness.

Time-signals are sent every two seconds to many places in Boston and its vicinity. The time thus furnished is in use by the principal railroads of New England, and by many important towns. A time-ball is also dropped in Boston every day at noon by an electric signal from the Cambridge clock.

Photographs of the transit of *Mercury* were taken in co-operation with the U. S. Naval Observatory. Observations have been made to determine the coefficient of atmospheric absorption at different times. Meteorological observations have been regularly made.

4th. The work done with the Equatorials during the coming year will largely depend upon the results of experiments now in progress with new forms of photometric and micrometric apparatus. The observations of *Jupiter's* satellites will be continued, and probably much attention will be directed to the opposition of *Mars* in 1879.

The principal work of the Meridian Circle will be the determination of the absolute positions of a number of standard stars.

5th. The second part of Vol. IV. of the *Annals* of the Observatory, and also Vol. IX., as well as the "Director's Annual Report for 1877," have been published during the past year.

Cambridge, Mass.: Physical Observatory of L. Trouvelot, Esq.

During the year 1878, the sun has been observed daily as usual, with the Telescope and Spectroscope; 230 observations were made, and one drawing of a group of sun-spots and 12 of solar protuberances were obtained. Besides, the total eclipse of the sun of July 29 was observed, under the auspices of the U. S. Naval Observatory, at Creston, Wyoming Territory, and a drawing of the corona made.

During the last twelve months the surface of the sun has been still more quiet than it was in 1877, only 22 groups of spots or single spots having been observed, most of them very small; the only group of importance having appeared towards the end of May. The faculæ and the veiled spots have also been of very rare occurrence, while the pores were fewer and the granulations not so crowded. The sun has been observed without any spots on 130 days. The total number of spotless days must have been greater, as two months of observations were lost on account of the eclipse expedition. In general the chromosphere has been very shallow, especially in the equatorial regions, and the protuberances comparatively few in number and dim.

The series of observations on the planet *Mars*, begun last year, has been continued as late as May 2—when the planet was too near the

sun to be observed with any advantage—and 80 more observations were made and 76 drawings obtained. With those obtained last year, the series of drawings numbers 212. These drawings, made under very favorable conditions, offer ample data for the construction of a reliable chart of the southern hemisphere of *Mars*. During these observations new markings have been observed, and high mountains notching the terminator have been recognized. This long series of observations will throw much light on the meteorology of *Mars*. *Deimos*, the outer satellite, has been observed independently on three occasions with the 6.3-inch refractor; its magnitude has been estimated at 14 of ARGELANDER's scale.*

The observations on *Jupiter* were continued, and 65 drawings obtained. The markings on its surface have continued remarkably steady throughout the year, and the successive returns of prominent spots to the meridian have afforded data for the determination of the period of rotation. But great difficulties will be encountered in deducing the true period, as it appears from these observations that the spots have a very irregular proper motion. Lately a very remarkable red spot has made its appearance outside of the rosy equatorial zone. This curious spot still exists, and its western end was on the central meridian on November 29 at $5^h\ 15^m$.

The planet *Saturn* has been carefully observed for the disappearance of the ring, and throughout the year up to date. Very curious phenomena have been observed, which seem to indicate that the surface of the ring is not parallel with its general plane, but somewhat inclined to it. The planet has been observed 108 times, and 4 drawings were made; besides, 92 diagrams, showing the position of the satellites, have been delineated.

Venus has been closely followed; it was observed 137 times, and 26 drawings obtained. Two prominent white spots, very similar to those of the poles of *Mars*, have been observed on the two opposite sides of the limb near the terminator, and were seen during three consecutive months before the inferior conjunction in February. After the conjunction, the white spots were seen no more.

Mercury has been observed fourteen times; no spots were recognized on its surface. Besides, the transit of this planet over the sun on May 6 has been successfully observed, a luminous ring around the black disk having been recognized, and the indication of the "black drop" seen.

Uranus has been seen several times; besides, many nebulæ were drawn and observed. The usual record of the meteors, auroræ, and zodiacal light has been kept.

The moon has been observed whenever the state of the sky per-

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* 13.2 mag. is the *minimum visibile* of a 6.3-inch refractor on ARGELANDER's scale extended.—E. S. H.

mitted, and numerous sketches made in view of constructing a map of her surface. So far a preliminary outlined map has been plotted out on a scale of 150 centimeters to the diameter. A duplicate sketch of this preliminary map has been made on 121 sections, these being intended as the working sketches, and are afterwards transferred to the large map. Several years will be necessary to complete this work.

During the year a paper on the "Transit of Mercury" has been published in the *American Journal of Arts and Sciences*, and a report on the total eclipse of the sun has been sent to the Naval Observatory for publication; besides, a paper on the "Observations of Deimos" has been sent to the *Astronomische Nachrichten*, also for publication. A great deal of material is on hand awaiting publication; but, as the expense would be too large for the limited means of a private individual, it will necessarily remain unpublished until adequate means are found.

During the coming year the physical observations of the sun and planets will be continued. The aim will be especially to study the planets *Mercury* and *Venus*, about which so little is known. *Mars* will also be studied in view of completing the map of its surface. It will be endeavored to draw as many nebulæ as possible to enlarge the collection of similar drawings already obtained. A series of observations on variable stars is about to be undertaken by my assistant, Geo. H. Trouvelot.

Chicago, Ill.: Dearborn Observatory.

Professor E. Colbert, Director.

1st. *Personnel.*—Superintendent, Elias Colbert, M.A.; Assistant, George P. Barton. S. W. Burnham, Esq., is using the Equatorial Telescope, but has no official position in the observatory.

2d. *Instruments.*—I enclose printed statement from the catalogue of the University of Chicago, with which the Dearborn Observatory is connected:

"The Dearborn Observatory forms the Astronomical Department of the university. Its objects are to make original researches in astronomical science, to assist in the application of astronomy to geography, in communicating exact time, and other useful objects, and to furnish instruction in astronomy to the students of the university, both those in the regular course and those who wish to give especial attention to the study.

"The principal instruments of the observatory are:

"(1.) The great *Equatorial Refracting Telescope*, made by Alvan Clark & Sons, of Cambridge, Mass., in 1861, and mounted in the Dearborn Tower, which was built by the munificence of the Hon. J. Young Scammon, LL.D. This instrument was the largest refractor

in the world till a few years ago; and now has only one superior in the United States. It has recently been refitted and much improved, and the upper portion of the tower has been reconstructed by the Chicago Astronomical Society. The Telescope is fitted with *Driving-clock*, *Micrometer*, *Spectroscope*, and other appliances necessary for first-class work. The dimensions of the Equatorial are: diameter of declination circle, 30 inches; reading by vernier to 5 minutes, and by two microscopes to 10 seconds, of arc. Diameter of hour circle, 22 inches; reading by vernier to single minutes, and by microscopes to single seconds, of time. Focal length of object-glass, 23 feet. Aperture of object-glass, 18¾ inches.

"(2.) A *Meridian Circle*, of the first class, constructed in 1867, by Messrs. A. Repsold & Sons, of Hamburg. This instrument has a telescope of six French inches aperture, and a divided circle of forty inches diameter, reading by four microscopes. In plan of construction it is like Bessel's celebrated Königsberg circle, by the same makers. Within the past two years a *Chronograph* has been added for making an electrical record of the times of star-transits.

"The observatory has a *Chronometer* (William Bond & Son, No. 279), two *Mercurial Pendulum Clocks*, and an astronomical library containing nearly one thousand three hundred volumes and pamphlets.

"Instruction in astronomy to the undergraduates is at present given by the Superintendent.

"The observatory is now supplying time-signals each day in the year, by telegraph, to several different points in the city of Chicago, and its time is the standard for many other points in the West."

3d. *Work of* 1878.—I have not much to report. The fire of 1871 and the panic of 1873 demoralized finances. I took hold in 1874, raised money by subscription to put on a new dome, etc., and have since taught in the university. I am not paid for any of this, and have little time left after this and a regular round of duty as one of the editors of the *Tribune*. Till last April I resided five miles away. I then removed to neighborhood of observatory, and have since done a little work.

Observed transit of *Mercury*, May 6.

Observed solar eclipse of July 29 at Denver, Col. Chief points: made a class-drawing of corona; and Professor Lewis Swift, of our party, found *Vulcan*. I published a pamphlet report on the eclipse which was widely distributed.

I am now using the Transit Instrument, and,

4th. *Work of the Future.*—I expect to continue work with it in 1879, observing stars in aid of Professor Safford, formerly Director here, and now at Williams College, Mass.

Mr. Barton keeps the *time*. He is the only salaried man in the

establishment, and we cannot pay him enough to enable him to do more than that.

Mr. Burnham is observing double stars with the Equatorial.

5th. *Publications.*—Our only publication of work done is the pamphlet above referred to.

Addendum.—The great Telescope could not be used previous to three years ago, the original dome being a mechanical blunder. This fact seems not to be generally known; and more than a little unjust remark has been made by parties who seemed not to be aware of it.

Clinton, N. Y.: Litchfield Observatory of Hamilton College.

Dr. C. H. F. Peters, Director.

The observatory, the gift of Mr. Litchfield, consists of a central building, with wings on the east and west sides. The central building is twenty-seven feet square and two stories high, surmounted by a revolving tower twenty feet in diameter. The *Equatorial* in the tower, constructed by Spencer & Eaton, has an object-glass of 13.5 inches in diameter and focal length of nearly 16 feet; it is provided with six positive and six negative *Eye-pieces*, with a *Ring* and a *Filar Micrometer*. For solar observations it has a *Prismatic Polarizing Eye-piece* of original construction by Mr. Robert B. Tolles, of Boston, Mass. The declination circle of twenty-four inches, by means of four verniers, reads to four seconds of arc; the hour circle of fourteen inches, by means of two verniers, reads to two seconds of time. The instrument is mounted upon a granite shaft, nine feet in height, resting upon a pier of solid masonry. A *Clock-work*, with Bond's isodynamic escapement and spring governor, causes the Telescope to follow the daily motions of the stars, by acting upon long arms attached to the equatorial axis. The wings are each eighteen feet square. The east room is used as an office for the director. In the west room is mounted a *Portable Transit Instrument*, of $2\frac{1}{2}$ inches aperture, the gift of Hon. Anson S. Miller, LL.D., of Rockford, Ill., and constructed by W. Wurdeman, of Washington, D. C. It has a cast-iron folding-stand invented by the maker.

Near the Transit is an *Astronomical Clock*, constructed by William Bond & Son, Boston, and presented by the late Hon. William Curtis Noyes, of New York. It is regulated for mean time, and provided with the *Break-circuit* for telegraphic operations. By the side of the clock is a *Chronograph* of Bond's most recent construction, and regulated by the spring governor, presented by Michael Moore, Esq., of Trenton Falls. These instruments have been connected by a telegraphic wire with the nearest station; and the longitude of the observatory has thus been accurately determined by exchanging star-signals with the Harvard College Observatory, at Cambridge, Mass.

In its turn, the Litchfield Observatory already has become the basis of several longitudes in the state, determined under the auspices of the Regents of the University at Buffalo, Syracuse, Elmira, Ogdensburgh, and of the longitude of the Detroit Observatory, which latter forms the fundamental point for the longitudes of the Lake Survey. The latest work of this kind has been to determine the longitude of the western boundary of the State of New York.

Besides, the observatory has a *Sidereal Chronometer*, constructed by the same makers, with HARTNUP's improved combination balance: this instrument was the gift of the late Hon. GEORGE UNDERWOOD, of Auburn.

A MORSE *Telegraph Apparatus* also has been presented by the late S. W. CHUBBUCK, of Utica, and an *Aneroid Barometer* by the late SIMEON BENJAMIN, of Elmira.

In order to observe the total eclipse of the sun, August 7, 1869, Mr. EDWIN C. LITCHFIELD presented a fine *Portable Telescope*. The Telescope, made by Messrs. STEINHEIL SONS, of Munich, has 4 (French) inches aperture, 5 feet focal length, and is mounted parallactically on a solid iron tripod. It has two terrestrial and six astronomical *Eye-pieces* (varying in power from 40 to 360), a *Ring* and a *Scale Micrometer*, and a sliding wedge for moderating the light. There is, moreover, fitted to the eye-tube a direct-vision *Spectroscope*, with five prisms, for analyzing the light of the sun and its protuberances. This instrument is particularly useful for the exercises of students who may make astronomy a special study.

Another *Portable Telescope*, of the comet-seeker construction, was brought from Europe by the director four years ago. It was made by Mr. HUGO SCHROEDER, of Hamburg, and its object-glass has 5 inches aperture. There are five *Eye-pieces*, varying in power from 25 to 275, with a *Ring Micrometer*, and a prism for more convenient observation. The telescope is mounted as an alt-azimuth.

[The above account is condensed from the catalogue of Hamilton College.]

Columbia, Mo.: Observatory of the University of the State of Missouri.

Professor JOSEPH FICKLIN, Director.

Position and Description of the Observatory.—The latitude of the observatory is 38° 56′ north, and its longitude is $1^h\ 1^m\ 6^s$ west from Washington.

The building, which is frame, is forty-four feet long from east to west, fourteen feet wide, fourteen feet high in the Equatorial room, which is at the west end, and ten feet high in the Transit room. It is situated eighty-six feet west of the main university edifice, and fronts east. The Equatorial room is surmounted by a roof in the

form of a cone, which revolves on strong iron rollers running on a cylindrical iron rail.

Instruments.—The instrumental equipment consists of an *Equatorial Telescope*, a *Transit Instrument*, an *Alt-Azimuth Instrument*, a *Transit Theodolite*, a *Sextant*, a *Sidereal Clock*, and a *Solar Clock*.

The Telescope is a refractor of $4\frac{1}{16}$ inches aperture and a focal length of 64 inches, made by HENRY FITZ, of New York. It is mounted equatorially, and is furnished with a *Finder* of $\frac{7}{8}$ inch aperture, and with *Eye-pieces* varying in power from 30 to 240, reflecting prism, and sun-shades. The declination and hour circles read respectively to two minutes of arc and four minutes of time. A sidereal motion is given to the Telescope by means of an endless screw attached to the hour circle and moved by hand.

The Transit Instrument was made by BRUNNER, of Paris. It has an aperture of $2\frac{1}{16}$ inches and a focal length of 23 inches. The circle is $10\frac{1}{2}$ inches in diameter, and is graduated on silver to five minutes, and reads by two verniers and microscopes to three seconds. This instrument has five vertical wires and one horizontal, and these are illuminated in two ways—one through the axis, and the other at the object-glass. The eye-piece is so arranged that it may be made either direct or prismatic. There are two spirit-levels belonging to this instrument—one attached to the circle, the other a striding level to be used on the axis.

The Alt-azimuth Instrument was made by E. & G. W. BLUNT, of New York. It has an aperture of $2\frac{1}{8}$ inches and a focal length of 22 inches. The circles are 12 inches in diameter, and are graduated on silver to ten minutes. The horizontal circle has four verniers with microscopes, and the vertical circle three; and each reads to ten seconds. It has both direct and reflecting eye-pieces and a collimating eye-piece. The system of wires and the arrangement of the levels are the same as in the Transit Instrument. The wires are illuminated by a lamp placed at one end of the axis.

The Transit Theodolite was made by GREGG & RUPP, of New York. It has an aperture of $1\frac{3}{8}$ inches and a focal length of 18 inches. The horizontal circle is $10\frac{1}{2}$ inch in diameter, and reads by two verniers and microscopes to half a minute. The vertical circle is 8 inches in diameter, and reads by a single vernier and microscope to one minute. The magnetic needle carries a vernier at each end, by means of which the arc of the compass-box can be read to single minutes. This instrument has two wires, and these are illuminated in the same way as in the Alt-azimuth Instrument. There is a strong portable tripod on which the instrument can be mounted for field-work.

The Sextant was made by E. & G. W. BLUNT. The arc is graduated on silver, and reads by a vernier and microscope to ten seconds.

The Sidereal Clock, which was made by GREGG & RUPP, has a mercurial pendulum.

The Solar Clock was made by W. H. C. RIGGS, of Philadelphia.

The Telescope, Transit Instrument, the Alt-azimuth Instrument, the Transit Theodolite, and the Sidereal Clock stand on slabs of limestone which rest on brick piers that descend about four feet into the ground, and have no connection with the floors. The Solar Clock hangs on the pier which supports the Telescope.

In May last a telegraph line was run connecting the observatory with the lines of the Western Union Telegraph Company.

Work Done.—During 1877–78 the seniors have had a large amount of practice, both in the adjustment and use of the instruments. The different methods of determining latitude and longitude have received special attention. In this work I have had the assistance of Professor Thomas J. Lowry, of the Department of Civil Engineering, who has an experience of seven years in the work of the U. S. Coast Survey.

The transit of *Mercury* which occurred on the 6th of May last was successfully observed by Professor Lowry and myself. I made observations, also, on the eclipse of the sun, July 29. Reports of these observations have been sent to the Superintendent of the U. S. Naval Observatory at Washington.

From the 3d to the 10th of May, inclusive, time-signals, made by connecting the pendulum of the clock in the Naval Observatory with the lines of the Western Union Telegraph Company, were received and compared here with our local time. This part of the work was of special value, as it enabled us to determine our longitude with great precision.

Columbus, O.: Ohio State University.

T. C. MENDENHALL, B.Sc., Physics; R. W. MCFARLAND, A.M., Mathematics.

This university has no *regular* observatory; but such appliances as we have are used on all proper occasions. The college owns one small *Portable Transit*—too small for valuable observations. But I have the use of one *Telescope* 2.2 inches clear aperture, made by SIMMS, of London; also of one *Alt-azimuth Instrument* belonging to Miami University, Oxford, O., 3 inches aperture, 28 inches focal length—excellent of its kind.

In connection with Professor T. C. Mendenhall, I made regular observations on the transit of *Mercury* in May, 1878—at least, of as much of it as was visible—an account of which was duly transmitted to the Washington Observatory.

The latitude and longitude of the Ohio State University building—centre of front entrance—has been very carefully taken several

times, the mean of which gives latitude 40° 0′ 1.45″, longitude 0^h 23^m 49.93ˢ west of Washington. With Alt-azimuth Instrument I also determined the latitude and longitude of Miami University, near Cincinnati, in preparation for observation of the eclipse of July 29, 1878. Washington noon signals were received, and everything was in most complete readiness, but final results failed by reason of the cloudiness of the sky.

Easton, Pa.: Lafayette College Observatory.

Professor Selden J. Coffin, Director.

This observatory was erected in 1865, and is used mainly for purposes of instruction. It is of cut stone, sixty feet front—including the wings—and fifty-six feet deep. The central room contains a *Reflector*, made by Holcomb, of 10 inches aperture and 9 feet 6 inches focal length, with *Finder* and *Micrometer*. It is mounted equatorially in a revolving dome sixteen feet in diameter, and commands almost the entire horizon.

In the wings are a *Meridian Transit*, *Sidereal Clock*, a 4-inch *Portable Refractor*, *Sextant*, *Reflecting Circle*, two *Field Transits* (by Stackpole & Gurley) for alt-azimuth use, Hough's *Printing Barometer*, a *Self-registering Anemograph*, and other meteorological apparatus.

The observatory is in latitude 40° 41′ 17″ N. and longitude 75° 12′ W. The classes are practised in the use of all the instruments, and in the determination of latitude, longitude, and time, and the meridian line. A recitation-room in astronomy is attached, and is provided with a fine series of charts and colored drawings of celestial objects.

Elizabeth, New Jersey: Private Observatory of Chas. W. Pleyer, Esq.

In reply to your postal-card asking information about my *Telescope*, I would say that it was made in 1873, by H. G. Fitz, of Peconic, L. I. It has an object-glass of 6¼ inches aperture and 90 inches focal length, and is equatorially mounted, and has hour and declination circles. I have the usual assortment of *Eye-pieces*, diagonal prism, and solar prism. I have also a small *Transit Instrument*, made by John Bliss & Sons, of New York.

My work for 1877 consisted chiefly of drawings of the surfaces of *Jupiter* and *Mars*.

Nothing has been attempted this year, owing to ill-health, making exposure to night-air somewhat hazardous.

My observatory is twelve feet square, wooden, with a peaked roof, divided into four sections, which slide away.

Fordham, N. Y.: Private Observatory of W. Meikleham, Esq.

My largest *Telescope* has an objective of $4\frac{3}{10}$ inches clear aperture, and 65 inches focal distance, and is furnished with a *Finder* of $1\frac{1}{2}$ inch clear aperture, magnifying twenty diameters. The *Eye-pieces* used with this telescope are seven in number, and give the following powers, viz.: 30, 45, 80, 150, 250, 350, and 450 diameters. There are also a right-angle prism for observing objects near the zenith, and a double right-angle prism for solar observations. This telescope is equatorially mounted on a heavy iron stand, fastened upon a brick and stone pier built from four feet below the foundation of the observatory to two and a half feet above the floor. The Equatorial is furnished with a right-ascension circle, divided to read to 20 seconds of time, and a declination circle reading to 4′ of arc. Both circles are supplied with tangent screws, and the object under observation is kept in the field of the Telescope by a *Driving-clock*.

I have also a smaller *Telescope* with an objective of $2\frac{7}{8}$ inches clear aperture and 44 inches focal distance. Eight *Eye-pieces* are used with the telescope, magnifying 20, 33, 50, 80, 100, 150, 225, and 300 diameters respectively; also a right-angle prism and solar prism similar to those used with the larger glass, and a sun-screen. This telescope has a *Finder* of 1 inch clear aperture, magnifying ten diameters, and is mounted on an alt-azimuth stand. It is my intention to mount this telescope as a transit instrument. The $4\frac{3}{10}$-inch objective was made by John Byrne, of New York. The $2\frac{7}{8}$-inch glass is a Bardon.

In addition to these telescopes and their equipments, my observatory contains a *Spectroscope*, besides other minor instruments usually comprising a part of the furniture of an amateur's observatory.

The principal work accomplished during the year has been a series of observations of the magnitudes, positions, colors, and distances of the double stars in the constellations of *Aquila*, *Aries*, *Auriga*, *Bootes*, *Cassiopeia*, *Cygnus*, *Delphinus*, *Hercules*, *Libra*, *Lyra*, *Ophiuchus*, *Orion*, *Perseus*, *Pisces*, *Scorpio*, and *Taurus*; also the clusters and nebulæ of these constellations. I have spent a good deal of time in solar and lunar observations, giving my attention in the former more especially to the spots, and, in the latter, to the ring-mountains and craters in the vicinity of *Tycho*.

I made a very careful observation of the transit of *Mercury*, and forwarded a report of the result thereof to the U. S. Naval Observatory.

Fort Dodge, Iowa: Private Observatory of F. Hess.

In response to your invitation to send you a brief account of my instrumental equipment, and of the astronomical work done therewith during the year 1877–78 at this place, the approximate posi-

tion of which is in N. latitude 42° 30′, longitude 1^h 8.5^m west of Washington, I beg to say that such equipment consists only of an old Dollond *Marine-glass* of 1½ inch aperture and 28 inches solar focal length; a small *Surveyor's Transit*, provided with the usual horizontal and vertical circles, each reading to single minutes only, and a *Telescope* of 1 inch aperture, 11 inches solar focal length; one horizontal and one vertical wire, and a diagonal *Eye-piece* with a magnifying power of about 10½ diameters; a *Reflecting Sextant*, and a common Elgin *Watch*, two *Barometers*, and a chemical *Storm-glass*.

The very insignificance of this equipment may perhaps invest the experimental work done therewith by an inexperienced novice, without previous training, and guided only by a very few of the most elementary text-books, with the only interest such work can have, in comparison with regular work done by skilled observers with instruments of higher powers and greater excellence.

From October 20, 1877, to October 20, 1878, the sun has been observed here on one hundred and thirty-seven days, at various hours, on an average three times each day, and spots were seen through the Marine-glass on twenty-one days, and observed with the Transit on fifteen days during the meridian passage of the sun.

Three of these spots—viz., one group of five seen about 9 o'clock A.M. on the 29th day of October, 1877, very near the sun's eastern limb, and two seen at noon of January 24, 1878, near the sun's western limb—have heretofore been reported to the Naval Observatory as possible planets.

In the first case, the possible planetary nature was not suspected at the time, and the spot nearest the eastern limb, and a little above the east point of the sun, was not observed with the Transit at once; and, being called away from home that day, no further observations were made until noon of October 30, when the times of the meridian passages and distances from the sun's upper and lower limbs of only four spots were observed.

On January 15, 17, 18, 22, and 23, at various hours, and on the 24th, at 8 A.M., the sun had been examined and found clear of spots; but, shortly before noon of the 24th, one large and one very minute spot were seen near the sun's western limb, and preparations for a closer observation were at once made.

The first spot, oblong east and west, and somewhat larger than *Mercury* as seen on the sun, May 6, through the same instrument, passed the meridian 32 seconds after the sun's first limb, 21′ north of the lower limb; and the second spot, a mere black speck, passed the meridian 35 seconds after the sun's first limb, and a trifle below the first spot. Unfortunately, the sun disappeared behind clouds soon afterwards, and before another observation of the differences of right

ascension and declination between the spots and the sun's limbs could be made, and remained invisible until sunrise of January 26, when both spots had disappeared.

The mean times of meridian passages and meridian altitudes of the sun were observed on seventy days; of *Venus*, on fifty-four days; of *Mercury*, on four days; of other planets and stars, on seventeen days; and the meridian was swept for intra-Mercurial planets within about 10° above to about 12° below the meridian altitude of the sun, on the respective dates as follows:

From 11 o'clock A.M. (A. T.) to within about ten minutes of the sun's meridian passage on February 23 and 24, March 20 and 21, May 8; September 7, 27, and 30; October 1, 2, 3, 4, and 5; and from about ten minutes after the sun's meridian passage until one o'clock P.M. on March 7, 8, and 31; April 1, 2, 3, 26, 27, and 28; May 20; July 8 and 9, and September 19 and 20, without any definite result so far, but perhaps not entirely without success.

A considerable amount of work was done in preparing for and observing the transit of *Mercury* on May 6 and the total eclipse of the sun on July 29, detailed reports of which have been made to the Naval Observatory at Washington.

For the purpose of studying the moon's path, parallaxes, and diameters, a good many computations of the moon's apparent place at various times were made, and a list of occultations of planets and stars down to the fifth magnitude was also prepared; but in the observation thereof I have been singularly unfortunate, clouds almost invariably interfering at the critical moment. Of the entire list of occultations, a majority of which were looked for, sometimes at very inconvenient hours, only two could be partially observed—viz., the immersion of *Venus*, December 8, 1877, and the immersion of δ *Sagittarii*, September 5, 1878; and with the lunar eclipse of August 12 I fared no better.

Since the 1st of last March a daily weather record, with notations of the Thermometer and Storm-glass, has been kept with tolerable regularity; but of quite a number of miscellaneous observations no regular record was made.

The zodiacal light was seen once, early in April, after sunset, extending about 10° above the western horizon. Of extraordinary auroral displays nothing has been observed during the year; but quite a number of meteors, including a few very bright ones, were seen. Notes of the most remarkable ones were made at the time; but the only record I can find now is of one seen March 15 at about 8 P.M. It proceeded from a point in *Leo* where lines drawn through *Regulus* and *Algeiba*, *Deneb* and *Zosma*, would intersect, and moved northwest towards *Capella*, apparently falling as it moved onward. It was visible for from three to four seconds; and, notwithstanding

the close proximity of a bright moon, it was much brighter and larger than *Venus* at her greatest brilliancy, and left a trail of bluish light behind it visible for several seconds after the meteor itself had disappeared.

A series of letters written for the Fort Dodge *Gazette* may yet be mentioned, through which the public has been kept informed on all the principal astronomical events of the year.

Germantown, Pa.: Private Observatory of Henry Carvill Lewis, Esq.

In answer to your letter of inquiry, I would state that my observations have been made from a detached building on high ground, so arranged that the observer stands on a platform immediately below an opening in a flat roof. This arrangement permits a table with light, note-book, and maps to be placed on the platform to be used by the observer when sitting, and enables him, by rising erect, to have the upper part of his body above the roof and to conduct observations entirely screened from the light beneath. This has been found the most convenient method, both as regards exposure and arrangement of light, for eye observations.

Observations have been confined to the zodiacal light, meteors, and auroras. They were begun in 1874, and have been continued with more or less regularity from that time. Special attention has been given to the zodiacal light. It has been found convenient for description to divide the zodiacal light into three portions:

1. The Zodiacal Cone—the zodiacal light proper of most authors—varying in visibility with the obliquity of the ecliptic and the duration of twilight. No pulsations have been observed. Photometric and spectroscopic observations have been made upon the zodiacal cone, and drawings made of its position.

2. The Zodiacal Band. This is a much fainter continuation of the zodiacal cone, which extends all across the sky from horizon to horizon as an arch of equal width and brightness throughout. It is seen at all times of the year and at all times of the night. It lies on or near the ecliptic, and does not alter in any way, so far as observed, throughout the year. It is about 12° in width.

3. The Gegenschein. This is a circular or oval spot of light, slightly brighter than the zodiacal band, lying in the zodiac, opposite, or nearly opposite, the sun. It has a mean diameter of about 7°, with sometimes a small brighter nucleus. When oval, its major axis lies along the ecliptic, and is often 15° in length. It continually shifts its place among the stars so as to keep opposite the sun in R. A., and is best situated for observation towards midnight.

A few desultory observations have been made on variable stars. The paths of a large number of meteors have been mapped. De-

tailed observations and drawings of a number of auroras have been taken. Several spectroscopes have been used in the examination of the aurora and zodiacal light, with results agreeing with those of previous observers. A few meteorological observations have also been taken.

No publications have been made.

Gettysburg, Pa.: Observatory of Pennsylvania College.

Professor PHILIP M. BIKLÉ, Director.

The *personnel* of the observatory consists of Professor P. M. Biklé as director, and U. A. Hankey, a member of the senior class, as assistant. The principal instruments are: (1) An *Equatorial Telescope*, (2) *Transit Instrument*, and (3) *Chronometer* (Negus). The observations during the past year were principally for procuring correct time. The transit of *Mercury* was observed in May, the final (internal and external) contacts with great care. The observations for the coming year will be chiefly in the line of those of the past, our observatory being used largely for the purpose of instruction in connection with the study of astronomy by the senior class. There have been no publications during the year.

Glasgow, Mo.: Morrison Observatory.

Professor C. W. PRITCHETT, Director.

In reply to your circular asking for information about this observatory, I have to say that my only assistance in astronomical work is from my son, a youth of fifteen.

Work on the Equatorial.—1. During the year we have continued the measures of close double stars, not systematically, but in some special directions. 2. Several series of observations on the satellites of *Jupiter* and *Saturn*. 3. Micrometric measures of diameters of *Jupiter*, *Saturn*, *Mercury*, and *Uranus*. 4. Of special observations, I may mention the occultation of *Venus*, December 8 of last year; disappearance of *Saturn's* ring, February 6; transit of *Mercury*, May 5–6; and the solar eclipse, July 29. 5. A series on the companions of *Sirius*. 6. A number of occultations of stars.

Meridian-Circle Work.—1. Regular observations for time. 2. A series of altitudes of circumpolar stars for latitude determination. 3. Observations of the moon and culminating stars.

Meteorological observations have been made and recorded three times daily. We have made no publications, except those in the astronomical journals. I might add that a large amount of work has been expended on the instrumental constants.

Hartford, Conn.: Private Observatory of D. W. Edgecomb, Esq.

The report made last year and printed in the *Annual Record of Science and Industry* for 1877 will serve equally well for this year. There have been no changes, either in equipment or work.

Hastings, N. Y.: Private Observatory of Henry Draper, Esq.

In answer to your circular, heads 3, 4, 5, I have to say that the subjects of observation of the past year have been principally of a spectroscopic and photographic kind, comprising a series of observations of the transit of *Mercury* on May 6, 1878, in which I had the valuable assistance of Professor E. S. Holden, of the Naval Observatory, Washington; and an expedition to observe the eclipse of the sun on the Rocky Mountains, July 29, 1878, in which I had the assistance of Professors George F. Barker and Henry Morton, and Mr. Edison.

The Transit-of-Mercury observations will be printed in the "Report of the Naval Observatory." The results of the eclipse expedition are printed in the *American Journal of Science* and in *Nature.*

It is intended to prosecute the research connected with my discovery of oxygen in the sun as the main work for the coming year.

Haverford, Pa.: Observatory of Haverford College.

Professor S. Alsop, Jun., Director.

In answer to the inquiries of your circular, I send the following:

1st. Samuel Alsop, Jun., Director.

2d. *Equatorial*, 8¼ inches aperture, 11 feet focal length. *Meridian Circle*, 4 inches aperture, 5 feet focal length. *Prime Vertical Transit*, 2 inches aperture. Bond's *Magnetic Register.* Two *Sidereal Clocks.*

3d and 4th. The observatory is principally for the use of students, and the adjustments of the instruments and observations for time comprise nearly all that has been done of late.

5th. No publications.

Jackson, Mich.: Private Observatory of O. Mulvey, Esq.

My astronomical instruments are very few and simple, and the work done by them by no means great.

The instruments consist of: 1. A small *Refracting Telescope*, 3 inches clear aperture, of good defining qualities (with a variety of *Eyepieces* varying from 30 to 200 diameters), mounted equatorially. 2. A *Chronometer.* 3. I am also constructing a *Clock* with a gravity escapement, intended for a good time-keeper.

The recorded work done in 1877 and 1878 consists of a few rough sketches of the dark markings and polar spot visible on *Mars* when

near his late opposition in the fall of 1877, and one or two of *Saturn* at and near the time of the edge presentation of its ring, one showing some bright spots or apparent thickening of the ring in places.

The only other recorded observations of any importance were made during the transit of *Mercury*, May 6, 1878, during which first and second contacts were observed. The others were lost by clouds.

Lowell, Mass.: Private Observatory of O. C. Wendell, Esq.

My instrumental equipment consists of a fine *Equatorial*, by ALVAN CLARK & SONS, of 6½ inches aperture, and about 7½ feet focus, which is unused at present for want of a suitable building. I also have the loan of a portable Clark *Telescope*, of 3½ inches aperture, with which, among other work, observations were made at the transit of *Mercury* on May 6.

Recently my attention has been directed to meteoric astronomy and variable stars.

By a concerted arrangement with a Boston party, observations are made by each of us every fair evening, when it is not bright moonlight, on shooting-stars for the determination of heights and radiants.

Some work has also been done on variables by naked-eye estimations.

Lately, however, Professor Pickering, of Harvard College Observatory, has been kind enough to lend me a Zöllner's *Photometer*, and it is probable that work upon variable stars will be continued during the ensuing year.

Meteoric astronomy will also receive its share of attention as heretofore.

Mt. Lookout, O.: Cincinnati Observatory.

Professor ORMOND STONE, Director.

1. *Personnel.* — Ormond Stone, Director; Herbert A. Howe, assistant; H. V. Egbert, student.

2. *Observations.* — With the Munich *Refractor* the revision of the double stars between 0° and 30° south declination has been continued. The working-list contains 941 stars, of which 389 have thus far been observed at least twice, and 212 once, leaving 340 unobserved. Two smaller working-lists have also been employed. These contain polar and equatorial stars suitable for the determination of personal equation. During September a short series of micrometrical measurements of *Saturn's* satellites was obtained.

With the BUFF & BERGER *Transit*, besides observations for the regulation of the standard time of Cincinnati, a series of observations has been made for the determination of the latitude of the observatory.

The sun has been examined with a CLARK *Refractor* on 147 days; spots were visible on 23 only.

A series of observations of the relative brightness of variable stars has been commenced. These observations are made on nights when the sky is clear, but the definition is too poor to use the *Micrometer*.

The observations of the transit of *Mercury* of May 6 were only partially successful. The eclipse of the sun of July 29 was observed at Schuyler, near Denver, under the auspices of the Naval Observatory at Washington.

3. *Publications during* 1878. — (1) Micrometrical measurements of 517 double stars, observed during the year 1877 (*Pub. Cincin. Obs.*, No. 4). (2) On personal equation in double-star observations (*Astr. Nachrichten*, No. 2201). (3) On the determination of time by means of a portable *Transit Instrument* out of the meridian (*Astr. Nachrichten*, No. 2229).

Nashville, Tenn.: Private Observatory of Edw. C. Barnard, Esq.

I have a 5-inch *Achromatic Telescope*, with eight different *Eye-pieces*, magnifying 52, 78, 85, 104, 173, 260, 390, and 520 diameters. The telescope has also a *Finder* and *Prism Eye-piece*. The objective is a first-class one, and was made by Mr. John Byrne, of New York. The mounting is simple equatorial. This telescope will show the sixth star in the trapezium of *Orion*.

I have no regular observatory, but I intend, as soon as circumstances will permit, to have my telescope mounted on a fixed equatorial stand.

I made observations of the transit of *Mercury* this year, which I sent to the Observatory at Washington.

Circumstances permitting, I hope, in the future, to make a more valuable report than this.

New Brunswick, N. J.: Schanck Observatory of Rutgers College.

Professor G. B. Merriman, Director.

The observatory is a two-story brick building, with revolving dome, 16 feet in diameter, and a wing for transit observations. It is equipped with the following instruments:

A 6½-inch Fitz *Equatorial*, 8 feet 4 inches focal length, with *Position Micrometer*.

A 4-inch *Transit Circle*, 4 feet 10 inches focal length, made by Stackpole & Brother, with circles 17 inches in diameter, and the usual accompaniments of level and reversing apparatus.

A *Sidereal Clock*, made by Bond & Sons, and a *Mean-time Clock*, by Howard & Co.

The observatory and all the instruments are donations by friends of the college.

The observatory is designed and used for class instruction. I have no assistance but what is afforded by students in practical astrono-

my. My other duties, as professor of mathematics and natural philosophy, leave me but little time for regular astronomical work. I have been in charge of the observatory but a year, and the work in that time, besides instruction, has been but little more than getting familiar with the instruments, testing their powers, determining errors, etc.

The transit of *Mercury* was observed last May, and the results communicated to the U. S. Naval Observatory. The longitude, as approximately determined at that time, is 10^m 25.7^s E. of Washington.

A *Driving-clock* will soon be attached to the *Equatorial*, after which it is intended to make measurements of double stars as leisure permits.

New Haven, Conn.: Observatory of Yale College.

In charge of Professor C. S. LYMAN; no regular assistants.

Instruments.—1. A 9-inch *Equatorial*, by ALVAN CLARK & SONS, with *Driving-clock*, *Bifilar Position Micrometer*, by DOLLOND; a *Multiple Ring Micrometer* (four concentric rings with widths and spaces equal); and a powerful CLARK *Spectroscope* of seven prisms twice traversed by the light.

2. A *Meridian Circle*, by ERTEL & SONS, altered by YOUNG, with 5-foot telescope of 3.8 inches aperture, and two 40-inch circles read by six micrometer microscopes.

3. A *Sidereal Clock*, by APPLETON, London, and another by HOWARD, Boston.

4. A combined *Transit Instrument* and *Zenith Telescope*, of 3 feet focus and 2.6 inches aperture. This instrument, the earliest of the kind, was constructed mainly in 1852–53, and is described in the *American Journal of Science and Arts*, vol. XXX., 2d series, and in the *Proceedings* of the American Association for the Advancement of Science for 1860.

5. A portable CLARK *Refractor*, of 5 feet focus and $4\frac{3}{8}$ inches aperture.

6. *Sextants*, and other minor instruments.

This observatory is connected with the Sheffield Scientific School, and is used chiefly for purposes of instruction. The only observations published the past year were those of the transit of *Mercury*. The city time is regulated by the observatory, as well as the chronometers coming to this port. Mr. Wm. Beebe and Mr. H. A. Hazen were in charge most of the year, in the absence of the director.

Yale College has also a 10-foot *Refractor*, of 5 inches aperture, by DOLLOND, and a 5-foot *Transit Instrument*, of 4 inches aperture, by TROUGHTON & SIMMS. The former is used by students in the Academical Department, and is in charge of Professor Loomis. The latter is not yet mounted.

The Winchester Observatory is still *in futuro*. The ample endowment, however, secured to it prospectively by Hon. O. F. WINCHESTER, makes its realization only a question of time. A *Flint Disk* has been purchased, and other steps taken towards the construction of an *Equatorial* of about 28 inches aperture.

New York, N. Y.: Private Observatory of William T. Gregg, Esq.

In reply to your card I would say that my observatory was built for the convenience of correcting objectives rather than for star observations; and yet, if I could do any work in it that you might suggest, I would be pleased to do so. I have in it a 6¼-inch *Equatorial* (my own make), not furnished with clock-work as yet, but which will be as soon as possible; and, as I have said, I would gladly undertake any elementary work that you might suggest.

Oxford, Miss.: Observatory of the University of Mississippi.

Professor R. B. FULTON, Director.

The equipment of the Observatory of the University of Mississippi consists of an equatorially mounted *Refractor*, 4½ inches aperture, by MERZ, of Munich; a *Portable Transit*, 2½ inches aperture, by PIKE & SON; an *Alt-azimuth*, with circles 10 inches diameter and verniers reading to 10^s; a *Box Chronometer* by WM. BOND & SON. With the present small equipment, there has not been much work undertaken. The determination of local time, and the observation of the transit of *Mercury* in May, is all that has been done. The observatory has been closed, on account of yellow fever, since July 1.

Peconic, Suffolk Co., N. Y.: Private Observatory of Geo. W. Fitz, Esq.

Our instrumental equipment is as follows:

1. A 6-inch *Telescope*, of H. G. FITZ'S make, mounted equatorially without circles. It is provided with a *Position Micrometer* and *Eye-pieces* of various powers.

2. A 4-inch *Telescope*, equatorially mounted on tripod stand, with small circles reading to 5′ of arc and 4^m of time respectively. It has also a tangent screw for slow motion in R. A.

3. A 32-inch fixed *Transit*, mounted on a barrel of gravel, capped with a square stone, in a small transit house. It is furnished with a *Level* and the other means of making the necessary adjustments, also a *Setting-circle* reading to 1′.

4. A Dent *Chronometer*, beating half-seconds.

We observed the transit of *Mercury* on May 6, last, the results of which were communicated to the U. S. Naval Observatory. The fol-

lowing are the times of the contacts in Washington time as obtained by telegraph:

1st	contact,	estimated	$10^h\ 4^m\ 25^s$	A.M.
2d	"	"	$10^h\ 7^m\ 33^s$	"
3d	"	"	$5^h\ 33^m\ 30^s$	P.M.
4th	"	"	$5^h\ 36^m\ 42^s$	"

These observations are all we have made hitherto; but next year I hope to make a better showing by transit work, occultations, etc.

I have obtained our latitude and longitude roughly by triangulation, using Horton's Point light and Southold spire; the latitudes and longitudes of these places taken from Coast Survey Report for 1851. They are as follows: Lat. 41° 2′ 15″ N., long. $4^h\ 49^m\ 51^s$ W. of Greenwich, long. $18^m\ 20^s$ E. of Washington.

Phelps, N. Y.: Private Observatory of Wm. Robert Brooks, Esq.

My apparatus is portable, and the "observatory" is really the yard and garden of my house. I am the only observer, my wife acting occasionally as assistant.

Two *Telescopes*, one a 2-inch achromatic, of 36 inches focal length, the other a Newtonian glass reflector, of 5 inches aperture and 50 inches focal length, both of my own construction, are available. My observations for the past year have been devoted to the planets, moon, and solar spots; of late, almost daily observations of the sun for spots, and watching for the transit of *Vulcan*, or other inter-Mercurial planet. These will continue to be my chief studies for the future. I observed the transit of *Mercury* last May. My publications have been confined to several notices of interesting phenomena coming under my observation, mainly in the daily and weekly press.

Poughkeepsie, N. Y.: Observatory of Vassar College.

Professor Maria Mitchell, Director.

1. The *personnel* of the observatory consists of myself only, although aid is obtained from one or more of the students.

3. *Subjects of Observation.* — The sun-spots are photographed on every fine day. Observations were made on *Saturn* and its satellites during fifty evenings in 1877, '78.

4. The above observations will probably be continued in 1879.

5. The only publication was a short article in *Silliman's Journal* on *Jupiter*.

Providence, R. I.: Private Observatory of F. E. Seagrave, Esq.

Leonard Waldo, Assistant at the Observatory of Harvard College, Director.

This private observatory was erected by Mr. Frank E. Seagrave in the rear of his residence, 119 Benefit Street, Providence, R. I. Its

position, referred to the neighboring Coast Survey stations, is latitude 41° 49′ 46.4″ N., longitude 52^m 34.51^s E. of Washington. The building is a substantial cylindrical tower 18 feet in diameter and built of brick, surmounted by a drum which revolves on gun-metal balls. It was completed, and the instrument mounted, in the spring of 1878.

The *personnel* of the observatory at present comprises my pupil, Mr. Frank E. Seagrave, Jun., and myself; the instruments are: 1. An 8-inch *Equatorial*, by ALVAN CLARK & SONS, completely furnished with clock-work, circles, etc., for micrometric measurement; 2. A number of small *Telescopes* from 3 to 1½ inches aperture for various uses; 3. Three *Spectroscopes* of from ten to one-half prism (of 60° flint) dispersion; 4. *Box Chronometer*, *Pocket Chronometer*, *Meteorological Instruments*, and the usual miscellaneous apparatus for use with an Equatorial.

During the past year the following subjects have engrossed our attention: 1. The observation of the total solar eclipse from Fort Worth, Texas; 2. The observations of the satellites of *Saturn;* 3. The observations of *μ Cassiopeiæ* to investigate its large proper motion; 4. Some desultory measures, when the Equatorial was not needed for the other series of observations, of Burnham's double stars.

During the coming year we hope to continue the above series of observations.

Our work under the first item will be included in the report of the Fort Worth eclipse party (now in press), and it is probable the work under the second item will be printed within six months.

Rochester, N. Y.: Private Observatory of Professor Lewis Swift.

My prospective observatory being not yet completed, and my present *Telescope*—a 4½-inch achromatic—being, as heretofore, mounted as an alt-azimuth, and therefore not well adapted to other work, I have devoted every clear moonless night to comet-seeking, and the charting of such nebulæ as had escaped detection during the many years devoted to comet-seeking.

I have had the good fortune to discover one new comet, which is, up to this date (Nov. 20), the only new one of the year. I first ran upon it on the morning of July 7, at 2 o'clock civil time, in, by estimation, R. A. 17^h 37^m, Dec. +18°. I immediately suspected its cometary character, and, during the half-hour only between then and dawn, my suspicions were verified by the detection of motion. I at once gave the customary notification to the Smithsonian Institution; but, although its discovery was immediately cabled to Europe, it seems not to have been observed there, owing probably to the presence of moonlight; though, to prove that its faintness was

not excessive, I was able, on the evening of the day of its discovery, to observe it in the presence of a nearly half-moon.

Professor Peters, the Director of the Litchfield Observatory at Clinton, N. Y., and O. W. Landreth, assistant observer at the Dudley Observatory, Albany, N. Y., were the only ones, in any part of the world, who were so fortunate as to get a glimpse of it. Professor Peters followed it until August, and his valuable observations enabled Professor Holetschek to compute its elements, which seem to be unlike those of any other known comet.

When the moon withdrew, and at the termination of a long period of cloudy weather, when it would have been possible for me to re-find the comet, I was on my way to Denver to observe the eclipse of July 29, at which time I discovered what I consider to be (and which I think astronomers generally, when they are conversant with all the circumstances, will concede to be) two intra-Mercurial planets. This, probably, is not the place to go into details; but if anything be said, it seems as if I could hardly say less than what follows: Professor Watson, at Separation, observed θ *Cancri*, and, 42′ southeast of it, what was undoubtedly an intra-Mercurial planet. I, observing in the same region, saw two stars, one of which, I took for granted, as did everybody, was θ *Cancri*, and the other the same planet Watson had discovered five minutes previously. But upon comparison of observations, and after the elimination of all probable errors, I found so much discordance as to justify the prediction that I had not seen θ *Cancri* at all, but, rather, had discovered two planets neither of which was seen by Watson, nor was his planet seen by me. It may be proper to state that Professor Watson discovered still another planet, farther from the sun and near to ζ.

On the 23d I shall start for Cambridgeport, to order, from Alvan Clark & Sons, my new Telescope. It will probably be of 9 inches aperture, and is to be provided with all the modern improvements.

The observatory will probably be ready for the reception of the Telescope when finished.

For the coming year I design to continue comet-seeking as heretofore; but, as I shall have enlarged facilities and improved means for micrometric measurements, I also purpose to determine the position of nebulæ, and to measure close double stars. I shall make determined effort with high powers to detect some of the intra-Mercurial planets while in transit, and perhaps near their greatest elongation.

San Francisco, Cal.: Office of "The James Lick Trust."

In response to your annual circular, recently received, I have little to say in addition to former advice.

The litigation is still progressing. In January last the trustees received a favorable decree in the Nineteenth District Court. The

cause has been appealed to the Supreme Court, and is on calendar for the next ensuing term thereof.

The trustees hope soon to receive judicial confirmation of their position beyond further appeal, and are unanimous in their desire to proceed with the work of erecting the "Lick Astronomical Observatory" as speedily as possible.

South Bethlehem, Pa.: Sayre Observatory of Lehigh University.

Professor C. L. Doolittle, Director.

Your circular inquiring as to the status, etc., of the Sayre Observatory came to hand in due time.

In reply to the same I will say that no change in the *personnel* or management of the observatory has been introduced during the year.

The object of the observatory is mainly that of instruction. Any other work which is attempted must be of such a character as not to interfere with this. I, however, try to do something in the way of scientific work, with such assistance as I am able to get from my pupils. The instruments are as follows:

An *Equatorial Telescope* of 6 inches aperture, by Clark & Sons; a *Sidereal Clock*, by Bond; a *Zenith Telescope*, by Blunt; and a *Portable Transit Instrument*, by Stackpole.

Besides the time given to the work of instruction, I have during the last year completed the determination of the latitude from a series of over 400 pairs of stars observed with the Zenith Telescope. The declinations of the stars used were reduced very elaborately from all the catalogues since that of Bradley, giving a series of mean declinations and proper motions which I hope will not be wholly without value for other purposes. Besides this, a series of measurements of *Jupiter's* satellites has been made, together with observations of eclipses and occultations of the same, which will soon be sent for publication to some scientific journal. The transit of *Mercury* was successfully observed, the time of all four contacts being noted, and notes made of the physical appearances.

It is my intention to continue the observations of *Jupiter* at the next opposition, and to give such attention to special phenomena as opportunity may offer during the coming year. All of our students in the departments of Civil and Mining Engineering have a pretty full course in practical astronomy, which includes observatory work; besides which I have several advanced pupils who are making astronomy a special study.

St. Louis, Mo.: Observatory of Washington University.

Professor J. K. Rees, Director.

In answer to your letter of inquiry, I beg to say that our observatory was built last June, and has been used mainly for class instruction.

1st. The *personnel* consists of myself and a volunteer assistant, Mr. E. A. Engler, a graduate of the university.

2d. *Instruments.*—A *Refractor*, by FITZ, equatorially mounted, and of 17 centimeters (6.69 inches) clear aperture. This instrument is supplied with a *Driving-clock* and a *Filar Position Micrometer.*

A *Refractor* of 7.5 centimeters (2.95 inches) clear aperture, universally mounted. This is about to be better adapted to transit-work. To this may be attached a fine diagonal *Micrometer Eye-piece* for determining latitude by TALCOTT'S method.

A *Sextant*, by GEO. W. BLUNT.

3d. *Observations.*—No regular observations are made except for time, which is supplied to the city by means of a *Central Regulator*, communicating by electricity with thirty dials situated at different points. This summer I was a member of the party stationed at Fort Worth to observe the eclipse of July 29.

I have a RUTHERFURD *Diffraction-plate* of 17,280 lines to 2.5 centimeters, which I expect to have mounted so as to do some work in solar physics.

Tarrytown, N. Y.: Private Observatory of C. H. Rockwell, Esq.

In reply to your note of inquiry, I would say that my astronomical outfit is so meagre, and the work done so unimportant, as scarcely to merit a public notice.

In company with Mr. Ward Carpenter, of this village, I made observations on the transit of *Mercury* on 6th May last, of which I sent an account to the Naval Observatory, Washington, by request of Admiral John Rodgers. The instruments used were a *Telescope* of 3¼ inches clear aperture, a *Mean-time Chronometer*, No. 459, by PARKINSON & FRODSHAM; and an *Engineer's Transit*, with diagonal *Eye-piece*, for time observations of stars.

I went to Central City, Col., as a member of the party under the charge of Professor Edward S. Holden, of the Naval Observatory, to note the solar eclipse of July last.

My interest in astronomical matters is largely on the side of mathematics, and the calculations which I make are only those of an amateur.

Troy, N. Y.: Proudfit Observatory.

Professor D. GREENE, Director.

This observatory is the gift of Ebenezer Proudfit, Esq., of Troy, to the Rensselaer Polytechnic Institute, and is just completed. It is designed mainly to furnish facilities for the practical instruction of students in astronomy. The building is of brick, and consists of a central part thirty feet square and two stories in height, with north, south, and east wings. The Equatorial room, in the second story, is

circular, and is covered with a revolving dome twenty-nine feet in diameter, which weighs but 4000 pounds, and can therefore be easily revolved without machinery. The piers for the meridian instruments are in the east wing. The central part of the roof of this wing is flat, and is surrounded by an iron railing; it is directly accessible from the Equatorial room, and forms a convenient place for the use of portable instruments.

The following are the only instruments yet in the possession of the observatory:

Transit Instrument, by KÜBEL, of Washington, of 2½ inches aperture and 31 inches focal length. It is so made as to admit of ready reversal, and is provided with delicate *Level* and *Micrometer*, to adapt it for use as a *Zenith Telescope.*

Another *Transit*, of 2 inches aperture and 30 inches focal length, is mounted in the prime vertical.

Telescope, by FITZ, of 3½ inches aperture, mounted on an equatorial stand.

For furnishing the time, there are two mean *Solar Clocks* and a *Sidereal Chronometer.*

Washington, D. C.: U. S. Naval Observatory.

Rear-Admiral JOHN RODGERS, U.S.N., Superintendent.

The report of the Secretary of the Navy for 1878 contains that of the Superintendent of the Naval Observatory, which gives an account of the work of the past year. The 26-inch *Equatorial* continues to be used in the observations of the faint satellites. The *Transit Circle*, besides its regular work of observations of the sun, moon, and major planets, has made a very large number of observations of asteroids, and is also engaged in the formation of a catalogue of the B. A. C. stars between 120° 0′ and 131° 10′ of N. P. D.

The number of observations made with the Transit Circle during the year is 3450.

The sun was observed sixty-one times, the moon sixty times, and there were made 110 observations of the major planets and 149 of the minor planets.

The Transit-of-Venus reductions are almost ready for publication.

The work of reducing the observations for the chronometrical longitudes of five southern stations is now completed. From 23 to 35 *Chronometers* were used, and the corrections to each one have been computed for every day from August 6, 1874, to January 30, 1875.

The principal work of this observatory is described under its appropriate heads—as Saturn, Mars, Solar Eclipses, etc.

Willet's Point, N. Y.: Field Observatory of Engineer Battalion.

Brig.-Gen. HENRY L. ABBOT, U.S.A., Director.

In reply to your request for information about our astronomical work, I would say that this post constitutes the school of application, at which officers of engineers receive facilities for becoming familiar with the practical duties of the corps.

In astronomy, we have a good field observatory, provided with all the instruments used in first-class boundary work, including *Transits*, *Zenith Telescopes*, *Astronomical Telescopes*, *Sextants*, *Break-circuit Chronometers*, and *Field Chronographs*.

The work during the past season has consisted in the usual observations for latitude, longitude, and time. Advantage was also taken of the transit of *Mercury*. A 5-inch *Equatorial*, used on the transit of *Venus*, was borrowed from the Naval Observatory, and a good set of observations were made. A detached report was sent to Admiral Rodgers, which will appear in his general report upon the subject.

For several years past a regular nightly series of records of displays of the *Aurora Borealis* has been systematically kept, which I propose to publish at some future time. They show clearly the well-known law connecting them with solar spots.

Yellow Springs, O.: Observatory of Antioch College.

Professor CHAS. H. CHANDLER, Director.

Your circular asking for an account of our observatory is received. I am very sorry that the fact is that we have none. We have a very good *Telescope*, by ALVAN CLARK & SONS, of 12½ centimeters (4.94 inches) aperture, mounted equatorially upon a portable tripod, as we have no building for its permanent location. This, with a NEGUS *Chronometer* and a small PISTOR & MARTINS *Reflecting Circle*, constitutes all the instruments that are in any way available for astronomical purposes.

These instruments are used only for instruction in the regular college classes, and the press of instruction devolving upon me is such as to prevent other work on my part.

REPORTS OF EUROPEAN OBSERVATORIES.

THE OBSERVATORIES OF ITALY.

Professor RAYET, of Marseilles, has recently been deputed by the Minister of Public Instruction of France to visit the various observatories of Italy, and to report upon them. His report is published in the *Archives des Missions Scientifiques*, 3me série, tome iii., p. 529.

and is much abridged in what follows. For details the original report must be consulted, or the excellent *résumés* in André and Rayet's "Astronomie Pratique," vol. v.

"In the course of my journey in Italy, I visited successively the observatories of Palermo, Naples, Rome (that of the Roman College as well as that of the Capitol), Florence, Bologna, Modena, Padua, Milan, and Turin, remaining some time at each. It is the intention of the government to maintain all of them, each one being devoted, however, to a different branch, so as to fulfil the various needs of astronomical science, now become so complex.

"Of these observatories, only that of Naples has a considerable number of assistants, and in no one is the work done under rigid regulations; each astronomer devotes himself, according to his predilections, to a special subject; emulation and the desire to make a name in science produce a continuity of effort, the result of which has in the last few years been manifest in various brilliant discoveries. To show this, it will be sufficient to describe briefly the situation of each observatory, and the work upon which it is at present engaged."

The Observatory of Palermo.

M. Cacciatore, Director; M. Tacchini, Astronomer.

"This observatory contains two important instruments: a *Meridian Circle*, by Pistor & Martins, and an *Equatorial*, by Merz, which was mounted in 1865. The *Meridian Circle* is daily employed in observations of the sun and the principal stars. The principal work, however, of the Observatory of Palermo, which is specially undertaken by M. Tacchini, is the daily study of the solar protuberances.

"In Italy this research is most vigorously prosecuted, and, in order to avoid the interruptions in a series of such observations which cloudy days may occasion, the observatories of Palermo, Rome, and Padua prosecute these observations in common.

"Among the interesting historical instruments of the observatory is the *Altitude* and *Azimuth Circle*, made by Ramsden in 1788–89, which served Piazzi in the preparation of his great catalogue of stars."

The Observatory of Naples.

M. De Gasparis, Director; MM. Fergola, Brioschi, and Nobile, Astronomers.

"The Observatory of Naples is the most important of those of Italy, in its equipment and its personal establishment. It was founded in 1812 by Murat, and it is built in agreement with modern ideas. In the west Meridian room are a *Transit Instrument*, by Reichenbach, and a *Meridian Circle*, by the same artist. These are still in use. The east Meridian room contains a *Meridian Circle* by Repsold, which has just been mounted, and which is one of the best of the instru-

ments of this class made by this celebrated artist. It is with this instrument that M. FERGOLA is observing the zone of stars which the Observatory of Naples has undertaken for the German Astronomical Society. Besides the three Meridian instruments, the Observatory of Naples has in active use two *Equatorials*, and is soon to obtain a third of larger dimensions. The first of these instruments was constructed in 1811 by REICHENBACH & UTSCHNEIDER, and has 3.27 inches aperture. It is with this small instrument that M. de Gasparis discovered nine asteroids, *Hygeia*, *Parthenope*, *Egeria*, *Eunomia*, *Psyche*, *Massilia*, *Themis*, *Ausonia*, and *Beatrix*. The second Equatorial was made by MERZ, of Munich, and has an aperture of 5.28 inches. M. NOBILE employs it in the measurement of the double stars of Struve's catalogue."

Observatory of the Roman College.

Padre FERRARI, Director.

"The observatory formerly under the direction of Padre SECCHI is built upon the top of the cupola of the Church of St. Ignatius; but in so solid a way that the stability of the instruments, during the night at least, is quite satisfactory. The principal instrument of the observatory is an *Equatorial* of 7.5 inches aperture, which is one of the *chefs-d'œuvre* of MERZ. There is still another *Equatorial*, by CAUCHOIX, of 5 inches aperture, which is used for the daily observations of solar spots, and also a *Transit Instrument*, by ERTEL, for time determinations. The situation of the observatory, in the centre of the city, has forced its illustrious director to devote his efforts to the study of physical astronomy, which, in his opinion, is too much neglected in government observatories.

"To recite the magnificent works executed in this branch of astronomy by Padre SECCHI would require too much space, but I may mention a new experimental method used by Padre SECCHI in his studies of the solar protuberances. For more than a year he has employed, in place of the prisms of his spectroscope, a diffraction-grating ruled upon a speculum metal by Mr. RUTHERFURD, of New York. This grating has 4000 lines to the English inch, and gives a spectrum whose definition leaves nothing to be desired. For the study of the solar prominences such a grating appears to me infinitely superior to any combination of prisms."

Observatory of the Capitol.

M. RESPIGHI, Director; M. SCARPELLINI, Assistant.

"The second observatory in Rome, that of the Capitol, is under the patronage of the Academia dei Nuovi Lincei. M. RESPIGHI is now occupied in observations of solar protuberances and in meridian observations, serving as basis for a catalogue of stars. For the first

purpose an *Equatorial*, by MERZ, of 4½ inches aperture, and a direct-vision *Spectroscope*, with five prisms, are employed.

"A beautiful *Meridian Circle*, by ERTEL, serves M. RESPIGHI for his observations of fixed stars of the first six magnitudes, which are to be employed by the Italian staff-officers in their geodesic operations. This observatory possesses also a *Reflex Zenith-tube*, made by ERTEL, from designs by M. RESPIGHI himself. The basin of quicksilver, by means of which the reflected stars are observed, is 21 meters (68.90 feet) below the objective, which thus masks but a small portion of the sky. When the telescope is directed towards the nadir, stars very close to the zenith may be observed by the declination-wires during their transit; at the same time, and without touching the instrument, the nadir may also be observed, so that the zenith-distance of each star depends upon the micrometer screw alone, and is determined with the great accuracy which this kind of observation allows."

Observatory of Florence.

M. WILLIAM TEMPEL, Assistant.

"The old observatory of Florence, formerly presided over by DONATI, has been dismantled, and a new and magnificent structure is nearly built at Arcetri, near the house formerly inhabited by Galileo. The old observatory is now used for a meteorological station.

"The new observatory possesses, 1, a small *Equatorial* suitable for a comet-seeker; and, 2, a large *Equatorial*, by AMICI, of 11 inches aperture, of excellent quality. Besides this, a small *Meridian Instrument* is mounted in the Meridian room. This room will subsequently contain a *Meridian Circle* of 7 inches aperture, and a *Transit Instrument* somewhat smaller. It is proposed to have for this observatory a staff composed of a director and five assistants."

Observatory of Bologna.

M. PALAGI, Director.

"The Observatory of the University of Bologna is one of the most ancient in Italy, and is placed on the top of a high tower, which unfits it for precise observations. It possesses a *Meridian Circle*, by ERTEL, mounted in 1851, but now little used, and also a DOLLOND *Equatorial*, of 3 inches aperture. Its collection of historical instruments is of high interest."

Observatory of Modena.

M. RAGONA, Director.

"The Ducal Observatory was founded in 1819 by BIANCHI, and was provided with the best instruments of that time; but now it

will probably become the central meteorological station of the surrounding states. Its *Meridian Circle* is of 4 inches aperture, with 3-foot circles. Its AMICI *Equatorial* has 2½ inches aperture only, and is thus too small for most astronomical purposes. Its collection of meteorological and magnetic apparatus is, on the contrary, very complete and noteworthy."

Observatory of Padua.

M. SANTINI,* Director; M. LORENZONI, Astronomer.

"This observatory dates from 1774. It is well situated for observations of precision, as the numerous catalogues of stars published by its celebrated director testify sufficiently. The principal instruments of the observatory are a *Meridian Circle* and an *Equatorial*, both by STARKE. There is also a *Spectroscope* by HOFFMAN. The two latter instruments are used by Lorenzoni for daily observations of the solar protuberances. The Meridian Circle is employed in observations of the sun, planets, and the principal stars."

Observatory of Milan.

M. SCHIAPARELLI, Director; M. CELORIA, Astronomer.

"The Milan Observatory is one of the most ancient of Italy, its foundation in the Brera Palace having been established in 1760. Among its directors have been the celebrated astronomers BOSCOVICH, ORIANI, CESARIS, and CARLINI. It contains two halls, one for the *Equatorial* and one for the *Meridian Circle*. The former, by MERZ, was mounted in February, 1875. It is to be devoted to a re-observation of STRUVE's double stars. The *Meridian Circle* is by STARKE."

Observatory of Turin.

M. DORNA, Director; M. CHARRIER, Assistant.

"The present observatory of Turin was constructed in 1820, and until 1864 it was under the direction of the illustrious PLANA; since that time it has been part of the university, and is under the charge of the Professor of Astronomy. Its instruments are: 1. A *Meridian Circle*, by REICHENBACH. This excellent instrument is used for observations of the sun and stars for the determination of the time, which is given to the city by means of a time-ball. 2. A *Comet-seeker*, mounted in a small dome. 3. A *Repeating-circle*, by ERTEL, used for purposes of instruction. 4. An *Equatorial*, 4.61 inches aperture, which will be used by Dr. CHARRIER for spectroscopic observations of the solar protuberances. A larger *Equatorial* is soon to replace this."

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* Died July, 1877.

OBSERVATORIES OF PORTUGAL.

From an official document of the Portuguese government we extract the following, which will contain something new to most readers:

"Portugal possesses three astronomical establishments: The Lisbon Royal Observatory, the Astronomical Observatory of Coimbra University, and that of the Lisbon Polytechnic School (in construction).

"In 1874 the ancient Marine Astronomical Observatory in Lisbon was abolished and annexed to the Naval School, for the practical study of astronomy and navigation in the course of the same school. It has under its charge the regulation of the chronometers and determination of error of the instruments destined for the men-of-war.

"The principal instruments that this observatory possessed were: 1 REPSOLD *Meridian Circle*, with a focal distance of 1.36 meter, and the objective of 0.10 meter of diameter; 1 *Transit Instrument;* 1 *Parallactic Refractor*, with a focal distance of 2.61 meters and objective of 0.155 meter; and 1 REPSOLD *Universal.*

"The Lisbon Royal Astronomical Observatory

is indebted to the love of science and liberality of the king, Don Pedro V., and to the initiative of Dr. Filippe Folque. The plan of the observatory is similar to the one of Pulkova. Height of the place, 93 meters.

"The collection of instruments of the observatory consists of 1 large *Equatorial* of a focal distance of 7 meters and 0.38 meter of objective aperture; 1 *Prime Vertical Transit Instrument*, STRUVE'S system, with 2.31 meters of focal distance and 0.16 meter of aperture; 1 *Meridian Circle*, with 0.15 meter of aperture and 2 meters of focal distance; 1 *Transit Instrument* of the system of OOM, with 0.07 meter of aperture and 0.78 meter of focal distance; 1 *Parallactic Refractor* of 1.95 meter focal distance and 0.117 of aperture; an *Explorator* of 0.64 meter of focal distance and 0.077 meter of aperture; a *Normal Pendulum* of KRILLE, regulator of electro-chronometric apparatuses; several *Chronometers* and *Pendulums;* 1 *Chronograph; Electric Apparatuses;* 1 *Zigometer; Collimators*, *Barometers*, *Thermometers*, and *Telegraphic Apparatus.*

"The Coimbra Observatory,

whose establishment is indebted to the Marquis of Pombal, is built alongside of the university building, and is destined principally to the practical teaching of astronomy in the faculty of mathematics.

"The principal instruments that it possesses are: *Equatorial*, *Meridian Circle*, *Prime Vertical Transit Instrument*, and sidereal pendulum of BERTHOUD.

"The technical *personnel* consists of a director, two astronomers, and two calculators."

OBSERVATORIES OF ENGLAND AND ENGLISH COLONIES.

The *Monthly Notices* of the R. A. S. for February, 1878, contains the reports of the proceedings of observatories, which may be summarized as follows:

Greenwich Observatory.

The *Meridian* and *Alt-azimuth* instruments are employed as in former years. The *Equatorial* has been used for drawings of *Mars*, on the spectroscopy of the sun, moon, *Mars*, and fixed stars, and of the "rain-band" in the solar spectrum: 169 photographs of the sun have been taken. The computations for the nine-year catalogue of 2363 stars are finished.

Radcliffe Observatory, Oxford.

The usual routine work has been done, and solar spots observed. The *Heliometer* has been employed on *Mars* and *Saturn;* twenty-five measures of *Saturn's* diameter have been made. The catalogue of stars is advancing.

University Observatory, Oxford.

The Savilian Observatory, Oxford, has published Part I. of its astronomical observations. It describes the instruments of the observatory, and gives a series of observations of satellites of *Saturn*—one of *Mimas* (?), ten of *Enceladus*, none of *Hyperion*, and from forty-five to ninety-seven of the brighter satellites. Part II. contains four hundred observations of 118 double stars. Part III. is devoted to the comets of 1877, which were well observed. Part IV. contains new orbits of three of the older binaries. Twelve hundred photographs of the moon have been taken, and are to be measured to determine the amount of libration. The geographical co-ordinates of the observatory are given to 0.001″, or about one inch on the earth's surface. These are quoted from Ordnance-Survey data.

University Observatory, Cambridge.

The zone observations are continued.

Dunsink Observatory.

The red stars of Schjellerup's catalogue have been nearly all observed, and the *Equatorial* has been employed in measures to determine the parallax of stars.

Edinburgh, Liverpool, and Glasgow Observatories.

The usual routine work is continued.

The Edinburgh Observatory has issued its fourteenth volume, un-

der the direction of Piazzi Smyth. Its main space is devoted to the formation of a "star ephemeris" from 1830 to 1890, which is to be compared with standard observations. Much of this is blank. Portions of the work are devoted to rain-band spectroscopy, to a discussion of the valuable series of earth-temperatures, etc.

Kew Observatory.

Besides reductions of solar photograms, the spots are observed with the eye.

Temple Observatory, Rugby.

The new observatory is completed, and measures of double stars continued.

Dr. Huggins's Observatory.

Photographs of the spectra of *Sirius*, *Mars*, *Venus*, *Jupiter*, *Saturn*, and the moon have been made.

Cape of Good Hope Observatory.

Three thousand stars between 125° and 135° N. P. D. of Lacaille's list have been observed. *Mars* has been observed thirty-eight times on the meridian for parallax. The time-service has been extended.

Melbourne Observatory.

The regular work is continued, including daily photographs of the sun. The zone observations between 150° and 160° N. P. D. are nearly complete. They comprise 48,000 stars, from first to tenth magnitude.

OBSERVATORIES OF THE CONTINENT OF EUROPE.

In the *Vierteljahrsschrift der Astronomischen Gesellschaft*, 1878, there have been collected short reports on the activity of various European observatories, of which reports we give an abstract here. The observatories chosen are usually such as do not regularly publish an annual (or other) volume; so that these abstracts, taken in connection with the published volumes, furnish a record of transatlantic work similar to that which we have collected for American observatories.

Observatory of the Academy of Sciences, Berlin.

Director of the Observatory, Professor W. Foerster; Director of the Computing Bureau, Dr. Tietjen.

The principal instruments are: a 7-inch *Meridian Circle* (Pistor & Martin's), under the immediate charge of Dr. Becker; and a 9.6-

inch *Equatorial* (MERZ), under charge of Dr. Knorre. The smaller Meridian instruments are under Dr. Tietjen's care.

The principal work of the Meridian Circle was the continued observation of the 521 fundamental stars of the V. Y. S. Catalogue. This work was interrupted in 1876 by the operations for determining the longitudes of Berlin, Vienna, and Odessa from Greenwich. One thousand three hundred and thirty transits and 1328 declinations were observed in 1877.

Various other stars have been added to the observing list, among others 360 stars of Tobias Meyer's catalogue, stars for Mr. Gill's *Mars* observations, etc. Publications have been made of the work of Dr. Schmidt on the division errors of the small Meridian Circle, and of Dr. Müller on the Micrometer screw of the Equatorial.

The time-service has been carried on as usual. Clocks are controlled at the Time-ball Stations of Neufahrwasser, Swinemünde, Bremerhaven, and Cuxhaven, as well as six different public squares in Berlin.

The principal work of the Computing Bureau has been, as before, the computation of the *Berliner Jahrbuch.* Twenty minor-planet circulars have been issued. Of the thirty-six planets whose new elements are given in these, twenty-seven were computed in the Bureau. Of the sixty-four ephemerides, forty-seven were computed in Berlin.

University Observatory, Bonn.

Professor E. SCHOENFELD, Director.

The *Meridian Circle* is engaged on the zone observations (zone $+40°$ to $+50°$). Dr. Hugo Seeliger observes at the *Telescope;* Dr. Deichmüller at the *Microscopes.*

Five hundred and seventy-four partial zones were observed up to December 31, 1877, and about four hundred and eighty reduced. Comets *a*, *b*, *c*, *e*, and *f*, 1877, were observed. The *Durchmusterung* has been carried on, and 70,517 star-positions determined.

For comparison, the catalogues of Lalande, Rumker, Piazzi, Schjellerup, Bessel's and Argelander's zones, and the Anonymæ of Yarnall's Catalogue, have been *completely* reduced to 1855. For the cluster M. 23 (h. 1990) G. C. 4346, a special *Durchmusterung* has been made. Over 145,000 star-positions have been fixed during 1876–77. The variable stars *Mira* and T *Monocerotis* were observed.

Royal Observatory, Brussels.

F. QUETELET, Director.

A new *Equatorial*, by MERZ, of 0.038^{m} (=14.96 inches, English) aperture, has been ordered, and will be mounted by COOKE. A *Meridian Circle*, similar to the Strasburg Circle, has been ordered from REPSOLD.

Another *Equatorial*, 0.015^{m} (=5.91 inches) aperture, is employed for spectroscopic work. Drawings of *Mars* were made with it by M. L. Niesten.

The new instruments, when installed, will be devoted to three principal objects: *first*, to double-star observations of binaries and proper-motion stars; *second*, to observations of *Jupiter's* satellites in transit; *third*, to spectroscopic observations, particularly of binaries. The sun is now observed spectroscopically by M. Fiévez.

Düsseldorf Observatory.

Dr. Robert Luther, Director.

In 1877 thirty-seven *Ring-micrometer* observations of fourteen planets were made. Since 1847 there have been made 856 observations of 103 planets.

Private Observatory of Dr. Eppstein, Frankfort-on-the-Main.

The principal instrument is a Newtonian *Reflector* of 6.3 inches aperture, made by Browning, costing £26. The *minimum visibile* is an 11.12 magnitude star.

The work undertaken with the instrument is a continuation of Herschel's sweeps. The field of view of the sweeping eye-piece is 30′, and two hundred fields have been swept and 6700 stars counted (1877—September, October, and November).

Gotha Observatory.

Dr. A. Krüger, Director.

During the necessary repairs of the *Meridian Circle* (0.075^{m} aperture, 1.160^{m} focus), the Helsingfors University has lent its *Transit Instrument* to Dr. Krüger, and this has been used for zone observations (zone +55° to +65°).

Private Observatory of Herr Von Konkoly, O'Gyalla, near Komorn.

This observatory has three domes, a Meridian room, and a chemical laboratory.

The instruments are: a Browning *Reflector*, 10¼ inches aperture, 7 feet focus; a Merz *Refractor*, 6 inches aperture, 6 feet focus; a small *Telescope*, 3 inches aperture, for sun-spot observations; a Starke *Meridian Circle*, about 3 inches aperture, circles reading to 1″; two *Comet-seekers* and minor instruments, and several *Spectroscopes*; a Zöllner's *Photometer*.

The work of 1876–77 has been the formation of a catalogue of one hundred and sixty stars (1^{m}–6^{m}) whose spectra have been observed. Dr. Schrader is assistant, and has conducted a regular series of sun-spot observations.

Hamburg Observatory.

Dr. Georg Rumker, Director.

The zone observations (zone 80°–81° N. P. D.) were continued on forty-five nights. *Mars* was observed fourteen nights. Observations of nebulæ, star-spectra, comets, etc., were made with the *Equatorial.* The Time-ball Stations of Cuxhaven, Bremerhaven, etc., are provided with time-signals, and the *Chronometers* of the Prüfungs-Institut are compared. Dr. Georg Koch is assistant.

University Observatory, Leipsic.

Professor C. Bruhns, Director.

Herr Weinek observes with the *Meridian Circle. Mars* was observed on 42 nights, and major and minor planets are regularly observed. Dr. Peter, with the *Equatorial*, has observed on 129 nights, making 176 observations of 35 asteroids, 84 observations of 6 comets, etc. Herr Leppig has observed sun-spots on 195 days with the small *Equatorial.* Herr Harzer has drawn a number of nebulæ with a 4½-foot *Refractor*, and with the *Comet-seeker.*

Herr Harzer has investigated the orbit of Brorsen's comet from 1842 to 1846. The first volume of "Leipsic Observations," containing Observations of Nebulæ and Double Stars, is printing.

The Transit-of-Venus observations are computed at this observatory for the German Commission.

Private Observatory of Dr. Hugo Gericke, Leipsic.

The instrument is a Steinheil *Refractor*, of 4 inches aperture, and 154 observations of 38 asteroids have been made.

University Observatory, Lund.

Professor A. Möller, Director.

Dr. Lindstet, assistant, has investigated the division errors of the *Meridian Circle. Mars* was observed on ten nights. Double stars and comets have been observed with the *Equatorial.*

University Observatory, Milan.

Professor M. Schiaparelli, Director.

Eight hundred and forty measures of double stars have been made with the 8½-inch *Equatorial* (Merz). Σ 2165, =*Hercules* 281 B, was found to be triple. Comets were also observed, and the surface of *Mars* studied, and a map made.

Professor Celoria is computing the longitudes of Monaco, Padua, Vienna, Milan, Naples, and Genoa. The time is furnished to the city of Milan.

University Observatory, Mannheim.

Dr. W. Valentiner, Director.

The cluster G. C. 4410 has been observed assiduously, so that to determine the positions of its 40 stars about 2000 differences in right ascension and about 1000 differences of declination have been made. Two other clusters, G. C. 1166 and G. C. 1454, are observed also, and will probably be completed during 1878. The reduction of the Meridian observations of Barry is so far complete that the printing has already begun in the *Jahresberichte* of the *Mannheimer Verein für Naturkunde*. Nine hundred and thirty-two stars were observed by Barry (about 1805) 2573 times, or an average of 2.8 times per star. The probable error of a right ascension of such an average star is $\pm 0.089^s$. The library of the observatory contains 1400 titles.

University Observatory, Moscow.

Dr. Th. Bredichin, Director.

In brief, the work of this observatory has been Meridian-circle observations of *Mars* for parallax, and of various stars; micrometric observations of the cluster in *Perseus;* comet observations; spectrum of comet 1877, II.; spectroscopic observations of the sun; and photographic observations of the sun and of groups of stars.

Vol. IV. of the Moscow Observatory, 1878, has arrived in this country. It is in quarto form, and in two parts. Part I. contains: 1. Meridian-circle observations of stars of a selected list. 2. A second memoir on the anomalous forms of comets' tails, by Professor Bredichin. This deals with comet 1861, II. 3. Meridian observations of *Mars* in opposition and comparison stars, by M. Gromadski. These observations extend from July 18 to September 24. The probable error ($\Delta\delta$) of a single observation is $\pm 0.58''$. Each observation of this series combined with one of the same weight in the southern hemisphere would give the solar parallax with a probable error $\pm 0.19''$, and hence from twenty such corresponding observations we may expect a value of this doubtful by $\pm 0.04''$. 4. This section is devoted to Meridian observations of a special list of stars. 5. Spectrum of comet 1877, *b*. Dr. Bredichin finds this to be: A, 556.4 ± 1.7; B, 515.4 ± 0.7; C, 469.7 ± 2.2. For Coggia's comet these numbers are: A, 563.0; B, 516.0; C, 471.1. For the spectrum of "*benzine*" they are: A, 563.2; B, 516.4; C, 471.2. Part II. contains: 1. Observations of *Mars* and comparison stars with the *Equatorial*. 2. Measures of stars in the cluster in *Perseus*. 3. Photomet-

ric observations with a ZÖLLNER'S *Photometer;* observations of comets, of bands on *Jupiter*, of a lunar eclipse, etc., and some photoheliographic observations.

Astrophysikalisches Institut, Potsdam.

The buildings are well under way, and some of them are now occupied. Besides the 5-inch STEINHEIL *Refractor*, one by GRUBB, of 8 inches aperture, has been in use. The principal instrument of the institute, a SCHROEDER *Refractor*, of 11.7 inches aperture, is now finished, except the mounting.

Dr. Spoerer observed the sun on 229 days in 1877, and on 103 days it was free from spots. The protuberances were also observed. Dr. Vogel has investigated the spectrum of *Nova Cygni*, and, together with Dr. Müller, has made photometric measures in the solar spectrum. *Mars* and *Jupiter* have been studied by Dr. Lohse, who has also examined the structure of solar spots. Dr. Müller has begun a series of photometric observations on the major planets.

University Observatory, Stockholm.

Dr. HUGO GYLDÉN, Director.

A 7-inch *Refractor* (REPSOLD) has been mounted, as well as a *Portable Transit.* The principal work of the observatory has been in computation of tables (now published) for general perturbations in comet orbits.

University Observatory, Strasburg.

Professor A. WINNECKE, Director.

The *Meridian Circle* is not yet mounted, and so could not be used on *Mars* observations as was hoped. Physical observations of *Mars* were secured on 19 days. With the small *Refractor* (6-inch) on 48 nights 124 nebulæ were observed in connection with neighboring stars.

Observations of six comets, of *Nova Cygni*, of double and variable stars, have been made with the *Equatorial.* The *Transit Instrument* has been employed by Dr. Schur, who has also observed 38 diameters of *Mars*, the diameter of the moon (during the total eclipses of February 27 and August 23), and a few double stars with the *Heliometer.* This instrument will next be employed in measures of the solar diameters; and this series it is intended to continue for a period of eleven years.

Dr. Hartwig has already made measures of the polar diameter on 64 days, of the equatorial on 65 days, without detecting the slightest difference. The diameter of *Mars* has been measured 30 or more times, and that of *Venus* on 21 days.

University Observatory, Warsaw.

Dr. I. Wostokoff, Director.

The instruments of this observatory are: *Vertical Circle*, 3 feet diameter; *Transit*, 4½ inches aperture; and a 6-inch *Equatorial*.

Dr. Kowalczyk observed with the *Meridian Circle* stars of the zone —1° 50′ to —7° 10′, on the plan of the German Astronomical Society. Fifteen hundred observations have been made. Three determinations of the latitude have been made at this observatory: 1830–43, Meridian Circle, 52° 13′ 5.6″; 1846, Universal Instrument, 52° 13′ 5.7″; 1877, Vertical Circle, 52° 13′ 4.6″.

Imperial Observatory, Vienna.

Dr. Palisa, with the 6-inch Fraunhofer, has observed asteroids and comets.

Dr. Weiss has used the same instrument in observing suspected variable stars discovered by him. One of these stars is Ll. 28607, which varies from 7.0 to 8.8 magnitude in a period of four months. This star has proper motions of —0.08ˢ and —0.35″. The neighboring star Ll. 28590 apparently has a proper motion of —0.2″. Another adjacent star, Ll. 28590 (double), is slightly variable.

Dr. Holetschek is observing, with the *Meridian Circle*, the fundamental stars of the Vienna zones, +15° and +18°.

The new observatory buildings will probably be completed in 1878. The crown-glass of Grubb's 27-inch *Refractor* is not finished. The Clark 12-inch is not yet mounted.

University Observatory, Zurich.

Dr. R. Wolf, Director.

Sun-spots have been daily observed; in 1877 on 307 days. Drawings of *Mars*, *Venus*, *Jupiter*, *Saturn*, the moon, a few nebulæ, etc., have been made by Dr. Wolf.

ADDENDUM.

The report of the Dudley Observatory, which should have been inserted among those of other American observatories, has not been forwarded to the compiler, although, had time allowed, it would have been prepared by the Director, and inserted here. From data kindly furnished by the Director, the following abstract is given of one important paper; and it may be further mentioned that actual work has commenced on the zone undertaken by this observatory.

In a paper on the Transit of *Mercury*, read before the Albany Institute, Professor Lewis Boss, the Director of the Dudley Observatory,

has discussed a large number of observations of contacts, and deduced the corrections to the *American Ephemeris* and the British *Nautical Almanac*, respectively. In the former, Leverrier's old theory of *Mercury* is used; and in the latter, his later tables; and the importance of the comparison lies in the circumstance that these latter include a term due to the supposed attraction of an intra-Mercurial planet. The mean corrections to the predicted times of contact resulting from the observations are as follows:

					s.		s.
1st contact,	6	ob. corr.	to	*Am. Eph.*	− 45.7	to N. A.	− 4
2d "	15	"	"		− 61.8	"	−20
3d "	11	"	"		−124.4	"	−18
4th "	10	"	"		−141.7	"	−35
Means.....					− 93.4		−49.25

Thus it appears that the later tables, with the term due to an intra-Mercurial planet, give a satisfactory representation of the fact. The apparent corrections to the *Nautical Almanac* range from -10^s to -1^s for first contact; -32^s to -10^s for second contact; -26^s to -4^s for third contact; and -41^s to -24^s for last contact. Taking simply the discordances from the mean in each case in the tables given by Mr. Boss, the mean error of an observation is 2^s for first contact, 6^s for second, and 5^s each for third and fourth. Considering the small number of observations of first contact, we should not be far wrong in taking the mean error as about the same for all four contacts, and equal to 5^s.

Micrometrical measures of the diameter of *Mercury* during the transit gave $11.30'' \pm 0.14''$, uncorrected for irradiation or possible expansion of the screw. This value would give 176.6^s as the interval between external and internal contact. The observed interval was 172.4^s between first and second, and 171.2^s between third and fourth.

PHYSICS OF THE GLOBE.

By CLEVELAND ABBE,
Of the Army Signal Office.

THE EARTH.*

INTERNAL CONDITION.

Professor H. Hennessy read before the British Association, at Dublin, an important paper on the Limits of the Hypotheses regarding the Properties of the Matter composing the Interior of the Earth. He maintains that the views long ago proposed by himself, in opposition to Hopkins, are those that now are coming to be generally accepted: that the mathematical investigations of Hopkins, Thomson, Darwin, etc., have little or no bearing upon the question, because these authors have assumed an incompressible homogeneous fluid nucleus to be surrounded by a solid elastic compressible shell; whereas we now know that the fluid nucleus is vastly more elastic than its rocky envelope—a reversal of conditions that entirely changes the problem. He finds evidence in the most recent writings of Thomson and Darwin of these more correct physical views.

A comparison of the diverse views of modern scientists upon the condition of the interior of the earth is given by Dr. F. Toula, in a lecture published in Vienna.

In a recent address, Sir G. B. Airy inferred from observations on internal temperature, and from the phenomena of hot springs and volcanoes, that "a large proportion of the interior of the earth is fluid and hot," and that this is surrounded by a solid crust of varying thickness and density, traversed by cracks which afford opportunities for volcanoes to burst forth where the crust is thin.

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* Prepared with the assistance of Prof. C. G. Rockwood, of Princeton, N. J.

UNDERGROUND TEMPERATURE.

The report of the British Association Committee on Underground Temperature, by Professor Everett (*Nature*, vol. xvii., p. 476; *American Journal of Science and Arts*, III., xvi., p. 134), gives results of observations, on a very elaborate scale, at Schemnitz, in Hungary, and also in England and in India. The former series was undertaken in response to a request from the Secretary, in 1873, to the Imperial School of Forests and Mines at Schemnitz, and was carried out by Dr. Otto Schwartz. It consisted of observations in no less than thirty-eight galleries connected with six shafts of the mines. Comparisons were made between the temperature of the deepest gallery of each shaft and the assumed mean annual temperature of the ground at the shaft-mouth, and also between the deepest and the shallowest observation in each mine. The result of the former was an average increase of 1° C. for 41.4 meters, or 1° Fahr. for 75.5 feet; of the latter 1° C. for 39.8 meters, or 1° Fahr. for 72.5 feet. The mean of these two would be 1° Fahr. in 74 feet. The report brings out incidentally the important variations of rock temperature, which may arise from the decomposition of metallic sulphides—as pyrites, the disturbing effect of which needs to be guarded against. The English observations were made at Boldon Colliery, between Newcastle and Sunderland, in two holes bored upward to a distance of 10 feet from some of the deepest seams. The results indicated, for the interval between the two holes, a rate of increase of 1° Fahr. in 37 feet; and for the whole depth from the surface a rate of 1° Fahr. in 49 feet. The Indian observations, published in the *Records* of the Geological Survey of India, vol. x., part i., were made in 1875, under very satisfactory conditions, in a bore 310 feet deep, at a place named Manegaon. The results indicate an average increase of 1° Fahr. for 68 feet.

Professor Everett has suggested a method of observing temperature in filled-up bores by a sort of modified thermopile. Two wires of different metals—as iron and copper—having been joined at both ends and covered with gutta-percha, except at the junctions, were to be placed with one junction buried in the bore, and the other above ground. Then a galvanic current would be generated in the wire whenever the

two junctions were exposed to different temperatures; and by regulating the temperature of the outer junction until a galvanometer indicated no current, that of the buried junction would be known. This is essentially the method employed by Becquerel for many years past. (*Nature*, vol. xviii., p. 505.)

Sir William Thomson (*Philosophical Magazine*, May, 1878, p. 370) proposes several problems regarding the conduction of heat through rock, the principal of which is this: "A fire is lighted on a small portion of an uninterrupted plane boundary of a mass of rock, of the precise quality of that of Calton Hill, and after burning a certain time, is removed, the whole plane area of rock being then freely exposed to the atmosphere. It is required to determine the consequent conduction of heat through the interior." The mathematical discussion leads him to a series of conclusions which may be found stated at length in the *American Journal of Science and Arts*, III., xvi., p. 132.

The temperatures in the St. Gothard Tunnel have been accurately observed by the engineers, and their observations discussed by Stapff and Hann. They, however, can give little or no reliable information as to the temperature of the earth in its interior, and the whole of our present knowledge on this subject is thoroughly unsatisfactory.

Mr. William Morris, of Earl's Hill Colliery, publishes an earnest remonstrance against accepting temperatures of the ground as observed in coal-mines, as having anything to do with the temperature of the earth at that depth. Such figures, according to him, are wholly dependent on the ventilation of the mine.

The temperatures of the spring-waters for two different springs in Tokio, Japan, are given, apparently by Knipping, in the last number of the *Mittheilungen* of the German-Asiatic Society for each month of the years 1873 to 1877, and from these he deduces a table for the correction to reduce any month to the mean of the year. These corrections he has then applied to observations of springs in other portions of Japan, from which he deduces the mean temperature for the year.

The influence of artificial coverings and of shade upon the temperature and moisture of the soil form the subject of a

volume by C. Wolling, whose investigations of this subject are, we believe, almost the only ones at present accessible, and form a portion of his work "On the Influence of Covering, etc., etc., on the Fertility of the Soil," Berlin, 1877. The temperature observations were taken at 8 A.M. and 5 P.M., at 6 A.M., and 2 and 10 P.M., for three years at depths of one tenth of a meter, or about 4 inches. Wolling finds that during the warm season the ground that is shaded by plants or otherwise is colder than the fully exposed: the daily variations are considerably less. In cold weather the snow-covered earth is considerably warmer than the naked earth: its temperature changes are less decided. The earth freed from all stones larger than peas is in summer slightly cooler than that on which large stones are allowed to remain, but in winter is slightly warmer. The temperature changes are greater in the latter kind of earth, since at the time of the daily maximum the temperatures are higher, and at the time of minimum are lower.

Messrs. Ayrton and Perry communicate to the *Philosophical Magazine* the results of an elaborate determination of the heat conductivity of stone. The methods of experiment occurred to them during the lectures of Sir William Thomson in Glasgow, in 1874, and admit of highly accurate results. The results bear directly on the accuracy of Fourier's equation for the flow of heat in solids of poor conductivity. The authors acknowledge their indebtedness to the Japanese students of the Tokio College of Engineering for assistance in their work.

The distribution of heat in a homogeneous spherical shell, whose surfaces have a temperature varying with the time, has been studied as a mathematical problem in an inaugural dissertation by Dr. P. Langer, of Jena. He elucidates many details in a problem whose general solution has been already treated of by Fourier, Poisson, and Riemann, and a modification of it by Neumann.

The temperature of the earth at St. Petersburg and Nukuss has been discussed in a memoir by Wild. The observations were made with an apparatus similar to that of Lamont. The observations at Nukuss were made by Dohrandt, with a similar apparatus, thrice daily for two years; and the temperatures close to the surface were also observed every two hours,

day and night, during eleven and a half months. These latter observations are, so far as he knows, the only complete ones that have ever been made anywhere for the determination of the daily period of the earth's surface temperature. His discussion of the diurnal variation, with his numerous references to preceding works, constitutes a very important addition to our knowledge. The theory of Poisson gives a very crude approximation to the truth, on account of the disturbances introduced by rainfall, air currents, etc.

By comparing his results for Nukuss with the observations at Melbourne, he finds that both the daily minimum in the temperature of the air and that for the surface of the earth occur almost simultaneously, namely about sunrise; but the maximum occurs in the earth sensibly earlier than in the air. According to the theory, however, the difference should be even greater than is found by observation, so that the maximum temperature on the upper surface of the earth should occur only a short time after midday. In order to reduce observations of the earth's surface for diurnal variation, a table of corrections is given for such combinations of hours as ordinarily occur. In discussing the annual variation of temperature, he shows that the observations of the thermometer lying upon the earth's surface are an important addition to the series, not only on account of their direct practical bearing on vegetation, but especially for their theoretical bearings, as enabling us to determine the thermal constant.

The irregular variations in the earth's temperature could scarcely be determined from the five years of observation hitherto treated of; but a parallelism with the air temperature is shown to exist.

The absolute mean temperatures of the ground are for both places found to be very materially higher than the temperature of the air. At 3 meters depth the temperature is at St. Petersburg so much higher than it is at the surface as to show the presence of a large disturbing cause, probably the water of the Neva. The next chapter of Wild's work is an exhaustive collation, discussion, and criticism of all observations of earth temperature made by twenty-two previous observers, which is followed by recommendations as to the best method of determining earth temperatures. His

summary of his results is too long to be given here. We need only endorse his expression of the importance of observations immediately above and below the earth's surface, and of hourly observations at a number of stations in America, as well as other parts of the world.

In connection with the subject in the previous paragraph, we call attention to a novel application of our knowledge of earth temperatures, to be found in the recent report of the U. S. Entomological Commission, p. 431, where Mr. Abbe attempts to estimate beforehand the amount of heat received up to any given date by the eggs of the Rocky Mountain locust, which are usually deposited in a warm, dry, soft soil from 1 inch to ½ an inch below the surface. In executing this work, which was published before receiving the above-mentioned memoir of Wild, Mr. Abbe made a large collection of data relating to the diurnal variation of the earth's temperatures, and by assuming a mean value appropriate to the dry soil of the West, has prepared a table of predicted dates, which agrees well with the observed dates of the hatching of the grasshoppers.

VULCANOLOGY.

Under the title of "Vulcanologische Studien" (Wien, 1878) Dr. Edward Reyer has published a memoir in which he discusses the nature of the materials which remain in a volcanic vent after the eruptive action has ceased, and the features presented by those volcanic cones which are formed by the quiet outwelling of liquid lava.

The same author in his "Beiträge zur Physik der Eruptionen," published in 1877, discussed the part which the demonstrated capacity of various substances in a state of igneous fusion for absorbing certain gases may have in accounting for many of the phenomena of volcanoes.

A. H. Everett shows (*Nature*, xvii., p. 200) that the impression is erroneous which regards the island of Borneo as having for ages represented an area of entire quiescence, nearly encircled by an active volcanic belt. Four recent earthquakes in the island are noted—one in 1874 and three in 1876. And the existence of thermal springs, in association with basaltic rocks, and the frequent occurrence of igneous rocks are thought to indicate an outbreak of volcanic activity in comparatively recent geologic ages.

Professor Doelter, of Gratz, has reported to the Vienna Academy of Sciences upon the extinct volcano Monte Ferru, in Sardinia.

Professor F. W. Clarke discussed the alleged volcano at Bald Mountain, N. C., before the American Association for the Advancement of Science at St. Louis.

The Rev. Samuel Haughton and Edward Hull delivered in 1875 a joint-report, but recently received by us, to the Royal Irish Academy on the chemical, mineralogical, and microscopical character of the lavas of Vesuvius from 1631 to 1868. Twenty specimens were examined chemically by Haughton, who shows that augite is always present in the maximum possible quantity; second, that magnetite is present eleven times out of twenty in the minimum possible quantity; third, that leucite is present only once in the maximum possible quantity; fourth, the minerals always present are, 1st, *felspathic*—leucite, nepheline, or sodalite, anorthite; 2d, *hornblendic*—augite, magnetite; fifth, the antagonistic minerals by examination afford some clue as to the process of formation of the lavas. Mr. Hull, in his microscopical examination, particularly speaks of the beauty of the structure revealed when we examine thin sections of these lavas. With polarized light the general field of view is converted into a dark groundwork, in which crystals of augite, hornblende, mica, and olivine—now transmitting the richest tints of crimson, green, and bronze, which rival the ruby, the emerald, and the topaz—are conspicuously set.

SEISMOLOGY.

Professor C. W. C. Fuchs has published his Statistical Account of Eruptions and Earthquakes for 1877. He notes 5 volcanic eruptions and 109 earthquakes. The latter were distributed as follows: in the winter months, 33; in the spring months, 31; in summer, 11; and in autumn, 34.

The notices of American Earthquakes, by Professor Rockwood, are continued by a list of 54 shocks, in the *American Journal of Science and Arts*, III., xv., p. 21.

An important historical paper upon Japanese Earthquakes was read before the Asiatic Society of Japan, by I. Z. Hattori, A.B. (Rutgers College), now of the University of Tokio. The author has collected from the native records notices of

numerous shocks, of which 149, which he has classed as destructive, were tabulated as follows:

1 in 5th century.	11 in 10th century.	15 in 15th century.
1 " 6th "	10 " 11th "	8 " 16th "
7 " 7th "	1 " 12th "	15 " 17th "
7 " 8th "	7 " 13th "	13 " 18th "
28 " 9th "	8 " 14th "	16 " 19th "

Also, taking the 11th, 12th, and 1st months of the Japanese old calendar as cold months, the 5th, 6th, and 7th as hot, and all the others as mild, he finds during the fifteen centuries 28 great earthquakes in the cold months, 47 in the hot, and 72 in the mild; or 75 in the extreme seasons, and 72 in the mild seasons, the difference being only three. He describes an ancient Chinese seismograph, invented by Choko in 132 A.D., whose indications were recorded by an officer of the government.

The Observatory of the University at Tokio is now provided with a Palmieri's instrument, with which the shocks now occurring are recorded.

Considerable attention has been given this year to the earthquakes and volcanoes of Japan. The memoir by Hattori, just referred to, was read March 23, and is published in full in the *Transactions* of the Asiatic Society of Japan, vol. vi., p. 249. It was followed by interesting remarks by Professors Veeder and Ayrton, Hon. Dr. Murray, etc. Professor Ayrton stated that he found in Mr. Hattori's data evidence of periodicity in the destructiveness of the earthquakes. This paper was followed on May 11 by one by Mr. George Cawley on Constructions in Wood and Stone and their Relative Suitability for an Earthquake Country like Japan. His conclusions are in favor of properly proportioned brick and stone buildings, and against the customary wooden Japanese structures: however he would not give the building a rigid foundation. Professors Ayrton and Perry suggest a yielding, elastic foundation, such as wooden beams or other buffers.

On page 320 of the same volume of *Transactions* Professor Ayrton gives an additional note on the periodicity of earthquakes in Japan, as deduced by him by combining Hattori's and Naumann's chronological lists into one. These lists agree very closely together. The latter gentleman has spent a vast amount of labor upon the subject for many years,

and published a very valuable memoir in the *Mittheilungen* of the German Asiatic Society of Yokohama, which was read some weeks before the paper of Hattori's.

On the 27th of April, Mr. D. H. Marshall read a memoir on Some of the Volcanic Mountains in Japan, abounding in curious and important facts.

On the 23d of June, W. S. Chaplin read an Examination of the Earthquakes Recorded at the Meteorological Observatory, Tôkiyô (Tokio), in which he compares the records since July, 1875, with the positions of the sun and moon, and finds nothing to confirm Professor Perry's results. There is no special increase of earthquakes at new or full moon, or at perigee or apogee, at time of meridian transit, etc.

The fifteenth number of the *Mittheilungen* of the German Society at Yokohama, for the Natural History and Ethnology of Asia contains the elaborate paper by Dr. Naumann on the Earthquakes and Volcanic Eruptions of Japan, which was read before the Society on the 16th of February, and is quite independent of the paper by I. Z. Hattori on Destructive Earthquakes, read before the Asiatic Society of Japan on the 23d of March. Dr. Naumann's paper is the result of a well-nigh exhaustive examination of Japanese literature, of which he enumerates the titles of thirty-three Japanese works especially devoted to this subject. He has, of course, carefully converted Japanese dates into the Gregorian calendar. Inasmuch as earthquakes of every grade of severity are noticed, he has, in order to a proper discussion of them, first enumerated in detail about two hundred of the more remarkable cases; then follow especial accounts of the earthquakes of 1847, 1854, and 1855, accompanying which are elaborate maps.

He recounts the phenomena which precede or accompany earthquakes, but which do not appear to us to always have any intimate connection therewith. Special chapters are then given on regions of special earthquake activity, beginning with the volcanoes of Asamayama, with its lava stream forty miles long, and Fujiyama, following which come the islands of the Idzu Sea and the eruption of the volcano Unsengatake in 1791.

Dr. Naumann then discusses the relations of the Japanese earthquakes and volcanoes to the geological formations of

Eastern Asia, and with reference to their chronological periodicity. In the latter chapter he distinguishes nine degrees of severity, from the slightest shock to the severest shock accompanied with tidal waves. He finds groups of earthquakes following each other at intervals of 6 and 11 years, with possibly others of 24 or 25 years. He also finds considerable analogy between groups that occurred in the 9th century and those of the 19th century. With some certainty, he says, we may conclude that after a period of 490 years, there occurs a considerable increase in the frequency of earthquakes, with some indications of a 980-year cycle.

He endeavors to compare his record with Falb's theory of the connection between earthquakes and the attraction of the sun and moon, by taking advantage of the fact that the Japanese use a lunar year in their chronology, and concludes that the occurrence of an earthquake must depend upon the position of the moon. The connection between earthquakes and sun-spots he does not clearly make out; but in reference to the connection between showers of shooting-stars and the frequency of earthquakes, he gives very many coincidences, and claims an agreement of eighty per cent. In the course of this discussion he enumerates several showers of meteors from Japanese records, which are probably new to English readers, as also several miscellaneous phenomena, as comets, etc. Possibly, however, he does not sufficiently estimate the importance of the fact that meteors and earthquakes are of such frequent occurrence that their coincidences are easy to find and have but little significance. As a contribution of facts, however, Dr. Naumann's memoir cannot be too highly estimated. Numerous smaller articles of interest have appeared during the year in the papers published in Japan.

Dr. Wagener gives, in the same number of the *Mittheilungen*, and following Dr. Naumann's memoir, a short article on the Measurements to be made on the Occasion of Earthquakes, and describes a proposed new apparatus which shall automatically register every shock—both its time, intensity, and direction. This apparatus differs, he claims, from others in the following points: first, the shocks are not made visible by the difference in motion of two bodies, both of which are exposed to its influence; but one part of the apparatus is almost entirely free from the effect of the shock, while the oth-

er part executes movements similar to that of the earth; second, no shock can occur without being immediately and permanently recorded; third, the apparatus measures directly the amplitude of the shocks, and shows them on an enlarged scale.

In the *Canadian Naturalist* (viii., 6), Principal Dawson gives a short account of the earthquake of November 4, 1877.

In *Nature*, vol. xviii., p. 265, is printed a list, communicated by Dr. Meyer, of 41 earthquakes which occurred in the Philippine Islands in 1876, distributed as follows on the several islands: Luzon, 33; Mindoro, 1; Masbate, 2; Leyte, 1; Mindanao, 4.

The first volume of the *Annals* of the Mexican Department of the Interior contains articles on the National Observatories, Astronomical and Meteorological, at Chapultepec, and a lengthy report of the Commission appointed to investigate the Earthquakes of Jalisco and the Eruptions of Ceboruco. A catalogue of earthquakes, a list of altitudes, and other important data accompany the report; and a further detailed topographical map is promised.

Under the title of "Das Erdbeben von Herzogenrath am 24 Juni, 1877" (Bonn, 1878), Dr. A. von Lasaulx has discussed the phenomena of the earthquake of that date, reaching the conclusions that the centre of disturbance was at the depth of 16.85 English miles, and that the velocity of propagation was 17.7 miles per minute, the general direction being southwest and northeast.

In the *Jahrbuch Vienna K. K. Geolog. Anstalt.*, 1878, p. 467, Hans Hofer reviews the works of Lasaulx on the "Earthquakes at Herzogenrath in 1873 and 1877." He maintains, with ability, that neither was a central shock, therefore Lasaulx's results as to depth and velocity are not trustworthy; also that both followed certain faults in the geological strata, and that the study of the faults and dikes are of first importance in unravelling the phenomena.

M. Ph. Plantamour, in *Archives des Sciences Physiques et Naturelles* (Geneva), and M. F. A. Forel elsewhere, prove that the phenomena known as *Seiches*, and consisting of occasional rhythmical movements in the level of a lake (*Nature*, vol. xviii., p. 100), have no connection whatever with seismic disturbances of its bed. During several earthquakes felt recent-

ly at Lake Geneva, not the least movement of the surface was shown by the recording instruments, which are sufficiently delicate to show a change of one millimeter in the level of the lake, and which will show the waves originated by a steamer passing at a distance of ten or fifteen kilometers. The explanation suggested for this fact is, that the phenomenon called Seiches is a wave of stationary oscillation, having a certain vibration-period, and susceptible therefore of being started only by *certain* movements of the earth which synchronize with it (*Nature*, vol. xvii., pp. 234, 281, 475). M. de Rossi notes a similar fact in regard to the pendulum seismograph, which is sometimes strangely unaffected by quite sensible shocks; the action appearing to depend upon a relation between the length of the pendulum and the rapidity of the earth vibrations.

General H. L. Abbott describes (*American Journal of Science and Arts*, III., xv., p. 178) some further experiments at Willet's Point, N.Y. harbor, to determine the velocity of transmission of earth-waves generated by explosions of dynamite. The velocities indicated vary from 5000 feet to nearly 9000 feet per second, being thus largely in excess of those heretofore found by Mallet. General Abbott reaches also the following general conclusions: first, a high magnifying power of telescope is essential in seismometric observations; second, the more violent the initial shock the higher is the rate of transmission; third, this velocity diminishes as the general wave advances; fourth, the movements of the earth's crust are complex, consisting of many short waves, first increasing and then decreasing in amplitude; and, with a detonating explosive, the interval between the first wave and the maximum wave at any station is shorter than with a slow-burning explosive. General Abbott then considers Mallet's objections to his former paper. Mallet's severe reply to *this* paper is published in the *Philosophical Magazine*, May, 1878.

J. Mansini describes in *La Nature*, 1878, p. 256, a curious apparatus designed by him for observing and recording the vertical component of earthquake shocks.

NOTABLE EARTHQUAKES AND ERUPTIONS.

On November 4, 1877, about 1 h. 50 m. A.M., Montreal time, a rather severe earthquake was felt throughout a large part

of Canada, New York, and New England. It appears to have been most severe in the Adirondack and Green Mountain regions, where the vibration was sufficient to do some slight damage. From this centre the tremors were felt through the valley of the Ottawa and the St. Lawrence, from Lake Ontario to Three Rivers, through Central New York as far west as Geneva, and southeastward through New England to the sea-coast. The direction of the shock was from west to east (*Monthly Weather Review*, November, 1877; *American Journal of Science and Arts*, III., xv., p. 21; *Canadian Naturalist*, vol. viii., No. 6).

On November 15, 1877, about 11 45 A.M., Omaha time, several shocks of earthquake were felt throughout the whole of Iowa and Nebraska, extending also into Kansas and Missouri on the south, and into Dakota and Minnesota on the north, the reports coming mostly from points on the Union Pacific Railroad. About 2 45 A.M. of the next day, a shock from west to east was felt in Tennessee and North Carolina (*Monthly Weather Review*, November, 1877; *American Journal of Science and Arts*, III., xv., p. 21).

On January 23, 1878, at 7 55 P.M., a severe earthquake was felt at Iquique, Peru, the influence of which extended to Arica, and other places along the coast and in the interior. It did some slight damage, but was not so destructive as the one of May 9, 1877, not being attended by any tidal wave.

A few days later, however, on January 27, the harbor of Callao was visited by a destructive tidal wave, which did much damage to the sea-wall and inundated the railroad station. The disturbance appeared to come from the north, and did not entirely subside for several days.

Nearly simultaneous with these disturbances in South America, a series of shocks were felt in Western Europe. On January 27, shocks were reported from Upper Styria, and about noon on January 28, several shocks were experienced in Southern England and Northern France, being most severe in the Channel Islands.

On February 27, 1878, at 5 P.M., shocks of earthquake were felt at Reykjavik and other places in the southwestern part of Iceland; and at 8 P.M. an eruption of flames and lava began on the northern side of Mt. Hekla. On subsequent

examination, the new openings, fourteen in number, were found to be in the Raudaskal valley, about four miles northeast of Hekla. Here there had occurred a considerable outflow of lava, which still continued to pour forth a month after the first outbreak. The locality is described by Mr. G. F. Rodwell, who visited it on August 12, at which time the new crater and the ejected lava were still giving off vapors. The deposit of new lava is from 10 to 100 feet in thickness, and, as mapped, it covers an irregular area of about 2½ Danish miles in length by about half a mile wide. The principal one of the new craters was 90 feet in depth and about 100 feet in circumference. The fact is also noted that Mt. Hekla is not a conical peak with a single crater, like Etna or Vesuvius, but rather an elevated volcanic rift with several openings, and that the new openings are ranged along a prolongation of the line thus marked (*Nature*, vol. xviii., pp. 596, 641).

On the evening of April 12, 1878, a severe earthquake destroyed the town of Cua, on the river Tuy, about 26 English miles southwest of Caracas, in Venezuela. The town was the centre of a flourishing agricultural district, and had about 3000 inhabitants. The shock occurred some minutes before a quarter to nine, being felt at Caracas at 8h. 41m. 34s., and in a few seconds all the centre of Cua, which was built on a small hill about 20 meters over the lower part, was in ruins. Only this upper part, about one square mile in extent, was destroyed, the lower part suffering but little. The centre of disturbance cannot have been very deep, as the destruction was so limited, although the transverse wave was felt 100 miles distant. The shocks continued for several days, but without further damage. About 300 persons were killed, and the loss of property was £300,000. The direction of the shock was from E.N.E. (*Nature*, vol. xviii., p. 130).

On August 26, 1878, earthquake shocks were felt about 9 and 11 A.M. in Belgium, Holland, and Rhenish Prussia; observed with especial care at Cologne.

On October 2, 1878, at 6 P.M., a severe earthquake occurred at the village of Jucuapa, and at many other towns in the southern portion of the Republic of Salvador, in Central America, attended by great loss of life and property. The neighboring volcanoes of Izalco and Santa Ana were ac-

tive; and Cotopaxi, in Equador, was in eruption at the same time.

On October 4, 1878, at 2 30 A.M., a shock sufficient to move furniture was felt in the valley of the Hudson River.

Observations by Professor Palmieri and others during September and October, 1878, indicate an approaching eruption of Vesuvius; but it progresses slowly, and, though ejecting flames and lava, had, up to December 1, done little damage.

TERRESTRIAL MAGNETISM.

John Allan Broun has compared the curves representing the mean ranges of the diurnal oscillations of the magnetic needle for the last three minimum epochs, viz., 1856, 1866, and 1876, showing that in the first of these the minimum is strongly marked, in the second not so clearly, while in the last the minimum period extends over more than two years; and inferring therefrom that we are now passing through a long minimum period similar to that which occurred at the close of the last century (*Nature*, vol. xvii., pp. 183, 259, 280).

Both Mr. Broun and Balfour Stewart have compared the cycles of declination ranges, and of sun-spots, and confirm the generally received opinion of a close accordance; the latter, however, finding, with the same length of period, a lagging of the magnetic epoch behind that of the sun-spots, amounting in one case to five months. They agree in attributing the two sets of phenomena to a common cause (*Nature*, vol. xvii., pp. 262, 326). The same subject is discussed by Joas Capello (*Nature*, vol. xvii., p. 488), and by M. Faye in the *Annuaire* of the Bureau of Longitudes for 1878; the latter finding in the sun's heat a cause for the phenomena.

Mr. Broun discusses M. Faye's paper, mentioned above, giving reasons for opposing his view that the diurnal oscillations of the needle are caused by solar heat; urging especially that there is no evidence of any decennial change in the solar heat which bears to the whole amount any such proportion as the decennial magnetic variation bears to its whole amount (*Nature*, vol. xviii., p. 126).

Mr. Broun also shows that the moon produces a variation in the earth's magnetism such that the needle makes *two*

complete and nearly equal oscillations—from an easterly to a westerly position—in a lunar day of 24.7 hours; that this action of the moon is dependent on the earth's position in its orbit, and on the position of the moon relative to sunrise and sunset; and that this lunar action is sometimes greater than the solar action at the magnetic equator.

In a lecture at the Royal Geographical Society, Capt. F. J. Evans treated of the secular changes in the earth's magnetism, especially in the variation and dip, drawing from them the conclusion that the changes are not sufficiently uniform over the whole globe to be attributed to cosmical action, but are rather to be attributed to movements in the interior of the earth (*Nature*, vol. xviii., p. 80).

A new magnetic observatory has been established at Pavlovsk, in connection with the Central Physical Observatory at St. Petersburg. It comprises three buildings for scientific purposes, and the necessary dwellings for the staff employed. It is furnished with the most improved scientific instruments, and special care has been taken to avoid the presence of any iron in the buildings devoted to magnetic observations (*Nature*, vol. xviii., p. 316). It was inaugurated on July 21, 1878.

On May 14, 1878, a magnetic storm was recorded simultaneously by the instruments at Stonyhurst and at Greenwich, England; at Melbourne, Australia; at Shanghai (Zi-ka-wei), China; and at Toronto, Canada, where the instruments were affected a few minutes earlier than in Europe. The character of the movements of the needle was the same at each station. The magnetic disturbance was strongly felt by telegraph lines in England, America, India, and Persia (*Nature*, vol. xviii., pp. 617, 641, 668; vol. xix., p. 220).

William Leroy Broun describes a new lecture experiment, to show the action of terrestrial magnetism. A rectangular frame of light wood, carrying twenty coils of insulated wire, was suspended in a horizontal position from the pans of a balance, so that the long sides of the rectangle were at right angles to the beam; and mercury connections were arranged at the middle of the short sides, so that a current could be sent through the wire. This apparatus being placed with the long sides of the rectangle perpendicular to the magnetic meridian, when the battery current passed from east

to west on the northern side, and from west to east on the southern side, the north side would be attracted, and the south side repelled by the earth currents, both influences combining to deflect the beam of the balance. On reversing the current the deflection was in the opposite direction (*Nature*, vol. xvii., p. 281).

The annual report of the United States Coast Survey for 1874–75 contains in its numerous appendices some highly important contributions to terrestrial physics. Among these we especially note the voluminous report of C. A. Schott on the Secular Change of Magnetic Declination in the United States and North America. This change, although well represented by the so-called circular functions, yet need not be of a periodic nature. The circular function merely represents the phenomena observed during the past few centuries, and nothing should be inferred as to the future course, or as to the true cause, of the observed changes. Forty-three stations are available to Mr. Schott in the study of the magnetic declinations. A cursory examination shows that the needle became stationary and then reversed its secular motion in the New England States towards the end of the past century, in the Atlantic coast States to the west and south early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon, and Washington Territory it has not yet reached its stationary point.

Another important memoir by Schott gives the results of the discussion of the photographic-magnetic record at Key West, 1860–1866. After considering the normal monthly averages, Schott takes the hourly and monthly means of all the disturbances by which he understands all those individual readings that are rejected by "Peirce's Criterion." The easterly disturbances exceed the westerly in every year but two. The evidence of a connection of some kind between the amplitude of the daily variation and the sun-spots is quite strong.

At the meeting, at Cassel, of the German Naturforscher Gesellschaft, the following papers were read: Dr. Fromme on Some New Magnetic Phenomena; Dr. Schering on a New Method of Employing the Induction of the Earth for the Determination of the Magnetic Inclination.

Professor Nipher has prosecuted the magnetic survey of Missouri during his summer vacation.

A very complete catalogue of papers and books on electricity and magnetism (being the catalogue of the late Sir Francis Ronalds) is being published by the Society of Telegraph Engineers.

The magnetic observations made by Secchi at Rome, in 1877, are published in full in the *Met. Italiana.* They were made eight times by day throughout the year, and embrace observations of the declinometer, and both horizontal and vertical force.

Sir Edward Sabine's fifteenth and last contribution to terrestrial magnetism, although presented to the Royal Society in 1876, has but lately come to hand, and completes his magnetic survey of the globe. The present number (XV.) embraces four zones, each ten degrees in breadth, from the equator to forty degrees south latitude, and gives for each zone the magnetic declination, inclination, and force, both in tabular form and upon charts, the mean epoch being from 1840–45. A table is also appended as in the preceding *Memoirs*, giving a comparison between Sabine's collection of observed data and the theory and tables of Gauss and Weber.

The Comparative Study of Observations on the Magnetic Needle and on Solar Spots forms a memoir, by Spee, in the *Bulletin* of the Belgian Academy. The author infers a very intimate connection between these phenomena.

Balfour Stewart has communicated to the Royal Society a memoir on the Variations of the Diurnal Range of the Magnetic Declination, as recorded at the Prague Observatory since July, 1839. He finds a persistent agreement between the times of sun-spot maximum and the variations of the magnetic needle.

On the Decennial Period in the Mean Amplitude of the Diurnal Oscillation and Disturbance of the Magnetic Needle and of the Sun-spot Area, an abstract of a paper by J. A. Broun is published in the *Proceedings* of the Royal Society at Edinburgh. In this paper, the author determines the epochs of maximum and minimum range of the diurnal oscillations of the magnetic needle. The author concludes that the increase of the diurnal variation is not due to a different cause

from that which produces the variation itself, and that this cause acts, when there are no sun-spots, in the same way as, though with less intensity than, when the spots have their maximum frequency and area; therefore the magnetic variations are not due to the sun-spots, although there is a general agreement in their respective changes. No theory which has yet been suggested connecting the two phenomena seems to him to be satisfactory.

De Parville presents to the French Academy of Sciences a very novel application of the telephone, by means of which he proposes to determine the direction of the magnetic meridian. He states that when in the ordinary telephone we replace the short bar magnet by a rod of soft iron, at least one meter long, the apparatus still transmits the sounds, but with an intensity which varies according to the orientation of the rod. The maximum intensity of the sound which is transmitted to the receiver corresponds to the orientation of the transmitter in the direction of the magnetic needle. The sound is heard more or less completely, when the telephone is placed in a plane perpendicular to the magnetic meridian. By a proper apparatus, he is thus able to determine the variations of magnetic intensity at different azimuths.

Capt. F. J. Evans read before the Geographical Association of London, in March, a discourse on Terrestrial Magnetism and its Secular Variations. After fully recounting the history of the progress of our knowledge, and the theories of Halley, Hansteen, Gauss, Sabine, etc., he explained some of the results of the magnetic observations of the *Challenger* Expedition; and showed the necessity of remodelling our views, or rather of continuing our search for the ultimate explanation of terrestrial magnetism. The evidences of change in the total intensity of magnetic force are very slight, and point to a sensible constancy in the northern hemisphere; but in the southern hemisphere such progressive change is just now going on very rapidly. The *Challenger* observations show that at Valparaiso the total intensity has in fifty years diminished one sixth; in Montevideo, one seventh; in the Falkland Islands, one ninth; in Bahia and Ascension, one ninth. The area of diminishing force extends from Tahiti to St. Helena, and from the Equator to the Cape of Good Hope.

J. Asmus gives, in the *Annalen für Hydrographie*, pp. 285 and 333, a review of various methods of graphically presenting the deviations of ships' compasses.

In reference to the subject of earth currents, possibly some light may be thrown by the observations that have been made upon them by underground telegraph lines, on the occasion of the longitude determinations between Berlin and Altona, a preliminary account of which is published by Albrecht in the *Astronomische Nachrichten*. The special object of the investigation was to determine the nature of the curve which indicated the intensity of the galvanic current on telegraph lines of different lengths, both above and below the earth. It is found that the increase of intensity was decidedly less for lines below than for those above the surface.

Professors Ayrton and Perry, of the College of Engineering, Tokio, Japan, communicate to the *Philosophical Magazine* a short note, proposing the hypothesis that the phenomena of earth currents, terrestrial magnetism, and atmospheric electricity are due to the fact that the earth is an electrified condenser, whose capacity or potential is continually changing on account of its rotation and its annual orbital motion, the successive cooling and warming of the air, the formation of clouds and rain, etc., etc. These changes produce electric currents tending always to restore the equilibrium, whence follow the phenomena in question. They suggest that observations of atmospheric electricity may be used to predict atmospheric changes.

An important memoir by Edlund upon Atmospheric Electricity and the Aurora is published in the *Transactions* of the Stockholm Academy, and translated in the *Philosophical Magazine*. Edlund first shows that "unipolar induction" is fully explained by his theory that the galvanic current consists in the translatory motion of a fluid going in the positive direction, or of two fluids following opposite directions. The latest confirmation of this theory is the experiments of Lemstrom. Edlund then proceeds to apply these views to the earth, whose lower atmosphere is a poor conductor lying between two good conductors, viz., the rotating solid and liquid globe and the external thin inter-planetary gas. Regarding the solid nucleus as a magnet, whose axis makes a certain angle with the terrestrial axis of rotation, and whose atmos-

phere and oceans are in motion, we have at once the phenomena of unipolar induction; and he then deduces the distribution of atmospheric electricity, terrestrial magnetism, auroral display, etc., etc., in minute agreement with actual observations. An excellent abstract of this paper is given in the *Zeitschrift für Meteorologie.*

S. Tolver Preston communicates to the *Popular Science Review* for January a popular article on the same subject—*i. e.*, the inductive effect produced by the rotation of a magnet on its axis—and incidentally suggests that the motion of the tides may cause an electric disturbance.

A memoir by K. S. Lemstrom on the Causes of the Earth's Magnetic Condition is published as an academic disquisition by the University of Helsingfors. The work is divided into five chapters: first, the observed magnetic condition from the earliest dates to the present time; second, the theories of Euler, Gauss, and Hansteen; third, an attempt at explanation by means of a new theory of his own; fourth, experimental data tending to establish this theory; and, fifth, further conclusions from the results which he has deduced. An imperfect acquaintance with the Swedish language forbids our saying more than that Dr. Lemstrom appears to have attempted to apply Professor Edlund's views to the electric induction of a rotating earth, and to have deduced a number of general results agreeing closely with observed phenomena.

The determination of the force of gravity by observations of the pendulum having attained great exactness by the use of the Bessel-Repsold symmetrical reversion pendulum, it has become important to investigate small sources of error that had previously escaped attention, and the last volume of the *Proceedings* of the fifth General Conference of the International European Geodetic Commission contains important papers by C. S. Pierce, Celloria, Oppolzer, and Plantamour on the corrections necessary on account of the vibrations of the supports upon which the pendulum rests. The general tendency of these vibrations is to give the length of the seconds pendulum too short, by a quantity that may amount to a considerable fraction of a millimeter.

THE OCEAN.*

DEPTH.

Under the direction of Dr. Patterson, Superintendent of the U. S. Coast Survey, the work of deep-sea soundings, the observations for serial temperatures from surface to bottom, current observations, and deep-sea dredgings in the Gulf of Mexico and the Yucatan and Florida channels have been continued this year by the steamer *Blake*, Lieutenant-Commander C. D. Sigsbee, U.S.N., Assistant Coast Survey, commanding, associated with Professor Alexander Agassiz, who directed the dredgings. The apparatus for deep-sea soundings with wire, and for securing bottom and water specimens, have been brought to a high state of perfection by Commander Sigsbee; and such improvements have been made in the dredges and trawls as to insure success, where all previous efforts have failed, notably when dredging in soft muddy bottoms. The formation of the bottom of the Gulf of Mexico has been completely mapped out. Serial temperatures, with specimens of the bottom, and of water from various depths from surface to bottom, have been obtained in all parts of the Gulf and of its immediate approaches, thus adding enormously to the data for solving the problem of its circulation, with those of the entrance and exit of the Gulf Stream. The greatest depth found was 2080 fathoms. The name of *Sigsbee Deep* has been given to a large basin to the northward and westward of the Yucatan Bank, lying within the 2000-fathom curve, and extending from lat. 22° 30′ to lat. 25° N., and from long. 90° to long. 95° W. The increase of depth is very abrupt on the slope of the Yucatan Bank, but much more gradual towards the coasts of the United States and of Mexico.

During the months of December, 1877, and January and February, 1878, a line of deep-sea soundings was run by the U. S. steamer *Essex*, Commander W. Scott Schley commanding, between St. Paul de Loando, Africa, and Cape Frio, Brazil, *via* St. Helena, and passing just to the southward of Trinidad Island. The soundings were made with wire, using Captain

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*Prepared with the assistance of Commander E. P. Lull, U.S.N.

Belknap's modification of the Thompson machine, with Belknap's detaching rods and specimen cups, and the Miller-Casella deep-sea thermometer for temperatures. This line furnishes an admirable cross-section of the South Atlantic, defining the limits of the two great longitudinal deep channels, and of the bank or ridge between them, on which latter are located the islands of Tristan d'Acunha, St. Helena, and Ascension. The soundings were taken, as a rule, about 100 miles apart. After leaving the coast of Africa, the depths increased very rapidly, 900 fathoms being reached within 60 miles of the initial point; 2200 fathoms were reached in lat. 9° 40′ S. and long. 10° 36′ E.; 2581 fathoms in lat. 10° 12′ S. and long. 8° 57′ E.; 3000 fathoms in lat. 11° 20′ S., long. 5° 34′ E., 700 miles from St. Paul. The greatest depth found in the Eastern Channel was 3063 fathoms. The 3000-fathom curve on the western side of the channel was passed in lat. 13° 30′ S., long. 10° W. Thence the depths gradually decreased until within 7 miles of the Sugar Loaf, St. Helena, where the depth was 2091 fathoms. Within the same distance to the westward of St. Helena the depths were scarcely less great, showing the remarkable fact that the island is the head of a pinnacle standing in 2000 fathoms of water. Continuing, a depth of 2333 fathoms was found in lat. 16° 52′ S., long. 9° 53′ W.; thence a gradual diminution, until in lat. 17° 57′ S., long. 15° 17′ W., a depth of but 1365 fathoms was found. This point is probably not far from the crest of the divide above spoken of, between the two channels, or, as they might better be described, the two great submarine valleys. It is to be regretted that the soundings in this vicinity had not been taken much nearer together, as a less depth might have been discovered. Sir George Nares, who ran, in the *Challenger*, a line along the crest of the ridge approximately, found at a point 90 miles to the northward and eastward of this a depth of 1415 fathoms. Proceeding, the depths increased rapidly from the last sounding: 2000 fathoms were reached in lat. 18° 15′ S., long. 16° 59′ W., 100 miles from St. Helena; 2652 fathoms in lat. 18° 48′ S., long. 19° 21′ W.; 3284 fathoms, the greatest depth found in the Western Channel, in lat. 19° 55′ S., long. 24° 50′ W. The 2500-fathom curve on the western slope of the channel was passed in lat. 21° 10′ S., long. 32° W.; the 2000-

fathom curve in lat. 22° 10′ S., long. 37° 20′ W., after which the depth rapidly diminished to 50 fathoms at a distance of 70 miles from Cape Frio.

The opening address at Dublin, by Sir Wyville Thomson, President of the Section of Geography, after recounting in detail the numerous voyages made for the purpose of investigating ocean depths, currents, and temperatures, proceeds to give a review of his own most recent results with reference to the general circulation of the ocean.

K. Möbius, in the *Deutsche Revue*, gives a comprehensive summary of the principal results of the latest investigations into the ocean and its life. The first European who, by a drag-net, brought up animals from the depths of the sea was Otto F. Müller, of Denmark, 1788, and earlier. Since his day the oceanic investigations have extended so as to embrace the depth and topography, the bottom formations, the salts and gases contained in the water, the temperatures, the currents, and the living organisms. Of the results of investigations in these departments Möbius gives a short review.

DENSITY.

Negretti and Zambra have contrived a new deep-sea thermometer, described and figured in *Nature*. To a cylindrical bulb containing mercury a tube is fitted, which is contorted and constricted near the bulb, and is enlarged at the remote end, from which end it is graduated. When the bulb is held downward, the mercury expands as usual, but when it is reversed, the column breaks at the narrowed portion of the tube, flows to the other end of this, and is there read. Hence, if the thermometer be lowered with the bulb downward, and reversed on attaining the desired depth, the reading on coming to the surface will represent the temperature at the time of reversal. To prevent the errors caused by pressure, it is enclosed in a glass sheath.

A very remarkable series of papers, by C. Schmidt, of Dorpat, on hydrology, is being published by the St. Petersburg Academy. In the latest numbers are given many notes on the waters of American lakes, and a general summary of all known observations on density, etc., of oceanic waters. Lake Baikal and other European seas afford interesting results.

CURRENTS.

In the *Canadian Naturalist*, H. Y. Hind publishes a thoughtful article on the Mechanical Effect of Arctic Ice in producing Ocean Currents.

The Labrador and Gulf Stream Currents and their Effects on American Fisheries are treated of in two memoirs by H. Y. Hind, published by the Fishery Commission at Halifax.

Dr. O. Krummel, in his Inaugural Dissertation at Göttengen, gives an analysis of our knowledge of the equatorial currents of the Atlantic Ocean, and an examination into the fundamental causes of the general oceanic circulation. In a note he calls attention to Aimé's Submarine Current Indicator, described in *Ann. de Chemie*, III., xiii., 1845, p. 461. His criticisms of most modern writers are very fair, although his conclusions seem to fall short of that which we are, perhaps, able to maintain with some certainty. He says: "The existence of a vertical circulation is undeniable, but the ascending current cannot alone account for the strong westerly equatorial current. Temperature differences do not suffice to explain the vertical circulation without taking account of the terrestrial centrifugal force. Two ascending currents, with the compensating Guinea current between them, suffice to explain the three equatorial currents of the Atlantic." This work is evidently well worthy of study by those specially devoted to this subject.

Zoppritz contributes to the *Annalen* and to the *Philosophical Magazine* a very important memoir on Hydrodynamic Problems in reference to the Theory of Ocean Currents. He has, namely, attempted to solve the analytical equation for the motion of a liquid ocean whose particles move over each other with appreciable friction—that is to say, if the wind blows steadily over the ocean, and the surface layer of water follows the lowest layer of air, what will be the resulting movements in the lower strata of water? The influence of the steady trade-wind must, he finds, extend to the bottom of the sea. By introducing Meyer's known value of the coefficient of friction for sea-water, he finds, for instance, that if the particles of the surface of the ocean begin to move forward with a constant velocity, in 239 years the stratum at a depth of 100 meters will be found moving with one half the surface

velocity; but at 10 meters depth the velocity will be the same in 2.39 years. Periodic changes in velocity are propagated very slowly. He shows that two layers moving in opposite directions can be sensibly in contact with each other without material disturbance. The mean motion of the sea as existing 10,000 years ago would to this day be the controlling factor in the present movements of the ocean.

In the *Astronomische Nachrichten*, No. 2226, Gyldén publishes a first paper on the Rotation of a Solid Body whose Surface is covered with a Fluid. He remarks that to definitely solve this problem we must have given the form of the solid and the quantity of the fluid. In the case of the earth we know not these data, although we can make approximate assumptions. After enumerating some of the uncertainties that surround the problem, and indicating the extreme limits of our knowledge and ignorance, Gyldén proceeds to develop the mechanical formulæ in the most general case practicable, assuming the only external force to be the mutual friction of water and earth.

An interesting paper on the Drifting Power of Tidal Currents appears in the last number which we have received of the *Royal Irish Academy* (January, 1876). The author, G. H. Kinaham, has studied the subject very carefully on a portion of the Irish coast, and submits the following conclusions: first, the driftage due to the incoming tidal current is during its progress always going on in deep water, and, more or less, in shallow water; second, the driftage due to wind-waves only occurs during gales, and even then is only due to the waves that break on the shores; third, to prevent the tidal driftage groins or piers should be erected; and if the pier is to form a harbor, transverse groins should run out from it, to stop the back-wash generated by the pier; for otherwise this back-wash would carry the drift seaward, to be sucked around the pier into the harbor; fourth, as the wind-wave driftage occurs during gales, and then only on the shore-line, it might be prevented from filling up a harbor by placing a breakwater across the direction from which the prevailing storms come. If such a breakwater were fixed, it would probably help to fill up the harbor; but if it be a floating one, it will break the wind-waves in deep water and destroy their drifting powers, while not interfering with their tidal driftage.

EQUALITY OF THE SURFACE LEVELS OF THE ATLANTIC AND PACIFIC OCEANS.

Lines of levels run from sea to sea across the states of Nicaragua and Panama, during the recent inter-oceanic canal surveys, made under the direction of Commander E. P. Lull, U.S.N., confirm the fact that the surface levels of the Atlantic and Pacific oceans at *mean tide* are exactly the same. The Atlantic terminus of the Nicaragua line was at San Juan del Norte, which is practically at the leewardmost part of the Caribbean. The theory that the waters of that sea are banked up by the northeast trade-winds, forming a head for the Gulf Stream, seems thus to be disproved.

TIDAL CURRENTS IN THE GULF OF MAINE.

A very interesting and valuable series of observations on the Off-shore Tidal Currents in the Gulf of Maine, begun in 1877, have been completed during the present summer, under the direction of Dr. C. P. Patterson, Superintendent United States Coast Survey, by Master Robert Platt, U.S.N., commanding the Coast Survey schooner *Drift*. These observations show that the tidal currents of this locality are of sufficient strength to render their consideration in the reckoning, especially of sailing-vessels, highly important; and from them Professor Henry Mitchell, of the Coast Survey, has deduced rules and tables (part of which have already been published, with a chart of the Gulf of Maine, showing the positions of tide-stations and the localities of a number of remarkable *tide-rips*.—(*Coast Survey Notice to Mariners*, No. 15, 1877.) It is found that on the line between Nantucket Shoals and Cape Sable Bank (covered by the published tables) the ebb-current runs southwardly during the first four and a half hours, and the flood-current northwardly from the sixth to the eleventh hour after the moon's transit (*northing* or *southing*). Table I. gives for each of the localities named the times of turning from the flood-current to the ebb, and of the reverse, with the direction and rate of the flow—all referred to the times of the moon's transit. Table II. gives, for the same localities, the direction and rate of the current for each hour after the time of *high-water* at Bos-

ton, Mass., as given for each civil day in the Coast Survey Tide-table for the Atlantic Coast. A discussion now being made by Professor Mitchell of the whole tidal phenomena of the Gulf of Maine will be of great interest, some hitherto unrecognized laws of tidal movement having been developed.

TIDES AND WAVES.

Of the tidal observations made by the English Arctic Expedition of 1876, the preliminary report has been published in Captain Nares's narrative.

Professor Haughton announces as the first result of the tidal observations made by the late British Polar Expedition the complete confirmation of the result obtained by Dr. Bessels on Hall's expedition—*i. e.*, the meeting of two tidal waves from north and south in Smith Sound—and confirming the idea that Greenland is an island.

An important paper on the Tides of the Southern Hemisphere and the Mediterranean, by Captain Evans and Sir William Thomson, was read before the Dublin meeting of the British Association, and an abstract of it is printed in *Nature.*

A self-acting tide-computing machine has, according to *Nature*, been designed by Mr. E. Roberts, of the *Nautical Almanac* office, and is being constructed for the India Office.

The great ocean wave due to the Iquique earthquake of May 9 has been considered in a memoir, by Geinitz, in the December (1877) number of Petermann's *Mittheilungen.*

The accurate self-registering "limnimeter" on Lake Leman has afforded Forel the demonstration of the existence of temporary rhythmic changes in the level surface of the whole lake, due to a bodily vibration of the whole mass of water. He has now traced these vibrations up to their primary origin, which is occasionally, perhaps, to be found in an earthquake shock, but more usually in sudden changes of atmospheric pressure at some part of the lake. He finds that the formula for the vibration of water in a basin, given by Mérian, at Basle, in 1828, and its simplification given by William Thomson, apply well to the seiches of Lake Geneva. Similar oscillations are reported by Jansen to be recorded upon the self-recording tide-gauge (mèregraph) at Brest.

Forel also has proposed a new theory of the variations in

the transparency of the waters of lakes in winter and summer. The theory is based upon the thermal stratification of the water during the summer, and its non-stratification during the winter.

THE ATMOSPHERE.

INSTITUTIONS, OBSERVERS, GENERAL TREATISES, ETC.

The Smithsonian Institution reports the continuation of work on the new edition of the "Rainfall Tables for North America." It has also printed the observations of Professor Caswell, from 1860 to 1876, in continuation of his previous work from 1830 to 1860. This record shows a steady increase in the rainfall at Providence. Work has also been done on the maximum and minimum temperatures, and on the preparation of a work on thunder-storms.

An exhaustive memoir on the Meteorology and Ocean Physics of Behring Sea and Alaska has been prepared by W. H. Dall for the Coast Survey, but is not yet published.

The report of the Chief Signal Officer for June 30, 1878, enumerates, among other features in the history of the Army Weather Bureau, the fact that its permanent organization has been established as embracing 150 sergeants, 30 corporals, and 270 privates. One hundred and forty-seven first-class stations and 24 second-class or sunset stations report telegraphically, and about 800 stations report by mail. Telegraph reports are received, as usual, from Canada and the West Indies. The average time elapsing between the moment of simultaneous observation throughout the country and that at which the resulting prediction is issued from the Central Office is one hour and forty minutes. The average percentage of verifications is 84.4. The percentage for the state of weather only, omitting the predictions for the barometer, thermometer, and wind direction, is 88.3. Cautionary storm-signals are displayed by day and night at 57 stations. A distinction is made between the cautionary signal for high winds in general and that for winds blowing off shore. Of the total number of signals displayed, 75.9 per cent. have been verified. Special display-stations have been established at about 30 subordinate stations. Weather maps and bulletins have continued to be exhibited at all public places of business and

resort. Six thousand and thirty-nine post-offices are supplied daily, at about 11 A.M., with the farmers' bulletin. The weather case or farmers' weather indicator has been prepared to be used in connection with the farmers' bulletin. River reports, giving the depth of water and notice of high or low water, have been regularly made: they will soon be extended to the rivers and valleys of California, for which rivers data are being collected to fix the danger lines. Special observations were made of the transit of *Mercury* on May 6, and the total eclipse of the sun July 29.

The *Weekly Weather Chronicle* and the *Monthly Weather Review* have been regularly issued. Observations taken on vessels at sea have been reported in a few cases. The *International Weather Bulletin* and the corresponding *International Weather Map*, embracing the whole northern hemisphere, are published daily.

The sea-coast service of the Signal Service, in connection with the Life-saving Service, has been continued and extended during the year. By means of telegraph lines running directly from the War Department to these stations, it has been possible to promptly communicate messages, and save much property and many lives. Vessels sailing past such sea-coast stations can communicate, by signals, with the shore, and thus, in pleasant weather, ascertain from the Central Office the probabilities of a storm.

The construction and operation of telegraph lines for connecting military posts and the protection of frontier settlements has progressed steadily. The lines in Arizona, New Mexico, and the Texan frontier are nearly completed. The lines in the Northwest are being rapidly built. A total length of 3200 miles was, July 1, in the care of, and operated by, the Signal Service. From each station on these telegraph lines, three daily weather reports are received. They have thus opened out to meteorology regions of territory otherwise inaccessible, and of the first importance to a proper care for the commerce and agriculture of the United States.

Professor Hinrichs has begun the publication of the *Iowa Weather Bulletin* with the number for March. This, as well as the quarterly reports, represents, of course, the results of the observations of the Iowa Weather Service. The *Bulletin* for March gives a graphic presentation of the daily obser-

vations at Iowa City, and a reprint of *Press Bulletin* No. 54, which is a brief review of Iowa weather during the month. The temperature averaged 15° above the normal; in continuation of the unusual high temperature that had prevailed since December, an excess of rain and southerly winds also prevailed. The fourth map, showing the distribution of thunder-storms—*i. e.*, thunder and lightning—is an important aid in the study of this subject.

The development of State systems of meteorology seems to make steady progress, as we have received the first monthly report of the Missouri Weather Service, organized by Professor F. E. Nipher, under the auspices of the Washington University at St. Louis. The present number of voluntary observers is sixty-five, and it is hoped that at least one in each county will be secured. At the central station Professor Nipher possesses the Dellmann electrometer used by Dr. Wisliczenus during the past fifteen years, and will soon take up a series of observations on atmospheric electricity, in continuation of those so faithfully made by that observer. It is to be hoped that Professor Nipher's labors will meet with a generous recognition.

In Nebraska a similar State service is, we understand, now organized, under the leadership of Professors Bailey and Aughey.

We learn that similar State organizations are talked of for Kentucky, Illinois, and Colorado. Whether such State systems especially attend to local climatology or to minute details of storms and atmospheric movements, they will equally serve the interests of science and of the State. The economic importance of an accurate knowledge of local climates is well illustrated by the action of the Central Pacific Railroad in maintaining a large number of observing stations well distributed over its extensive territories. A similar work was some years ago contemplated by the Alaska Company of San Francisco, but we do not know how thoroughly the idea has been carried out.

Meteorological work is kept up to a limited extent at some of our professedly astronomical observatories. Professor E. C. Pickering, of Harvard College Observatory, writes as follows: "Regular meteorological observations have been carried on here since the establishment of the observatory. The

daily number of observations has varied at different times from one to five. At present, according to a system adopted at the beginning of 1877, the hours of observation are 8 A.M., 2 P.M., and 8 P.M. The observations consist of readings of the barometer, and of the dry- and wet-bulb maximum and minimum thermometers, as well as of notices of wind, clouds, rainfall, aurora, and zodiacal light. Meteors are not ordinarily observed unless they attract attention by their brightness, or some other peculiarity; and the same remark applies to other miscellaneous phenomena. For some months past frequent observations have been made in the evening, with the object of numerically determining the coefficient of atmospheric absorption. An observation of this kind consists in the selection of two stars differing considerably in altitude and apparently of equal brightness. Knowing the true excess in brightness of the lower star, and determining the altitudes of both from the time of the observation, we can deduce the numerical value of the quantity required. Professor Langley intends to adopt this method in his observations at Mt. Ætna, and I hope that it may also be tried elsewhere."

The following notes on the year's work of the New York Central Park Meteorological Observatory have been kindly furnished by Dr. Draper:

The report of the New York Meteorological Observatory in Central Park, for the past year, by Daniel Draper, contains the usual tables from the self-recording instruments, and also a discussion on the two following questions:

1st. "Has there been in late years a change in the rainfall of New York City or its vicinity, affecting seriously its water supply?"

It was found by the observations used that there had been an increase of rain until 1869, and after that year a steady decrease.

2d. "Does the rainfall of New York still diminish, will it continue to do so, and does this variation occur in the early or latter portion of the year?"

By the observations used it appears that the rainfall of the city will most probably continue to decrease by fluctuations for several years to come, and that the variations are nearly the same in the two portions of the year.

To substantiate these questions, observations of other cities —as Washington, Philadelphia, Providence, and Paris—have been selected; they all tend to show the same results. Those of Paris, extending back 190 years, give a slight increase in the rainfall—not steadily, but with three oscillations of many years each.

This report is a continuation of a former one on, Does the Clearing of Land Increase or Diminish the Rainfall? From the tables produced, it appears that the widespread public impression that the clearing of land diminishes the volume of rain is not founded on fact.

Mr. Jerome J. Collins has published in *Nature*, for May, 1878, an essay on his American Storm-warnings, which will attract the attention of all, and especially of European meteorologists. He also contributes the following brief summary of the meteorological work accomplished in 1878 by the *New York Herald:*

From November 15, 1877, to the corresponding date in November, 1878, 51 warnings were cabled to London, and distributed by telegraph to the principal commercial centres of Europe. Of these 2 were sent after the 15th of November, 1877; 3 in December; 4 in January, 1878; 5 in February; 7 in March; 4 in April; 3 in May; 3 in June; 3 in July; 4 in August; 4 in September; 6 in October; and 3 to the 15th of November last. Of the total number—51—34 have been completely fulfilled, 13 partly fulfilled, and 4 fulfilled only as to some one of the conditions predicted. The percentage of complete fulfilments is 66, and of complete and partial fulfilments, 92. An analysis of the predictions as to date of arrival, barometer, etc., gives the following percentages: Date of arrival of storm-centre or depression, 84.5; barometer, 87.8; wind-force, 89.1; wind direction, 87.8; weather, 98.3; locality of arrival or regions immediately affected, 91.0. Of the 51 warnings cabled, several referred to more than one storm or depression then in movement; but 23 of the warnings referred to "storm-centres," or "cyclones," 27 to "depressions," and 1 to a "disturbance." The maximum in fulfilments was reached during November, 1877, and January, August, September, October, and November, 1878. The next best months were December, 1877, and February and March, 1878. The least success was expe-

rienced in May, June, and July, the lowest percentage being in June. Besides predictions for the European coasts, the *Herald* Weather Bureau has given repeated warnings of bad weather in the Middle and East Atlantic, for the benefit of vessels about to leave European ports. Numerous reports from ship-captains have reached the Weather and the Ship News Bureau of the *Herald*, announcing the complete fulfilment of these ocean warnings, and their great use to navigators.

Mr. R. H. Scott, Director of the London Meteorological Office, has published in the *Nautical Magazine*, for March, an exhaustive review of the early work of the *New York Herald*. He reports 47 predictions — 7 fully, 10 partly, 6 slightly verified, and 17 total failures. A detailed reply to Scott's criticism has been printed in the *Herald*.

The opinion that any storm ever crosses the Atlantic from America to Europe has been of late years very coldly received by the London office, but seems to have gained a strong hold upon the mind of the British public, owing especially to the apparent fulfilment of a portion of the storm predictions published from time to time in the London papers on the authority of the *New York Herald*. During several years the London office was in receipt of daily despatches from Heart's Content, and in 1869 Leverrier entertained the idea of obtaining a daily synopsis of American weather from the Cincinnati *Weather Bulletin*; but it remained for the *Herald* to awaken in England and France that interest in the subject that has been manifested during the past year, and which is, we believe, likely to lead to an important step in international meteorology. It is, indeed, now evident that weather predictions can be made by Europeans much more satisfactorily when the region from which they receive daily weather reports is made to include as much as possible of America and the Atlantic, although no one has thus far demonstrated exactly what becomes of the areas of high and low barometer after they disappear off our Atlantic coast.

The monthly reviews of the German Meteorological Office contain numerous contributions on the subject of the preceding paragraph. A large number of valuable ocean observations are tabulated in the *Review* for July, just published;

and among the very numerous storms whose history is given in detail by Dr. Neumayer are some whose connection with American weather is specially noted by him.

Among the journals which disseminate meteorological items throughout the United States, we may mention the *Valley Naturalist* of St. Louis, and the *Kansas City Review*, which usually contain several meteorological summaries for points west of the Mississippi.

The seventh annual report of the Meteorological Service of the Dominion of Canada for the calendar year ending the 31st of December, 1877, shows that the Canadian Service now extends quite thoroughly over all the provinces of the Dominion, and that increased accuracy and usefulness continue to be attained in their official prognostications of storms and weather. There are 10 chief stations, where 8 or more observations are taken daily; 14 telegraphic reporting stations; 4 reserved telegraphic stations; 100 additional ordinary stations; 39 cautionary storm-signal stations; and 95 probability stations, where agents officially receive by telegraph the daily probabilities. Five hundred and ten storm warnings were issued during the year, 69 per cent. of which were considered to be well verified. It is proposed to establish a cautionary storm-signal at Winnipeg, to give warning of the approach of the terrible blizzards which cause so much destruction to life and property in the winter. Of the probabilities, 79 per cent. were fully verified, and 13 per cent. additional partially verified. For the last month—viz., December—the reports of the agents at the different stations show that 88 per cent. were fully verified. Forty-six stations were inspected during the year. A new book of instructions has been issued to the observers. A monthly *Weather Review* was published throughout the year. The Central Office of Toronto receives tri-daily reports from a considerable number of stations, and also warnings of approaching storms from the Chief Signal-Office at Washington. "These form an important share of the data on which the predictions of the weather are based."

The annual reports of the Canadian Department of Marine and Fisheries contain innumerable miscellaneous notes as to ice, storms, fog, and miscellaneous meteorological phenomena from a portion of our continent whence otherwise we

should rarely have any information. In the report published in 1877, we note the record of ice in or near Newfoundland, and full details of a tornado and water-spout, August 18, 1876, at St. Paul's Island.

Mr. Maxwell Hall has drawn up a well-considered scheme for the establishment of a meteorological system of stations and storm warnings throughout the West Indies, having its central office at an observatory near Kingston, Jamaica. According to the *Philosophical Magazine*, he hopes for contributions and support from all the West Indies and the United States. (The United States Signal Service has for many years maintained a small number of telegraphic reporting stations in the West Indies.)

The meteorological bulletins of the Central Observatory at Mexico are published at irregular intervals, in the *Anales del Ministerio de Fomento*, and begin with the month of March, 1877, which is published in the *Anales* for December, 1877. The first number of the *Bulletin* gives a history of the establishment of the Observatory—its location, officers, and apparatus—and the methods adopted therein. All observations are made hourly, and seem to correspond to the requirements of exact science. The staff consists of the director, Barcena, and two assistants, Reyes and Perez. The principal meteorological observations that have been made in Mexico previous to the establishment of this national observatory are mentioned in the *Bulletin* as follows: by Humboldt Burckhardt (in 1839 and 1840), Bevard (1838 and 1839), Dr. Berlandier (1830 to 1851), Moral, Léon, Mier, Teran, Sartorius (1854 to 1870), Nieto (1858 to 1864), Ibarrola (1857 and 1858), Poey (1867), and Cornejo (1863 and 1865). In 1874 the Meteorological Observatory of the Medical Department was established, and afterwards removed to the School of Agriculture. The Observatory of the Department of the Interior, under Barcena, is in longitude $6^h\ 36^m\ 27^s$ W. from Greenwich, and latitude 19° 26′ N.; its altitude is 2290^m.

The Central Office contributes to the *Daily Bulletin* of the Minister of the Interior an astronomical and meteorological chapter, in which latter are published the complete record of the hourly observations at Mexico, the telegraphic bulletin of simultaneous observations at about thirty stations in that

republic, and the botanical calendar for about fifty families of flowers in the valley of Mexico.

Dr. B. A. Gould has published Vol. I. of the "Annals of the Meteorological Office of the Argentine Republic." He gives a large amount of data for Buenos Ayres—a wholly new meteorological field—and has subjected it to an elaborate study, with many curious results.

The Council of the London Meteorological Society have arranged a course of six lectures on meteorology, to be given by eminent specialists. Lectures will be open to the public, and tickets of admission can be obtained of the Society. The first lecture, by Mr. Mann, on the Physical Properties of the Atmosphere, we are sorry to see, promulgates Tyndall's opacity of aqueous vapor, and the radiation-of-heat theory of clouds and rain—errors to which, we presume, the Royal Society Meteorological Council will hardly lend their approbation. Probably no more effective method could be devised for disseminating a knowledge of meteorology in America, since such lectures are sure to be supplemented by their still wider distribution through the newspapers.

Among the subjects of investigation to be assisted from the government fund of £4000 for the advancement of science, we note that £50 have been voted to the Scottish Meteorological Society for aid in carrying on a simultaneous series of anemometrical observations at different heights, and in sheltered and unsheltered situations; also £200 to Dr. J. P. Joule for an exhaustive inquiry into the change which takes place in the freezing- and boiling-points of mercurial thermometers by long exposure to those temperatures.

The London Meteorological Office has begun the publication of a *Weekly Bulletin.*

The Leipsic Observatory, under Bruhns, now publishes weather forecasts for the agriculturists.

The *Annalen der Hydrographie und Maritimen Meteorologie*, published monthly by the Admiralty, at Berlin, contains regularly a few pages, in double columns, comparing, month by month, the weather of America and Europe. Full abstracts are given of the ships' logs that carry verified instruments, and that report to the Deutsche Seewarte. There are also a tabular review of the weather at the German seacoast stations, and very numerous excellent special meteoro-

logical and physical articles. The observations made at sea by the German vessels, under Dr. Neumayer's supervision, rank as the best now made by any navy or marine in the world.

The Seewarte, at Hamburg, publishes a *Monthly Weather Review*, of great value and accompanied by excellent charts. The daily forecasts that issue from this office are said to give eminent satisfaction. They are based on telegraphic reports from 92 stations, and are published in three styles — first, in full, with charts and tables; second, special abstracts, and 24 selected reports for the use of subscribers and newspapers; third, shorter abstracts, and about 10 selected reports for the use of seaport towns. A detailed list of the abbreviations and technical terms used therein is given in *Annalen Hydrog.*, p. 221.

A Central Meteorological Bureau for Bavaria, with Von Bezold as its director, has been organized, with 34 stations. Lamont and Ebermayer continue their own independent meteorological work.

The future of French meteorology has been established by a decree of the Minister of Public Instruction, dated May 13. According to *Nature*, this decree can hardly be considered as an innovation. It separates the Central Bureau from the Astronomical Observatory, and gives to the Central Bureau authority over the smaller meteorological observatories which have been established, or will be, throughout France. A translation of the full decree is given in *Nature*, vol. xviii., p. 134. In conformity with the decree, E. Mascart has been appointed Director of the Meteorological Bureau.

The Central Meteorological Bureau at Paris is located in the Rue de Grenelle St. Germain. It is probable that meteorological and magnetic observations will continue to be kept up at the Astronomical Observatory, under Admiral Mouchez, in order to maintain the long series that has already been made in that locality.

The *Bulletin Internationale*, formerly the organ for the Paris Observatory, is now edited by the new Weather Bureau, under Mascart, and is entirely devoted to meteorology.

The *Association Scientifique de France* continues to be the medium of communication with the agricultural community, and about 6500 stations are supplied by it with barometers and weather reports.

It is contemplated to establish ten new meteorological observatories in France, each possessing a complete set of self-registering instruments. According to *Nature*, the probable locations of these observatories will be—Lille; Mont Souris, under Marié Davy; for the Hydrographic Office, La Marche, under Herve Mangon; Bordeaux, Toulouse, Marseilles, Lyons, Besançon, Pic du Midi, Puy-de-Dôme, and Mont Ventoux.

At the Paris meeting of the French Association for the Advancement of Science, the only memoirs read of interest to meteorologists were: Wojeikeff, on Climatology; Nogues, on the Climatology of Geological Times; and Montigny, on the Scintillations of the Stars.

The meteorological section of the French Association for the Advancement of Science, as also the Meteorological Society of France, and numerous observatories, united in endeavoring to secure a very complete meteorological exhibit at the Paris International Exposition. The French Weather Service published daily two maps for 7 A.M., showing the isobars and isotherms, and their respective changes, together with other meteorological data.

An International Meteorological Congress was held at Paris, in the Trocadero Palace, August 24 to 28, at the call of the Minister of Agriculture and Commerce, and of the Meteorological Society of France, the French Association, and the Scientific Association. This was, in no sense, an official congress, yet it afforded a very pleasant opportunity for interchange of views. It was well attended by representatives from all nations, and almost every Frenchman of note in meteorology was present. A full report of the papers and discussions is promised by the French government, but no copy has as yet been received.

On the occasion of the International Meteorological Congress at Paris, August, 1878, Mr. H. Tarry, of Bordeaux, presented an appeal for sympathy in reference to meteorology in Algiers. It would seem that he has labored faithfully since 1873 to establish a meteorological service in Algiers, and to secure its connection with the International Meteorological Service of Europe. His own attempts were ably seconded by Farre, and his successor as chief of the staff in Algeria, and by Governor-General Chanzy, and also by St. Claire de Ville, Inspector-General for Meteorology; but were strenu-

ously opposed by Leverrier. We believe, however, that the Algerian system in and of itself is now quite complete, and that under the present administration its connection with the present French system is generally very satisfactory, notwithstanding a short interruption that occurred in August, 1878.

Bischofscheim, the celebrated banker at Paris, has contributed sufficient to construct a meteorological observatory on the top of Mont Ventoux.

Mr. Markham has published the long-promised second edition of his memoir on the "Indian Surveys." This brings down the history of geodetic and meteorological and other work in India to the end of the year 1877. The geographical and geological work has made extraordinary progress during the past seven years; and the meteorological work has been concentrated to a uniform system subordinate to a Central Bureau, under the direction of Mr. H. F. Blanford.

The whole volume is full of exceedingly interesting historical details, and from the chapter on Meteorology we take the following notes: A meteorological journal was kept by Colonel Pearce, at Calcutta, in 1785 to 1788; and by Mr. Henry Traill in 1784 and 1785. From that time to the present but few gaps occur in the series of records for that station. The principal collections of meteorological registers are to be found in the successive volumes of "Asiatic Researches;" the *Madras Journal;* the *Journal* of the Bombay Branch of the Asiatic Society; Glashier's "Report on the Meteorology of India," London, 1863; Neil's "Annual Reports for the Punjab;" Thomson's "Reports for the Northwest Provinces;" Blanford's "Reports for the Government of Bengal;" and Chambers's "Annual Reports for Bombay." Of the more recent works by Blanford, we have already given notice in our preceding *Annual Record.*

The voluntary Association of the Meteorological Offices of Bengal, the northwest and central provinces Berar, Ceylon, and Singapore, began in 1873. This resulted in the appointment, in 1875, of Mr. Blanford as Meteorological Reporter for the Government to India; and the net-work of stations has now been extended over the Punjab, Bombay, Madras, Burmah, Assam, the Nicobar Islands, Ceylon, portions of Afghanistan, and Thibet.

The progress of meteorology in Italy is being actively fos-

tered by the Italian Alpine Club, to which organization is due the existence of the completely equipped Meteorological Observatory, inaugurated November 25, at Fiesole. Very many of the existing stations in Italy are due to the Alpine Club; and still another is about to be opened at Castel Piano, on Mt. Piano, near Siena.

The publication of the *Bulletin* of the Arcetri Observatory will be continued by Tempel.

An Italian meteorological society has been organized, with its headquarters at Modena, where also is published, by Ragona, the *Annuario*, or *Monthly Meteorological Journal*, which will be the organ of the society, and must tend to disseminate a healthy spirit among the Italian amateurs and specialists. It appears thus far to have worthily supplemented the work done by the Meteorological Office of the Department of Public Instruction at Rome, very much as has been done in Vienna by the *Zeitschrift* of the Austrian Association. Were it not for the annoying multiplication of scientific journals, we are not sure but that a meteorological association and monthly would do a good work in the United States. The Meteorological Offices of the Departments of the Marine and of Agriculture and Commerce have been merged into one, under the Department of Public Instruction, by which the *Bulletino* and the *Memorie e Notizie* are now published.

Denza, of Moncalieri, announces that it has been decided to give the meteorological station on the summit of the Stelvio Pass the name, "The Secchi Station at Stelvio," in permanent commemoration of the great work accomplished in Italy by Father Secchi, who, among many other things, began in Rome the publication of a *Telegraphic Meteorological Bulletin* a year before Leverrier began the *Paris Bulletin*.

Professor P. G. S. Ferrari succeeds Father Secchi in charge of the Observatory of the Roman College.

Mr. G. F. Rodwell writes to *Nature*, urging the execution of the proposal made two years ago by Tacchini, that a meteorological and astronomical observatory should be established near the summit of Mt. Ætna.

At the Dublin meeting of the British Association the following papers were read: Professor Everett, Report on Underground Temperature; Professor G. Forbes, Report on Atmospheric Electricity; James Glaisher, Report on Lumi-

nous Meteors; G. J. Symons, Report on the Rainfall of Ireland; S. P. Thomson, Report on Rainbows; W. Morris, Report on Temperature of the Earth; C. Meldrum, Report on Sun-spots and Rainfall; R. Anderson, Report on Lightning-Conductors; Professor H. Hennessy, Report on Climate of British Islands; Wheeler, Report on River Administration.

According to *Nature*, the Swedish Diet has granted the necessary funds to establish a meteorological observatory at Upsala, separate from the Astronomical Institution.

The Permanent Committee of the Vienna Congress of Meteorologists held a session in Utrecht, October 16 to 20, and, among other things, are understood to have expressed themselves very favorably relative to international simultaneous observations. Their report embraces sections by Everett on Atmospheric Electricity, and Scott on Maritime Meteorology. The next general Congress will be held in Rome in April, 1879.

The possibility of carrying on successful weather predictions for the Mediterranean and its shores is discussed by Hellmann, who shows that probably a greater efficiency can be attained than in Western Europe.

The Russian Geographical Society warmly advocates the establishment of polar meteorological stations. The extensive magnetic survey of Russia by Smirnoff (declinations and inclinations at 287 localities, and declinations alone at 261 other localities) have been brought to its notice by Colonel Thilo of the general staff.

A Russian meteorological association is announced as being formed, with its headquarters at St. Petersburg.

Wild has published a description of the new meteorological and magnetic station at Pavlovsk, near St. Petersburg, at which regular observations began January 1, 1878, while preliminary and comparative observations have been made regularly since June, 1877. This new observatory, furnished with everything that physical science can suggest, and located in the midst of an extensive imperial domain, promises to do for meteorology and magnetism work as important as the Astronomical Observatory in the neighboring village of Poulkova has done for astronomy.

The annual report for 1876 of Mr. Meldrum, the Director of the Royal Alfred Observatory at Mauritius, was received

in November, 1877. Twenty-nine rainfall stations distributed over that small island report monthly to him. The Central Observatory makes full return for the slight expense of its maintenance by keeping up a sharp lookout for the cyclones of the Indian Ocean. The study and prediction of these storms has for years been Mr. Meldrum's specialty, and he has now attained to such expertness that "there is no country in the world so well provided for in this respect as the little colony of Mauritius." The incurving vortical motion of the air in every cyclone has for seventeen years been maintained, and is now further considered in opposition to the purely circular theories. Charts showing the tracks of cyclones in the Indian Ocean for the thirty years 1847 to 1876 are now nearly complete. The annual rainfall for 1876 shows a remarkable deficiency over the whole island; the cyclones were fewer, and of notably less extent and intensity, both agreeing with Mr. Meldrum's former conclusions as to a sun-spot cycle in meteorology, for 1876 was a year of minimum sun-spot frequency. The most important magnetic storms occurred on February 19 and 20 and March 25 and 26.

The reorganization of the meteorological system of India, which was effected in 1873, and by which Blanford, of Calcutta, was made Government Reporter for the whole of this most extensive country, promises to result in work of the highest importance in the progress of both observational and philosophical meteorology. We have already had occasion to refer to the valuable studies into the origin of the cyclones of the Bay of Bengal. The first official publications of the Calcutta office consist of the "Report for the Year 1875," and Vol. I. of the "Indian Meteorological Memoirs." The former, a quarto of 387 pages, contains the details of the observations at 88 full and 198 rain stations, and a general review of the atmospheric phenomena during the year, as shown by monthly maps. The second publication contains important memoirs by Blanford on the diurnal variations of the winds and barometer, and on the climate of Kashgar.

The Magnetic and Meteorological Observatory of Zikawei, near Shanghai, has substituted for its daily weather report a more convenient *Bulletin Mensuel*, and annual reports.

That for 1877 embraces 200 pages, and gives in detail the hourly observations, with their means and the wind-roses.

In the *Bulletin Mensuel*, besides the minute observations at the Observatory, there also appear numerous contributions from other portions of Eastern Asia. In the *Bulletin* for July will be found a description and an interesting series of diagrams, showing the successive changes in a waterspout observed near Shanghai.

The progress of meteorology is now seen to be so dependent on the prompt formation and study of daily weather maps, and this work is so materially assisted by the use of the electric telegraph, that we are not surprised to find combined in one person—Mr. Charles Todd, of Adelaide, South Australia—the various positions of government astronomer, meteorologist, and director of the post-office and telegraph lines. In this last capacity Mr. Todd has been able to greatly further the extension of the telegraph, and its utilization in weather study and predictions. Since January, 1876, he has published regularly the weather observations from about 80 stations, most of which send in daily reports by telegraph. His pamphlet entitled "Observatory and Climate of South Australia" contains a mass of details relative to the climate of the interior of Australia, which has hitherto been to meteorologists an unknown region. Similar bulletins are published by Ellery at Melbourne, and Russel at Sydney.

With the extension of telegraphic communication throughout Japan—where it is estimated that even now there are 125 stations in operation—it is confidently hoped that a system of telegraphic weather reports will be organized, possibly under the initiation of the Department of Public Instruction, at the head of which is Professor Murray, of New Brunswick, N. J. The Imperial University at Tokio, under the Department of Public Instruction, and the Imperial College of Engineering, under the Department of Public Works—the former under American and the latter under English influence—are both advocating such a system.

GENERAL TREATISES.

In our last annual summary a very brief note called attention to the publication by Blanford of the Indian meteorologist's "Vade Mecum," and the accompanying tables.

These important volumes are worthy of much more extended notice, and ought to be in the hands of every student of meteorology, and every observer as well.

The "Vade Mecum" is divided into two parts: first, instruction to observers; second, the meteorology of India. The instructions are certainly clear, without superfluous words, and every word to the point; and, while especially adapted to use in India, afford valuable suggestions for observers everywhere. The second part of "Vade Mecum" is what especially interests the student of meteorology, as distinguished from the mere observer, and in the introduction he states that in this part of his volume, a knowledge of the laws that regulate the internal movements of the atmosphere is the business immediately before us. He entertains the view, apparently very nearly correct, that in India we have an epitome of atmospheric physics, even as in England we have an epitome of strategraphic geology.

The author gives the most recent results in his next chapter on the physical properties of air and vapor. He especially calls attention to the erroneous custom, now rapidly becoming obsolete, of subtracting the tension of aqueous vapor from the total barometric pressure. The diurnal variation of vapor tension he partially explains as due to the ratio between the rate of production and the rate of removal. The effects of condensation of vapor in retarding the fall of temperature are very fully developed.

The conclusions of Tyndall in reference to the absorption of heat by aqueous vapor are not adopted by him; and he inclines, with most physicists, to adopt the conclusions of Magnus, confirmed, as they have been, by Hoorweg and Buff —namely, that air and vapor differ little in absorptive power; and that in atmospheric phenomena it is most important to distinguish between true vapor and that which is in the first stage of condensation. The results of direct observations on atmospheric absorption by Forbes, Hennessy, Hodgkinson, Neumayer, Strachan, and Harrison are adopted by Blanford to the general exclusion of purely physical theories.

The dynamic heating and cooling of the atmosphere, as deduced from the dynamical theory of heat, are very fully appreciated and exposed. The physical geography of India has, as in every country, the greatest influence over its me-

teorology, and is very graphically presented in the second chapter. In the chapter on radiation and temperature, he states that the predominating feature of Indian meteorology is the semi-annual reversal of the system of winds, the primary cause of which is the variation in the quantity of solar heat, which is then followed out in all its details. From paragraph 62 we extract the following: "The maintenance of an ascending convection current over India in the rainy season, and of a descending convection current in the cold dry season, is in both cases consistent only with a vertical decrement of temperature less rapid than in regions where no such movement is in progress." In the chapter on atmospheric pressure and winds, Mr. Blanford first explains the laws that have been known as Dove's law and Buys-Ballot's law, as particular consequences of Ferrel's law. In the section on Indian monsoons the tables and diagrams showing the monthly variations of temperature, pressure, wind, and clouds are extremely satisfactory. He finds that the depth of the winter monsoon in January and February in the neighborhood of the hills is probably less than 7000 feet, while the summer monsoon is much more than 11,500 feet. The summer monsoon has a greater average velocity, depth, and volume than that of the winter, but a lower velocity than the winds of the hottest season. During the height of the southwest monsoon there is a region in the Arabian Sea in which the winds are light and the sea smooth; this is known to navigators as the soft place in the monsoon. To the north of this the monsoon blows with great force.

The diurnal barometric oscillations are given for a number of stations, and the theory that Mr. Blanford proposes is ingenious, if not satisfactory. It is that originally worked out by Kreil and Lamont, modified by the fundamental assumption that the pressure exerted by the expansion of the lower layers of the atmosphere is only slowly communicated to the upper layers, and that the inertia of the latter, when once in motion, accounts for the barometric minimum in the afternoon. In the chapter on hygrometry, cloud, and rainfall, Mr. Blanford gives some comparisons between Wolf's sun-spot numbers and the register of rainfall at six stations in India since 1813. He finds the cyclical variation of the rainfall very distinctly indicated, especially from Madras.

In the chapter on storms, he considers that there is some reason to believe that the simoom has some special qualities besides heat and dryness, warranting its name of the poison wind, and that it should not be treated of merely as a case of hot wind.

The northwest wind of Calcutta advances from some point between northeast and west, or even southwest. The wind that precedes the rain is very cool, and is heralded by a sudden rise of the barometer. Wind pressures of fifty pounds to the square foot have been recorded on these occasions.

In the chapter on cyclones Ferrel's formula for gradients is applied to the case of storms in the tropics; and the angles of incurvature of the wind are given for several localities in the storm of October 15, 1874.

The monthly distribution of 115 cyclones in the Bay of Bengal throughout the year was as follows:

January	2	May	21	September	6
February	0	June	10	October	31
March	2	July	3	November	18
April	9	August	4	December	29

The origin of the cyclones, he finds, in accordance with his own and Mr. Elliott's investigations, is the production and ascent of a large quantity of vapor, which is condensed with the liberation of its latent heat over the place of its production, instead of being carried away to some distant region. He considers that there is a consequent local lowering of the atmospheric pressure, causing, or tending to cause, an indraught of air towards the place of minimum pressure.

Mr. Blanford would seem to imply that the barometric depression in the central portions of this region is mainly due to the ascent of vapor and its condensation; but it has already been shown by others that these alone can produce only a very insignificant diminution of pressure at the earth's surface; and the true explanation of the origin of the latter involves the consideration of the inertia, centrifugal force, and internal friction of the atmosphere. The volume closes with a very excellent chapter of suggestions as to subjects requiring further investigation.

Among the general treatises on meteorology there has been published one in Italian—the "Manual Nautico di Meteorologia," by Captain F. Viscovish, of the Austro-Hunga-

rian Lloyd Service—in which special attention is, of course, given to the law of storms, and which shows a very general appreciation of the most recent works on this subject.

A little volume has been published, at the price of one English shilling, by Hoveste & Sons, London, entitled "Weather Warnings for Watchers, by the Clerk of the Weather." The book is mostly occupied with the details of instruments.

A series of articles on meteorological topics, by Captain Ansart, have appeared in occasional numbers of the *Revue Maritime et Coloniale* during 1874, 1875, and 1876. In these many new ideas and formulæ are propounded which are not likely to be generally accepted; and yet the work will repay attention.

Rev. Samuel Haughton communicates to the Royal Society of Dublin a geological proof, based on the examination of the fossils found in the earth, that the changes of climate in past times were not due to changes in the position of the earth's axis, and gives as the lower limit to the duration of geological time a minimum of 200,000,000 of years.

Dr. Wocikoff exhibited in the Russian section of the Paris Exposition a series of maps of isobars, isotherms, rainfall, etc., for the globe; and the "text explanatory," which has been widely distributed, shows that these charts, drawn from the best sources, are, in general, an improvement upon those produced by Buchan, Wild, Buys-Ballot, Coffin, Schott, etc.

On the climate, especially the temperature, of the United States, Wocikoff has published in the Austrian *Meteorologische Zeitschrift* an extended review, basing his tables and figures partially on the publications of the Smithsonian, Army Engineers', Army Signal-Office, New York and Canadian Meteorological reports, etc.

As a question of climatology, nothing can be more interesting than the fluctuations of Great Salt Lake, as these are now brought to light by the labors of Mr. Gilbert. It is to be hoped that he will also investigate some of the other lakes of the Rocky Mountain region, in order to eliminate the influences of purely local circumstances. Great Salt Lake was low from 1847 to 1850, was 5 feet higher in 1855, but again as low as before in 1861 and 1862; from 1868 to 1877 it has averaged about 10 feet higher than in 1850. A very ancient beach-mark that exists about 4 feet above

that of 1850 shows what was its level at some remote period.

The Commissioner of Immigration for Iowa, M. M. Moulton, Esq., of Monticello, Iowa, has rendered a most acceptable service to his town, and set an example worthy to be followed by many others, in publishing a little pamphlet review of the meteorology of Monticello for 1876 and 1877, and a comparison with the records of the preceding 25 years. He gives for 25 years the number of days between the last frost of spring and the first of autumn as ranging from 77 to 166. The first frost of autumn occurs between August 28 and October 13; the last frost of spring occurs between April 20 and June 21. The average dates are respectively September 20 and May 20. The Maquoketa River is closed by ice from 25 to 118 days during the year; the average dates of opening and closing are March 10 and December 10. Many interesting climatological items are given, and Mr. Moulton closes by saying, very correctly, as we believe, that "it would prove a paying investment for the different agricultural societies to offer liberal premiums for the best meteorological record for the preceding year or years." It is to be hoped that all who know of existing climatological records in private hands, including records of frost, rivers, budding, ripening, harvesting, etc., etc., will exert themselves to see that such records are transferred to some official Weather Bureau, or are safely deposited where they may be accessible.

In the same strain with Mr. Moulton's closing paragraph, we quote from an essay read by W. T. Harris, at the National Educational Association, so long ago as August 7, 1872: "Of all subjects of investigation that claim the attention of the active laborers in physical science at the present day, that of meteorology holds the foremost rank. The next great victories over nature are likely to be obtained in this province, and the benefits to be derived from an application of discoveries in this realm will far transcend anything hitherto achieved."

The *Canada Review*, for August, devotes a short postscript to the tornado and terrible hail-storm which passed over Norwood and near Toronto on August 8; hailstones weighing one pound and a half were caught and measured. The average weight of a large number was half a pound. The

larger ones averaged one to every yard, the smaller ones one to every inch. The *Review* for the State of Iowa, by G. Hinrichs, gives maps showing the rainfall during thirteen storms, and illustrating the definite regular gradation of rainfall from the centre of a storm outward. The *Signal Service Review* for August has an especially interesting abstract of a report, by Professor W. H. Brewer, on the tornado at Wallingford, Conn., on the 9th; it also gives a remarkably long list of tornadoes and local storms during the month. At the close of this *Review* there is given a list of Signal Service stations at which the duration of the total eclipse was observed. As showing the extensive correspondence of this office, it may be added that 295 stations are stated to have sent in reports concerning this eclipse.

The February number of the *Journal of the Scottish Meteorological Society* contains a discussion, by Mr. Buchan, of a series of observations made at Gordon Castle, by Mr. Hoy, Secretary to the Duke of Gordon, and extending over 46 years, 1781 to 1827. The tables of mean monthly pressure, temperature, rainfall, weather, and auroras form a remarkably uniform and valuable series of observations.

Captain Hoffmeyer, of Copenhagen, in some notes on the recent winter in Iceland, states that in the autumn of 1877 very beautiful weather prevailed; the temperature of September was the highest in thirty years. A sudden change in the weather occurred October 11, and a very stormy period intervened, culminating in a hurricane from the northwest, with a very cold snow-storm on January 6 and 7, 1878. February and March were mild and damp.

The climate of the well-known English resort Bath is treated of in an essay by Rev. L. Blomefield, published in the *Proceedings* of the Bath Natural History and Antiquarian Field Club. This paper is based upon ten years of observations by the Bath Literary Institution.

The importance of collating all data that can be obtained from old records bearing upon climate, or questions of climate, cannot be too strongly urged upon those having access to ancient records. Mr. Symons states that almost every parish register or county history in England will repay one for the search. He has already had the Saxon Chronicle searched, and states that that of Holinshed is in hand.

Dr. Fines has published the "Bulletin Météorologique du Département des Pyrénées-Orientales" for 1876, the cost of which is defrayed by the city of Perpignan and the Département des Pyrénées-Orientales. In this volume are contained the observations in detail, made eight times daily at the Observatory of Perpignan, together with the monthly means, etc. These are followed by monthly means of observations at numerous stations throughout the Département, and, in detail, the observations made at the high station Montlouis (altitude 5204 feet). To these observations are appended a chapter on the Atmosphere, the Rain, and Dryness, by Ch. Naudin, and one on the Trombe de Rivesaltes, August 19, 1876, by Dr. Fines. This latter tornado, as we call it in America, lasted about 20 minutes, and extended over a path about 6 miles long and 1000 feet broad, or less. A slight fall, followed by a rise, in the barometer was noticed at a distance of 10 miles, where also the wind increased to high for a few minutes. In some general notes Dr. Fines maintains that in some tornadoes or trombes we have ascending, and in others descending, vortex currents of air.

A Summary of Twenty-eight Years of Meteorological Observation at Erfurt is given by Dr. Koch in the Erfurt *Jahrbuch der K. Acad. der Wiss.*

The first publication in Germany of observations at numerous stations, in precisely the form and style recommended to all nations by the Permanent Committee of the Vienna Conference, has come to hand in the volume of observations at seventeen German stations of the second order—published under the joint action of Neumayer, Schoder, Sohncke, and Bruhns—representing respectively the Deutsche Seewarte, Würtemberg, Baden, and Saxony, to which Bavaria possibly will be added next year.

Van Bebber communicates to Petermann's *Mittheilungen* a Study of the Weather Phenomena, based on the simultaneous observations made for the German Seewarte at Hamburg. He sketches the condition of meteorology previous to the present decade as contrasted with the present. Formerly we studied climatology; but now the movements of the atmosphere, or dynamic meteorology, and the study of the atmosphere as a whole, by means of synoptic charts, occupy our attention. He gives in detail the telegraphic meth-

ods employed in Germany, and the four charts of Prussia: pressure, wind, and cloudiness on the 1st; temperature and precipitation on the 2d; 24-hour changes in pressure on the 3d; and 24-hour changes in temperature on the 4th. Numerous details are given with reference to the methods of doing work in Germany, England, Denmark, France, Austria, and Belgium.

Under the misleading title of Physical Astronomy, the editor of *Les Mondes* republishes one of the last contributions of Secchi to meteorology, in the shape of a short article written in March, 1878, on the Prediction of the Weather. Secchi's idea appears to be that, at least in Italy, the probability of coming clear, cloudy, or rainy weather depends on the direction of the wind and changes in the pressure; and that the prediction of future weather may be founded upon the conditions of the atmosphere in the regions all around Italy, because the weather in that country will be the result of the conditions existing in the surrounding countries.

The Climate of Rome, by R. P. Ferrari, who succeeds Secchi as Director of the Observatory of the Roman College, is a valuable monograph compiled by Ferrari as a part of an archæological and statistical monograph on Rome and the Roman Campagna. It reviews the history of meteorology since the year 1780, and the meteorological work of Philippe Gili (1797 to 1821), Calandrelli (1782 to 1801), Conti, Du Monchel, and De Vico (1822 to 1854), and of Secchi (1854 to 1878). He has drawn freely from the memoirs of Respighi, Mancini, and Secchi. The last chapter of his work is devoted to the hygienic conditions of the climate of Rome.

The meteorological journal kept by Tycho Brahe from 1582 to 1597 has been published by the Swedish Academy of Sciences, under the editorship of Paul de La Cour, who subjects the observations to analysis and criticism.

The climate of Eastern Switzerland is elucidated in a memoir by Wanner in the annual report of the Association of St. Galle. The suddenness of the changes in temperature attending the occurrence of a Föhn wind is shown by a rise of 14.8° C., or 32° Fahr., in half an hour.

Interesting notes on the climate of Greece are contributed to the *British Meteorological Society* by Boys, of Patras. The

drought of 128 days, the storm of November 21, 1874, and the variability of the climate are specially treated of.

The extension of the dominion of the Khedive of Egypt southward into Equatorial Africa, and over the entire watershed of the Nile, has, under the administration of Colonels Gordon and Purdy, and their chief, General Stone, Pasha, given occasion to the execution of some desultory meteorological observations. These are published by the Egyptian general staff; and the most valuable is the hourly series observed at Fascher, in Darfour, July 14 to August 10, and on September 5 and 6, 1876.

Some notes on the meteorology of Herero-land, or that portion of Africa immediately north of Cape Colony, are given in Petermann's *Mittheilungen*, vol. xxiv., p. 311, where it is stated that the rain in the western portion of the land diminishes more and more from year to year, and that only the eastern portion of the country can now count upon sufficient rainfall. It has been remarked that in the last ten years the cloud-and-rain wind, or the east wind, has become notably feebler.

Papers on the Climate of Lundy Island, and on the Meteorology of Natal—respectively by A. J. H. Crespi and Dr. R. J. Mann — were read before the British Meteorological Society at its meeting in June.

Mr. R. H. Scott publishes in the *British Meteorological Journal* a paper, by Mr. Strachan, on the Meteorology of the Fiji Islands, based on observations in 1860, 1862, and 1865 at Leunka; in 1872 and 1873 at Bua; and in 1873 and 1874 on H.M.S. *Pearl*. The healthiness of these islands is equal, if not superior, to that of any other portion of the world.

Mr. Eliot, of Calcutta, has ventured on predicting the approaching monsoons and rains, basing his reason upon the general distribution of pressure-winds and rain during the preceding season. In nearly every respect his predictions have been fulfilled.

Mr. Meldrum, of Mauritius, has prepared a series of twelve monthly charts of weather over the Indian Ocean, and also a storm-atlas of the same region, exhibiting the principal results of his studies upon the storms of the past thirty years. This very important work is now offered for publication to the Meteorological Society of Mauritius and the Colonial Government.

The "Meteorology of the Bombay Presidency," by Charles Chambers, Superintendent of the Colaba Observatory, has been received during the year. In this great work there is given a very brief sketch of the history of the observatory, and a full discussion of its meteorological records for twenty-six years; and similarly for four small observatories at the military stations. Part III. gives the principal results of observations, and especially rainfall, at civil and military hospitals and revenue stations. Part IV. gives some principal points in the general character of the climate, which are elucidated by a reference to known physical laws. The volume is accompanied by a collection of elaborately prepared systems of graphic presentation of the meteorological observations. A barometric variation, having a period of one eighth of a year, is deduced. The thermometers for temperature were during part of the time protected from radiation on all sides, but were exposed on the ordinary English stands during the greater part of the period. The vapor pressure is calculated by Apjohn's formula, and the dryness of the air is expressed by figures, which give the capacity of the air to contain more vapor. The temperature of the ground is given for the depth of 1 inch, 6 inches, etc., down to 12 feet. The temperature is also given for a thermometer laid on the ground, with the bulb in contact with it. The thermal coefficients of the soil for each pair of thermometers have been computed according to Professor Everett's method. It should be noted, however, that the soil at Bombay, for a large part of the year, is permeated by rain-water. The rainfall for 282 stations is discussed with especial thoroughness. He shows that the rains accumulate in the stratum of air just above the earth's surface, and the light rains accumulate more than the heavy rains do, to the extent of nearly 7 per cent. The wind velocity is recorded by Robinson's anemometer. The wind directions are subjected to elaborate computations, showing the components of the winds, their annual mean motions, their persistency, their systematic oscillations of short period, etc., etc.

A peculiar interest attaches to his chapter on the physical explanation of the meteorology of the Bombay Presidency. With this chapter goes the best map on the topography and drainage of the Bombay Presidency that has as yet been published.

In the chapter on topsy-turvy movements, he develops those views and formulæ which have been elucidated by Espy, Thomson, Raye, Hann, Peslin, etc., in which work he appears as an entirely independent investigator. In the succeeding chapter, on lateral currents, he gives the formula for the elucidation of the monsoon-winds and trade-winds, and concludes with some suggestions as to the origin of Indian storms. He points out the fact that the condensation of atmospheric vapor cannot possibly of itself give rise to any low barometric pressure; for the latent heat liberated by such condensation expands the air to a greater volume than before.

Wagner, Chief of Section I. of the Deutsche Seewarte, communicates to the *Annalen der Hydrographie* an excellent summary of Our Knowledge of the Monsoons and Typhoons of the Chinese, Japanese, and Indian seas.

The climate of Japan is elucidated in a memoir by Dr. J. J. Rein, read before the Asiatic Society of Yokohama, and published preliminarily in the Japan *Weekly Mail* during August and September, 1878. He acknowledges that he has to deal with a great many untrustworthy observations. Those of which he makes the most use are by G. Hostetter, three years at Tokio; E. Knipping, two years at Tokio; Mourier, Hepburn, and Sandwith, in all eight years at Yokohama; Leysner, five years at Niigati; Blackiston, six years, and Albrecht, five years at Hakodate; Gratama, one year at Osaka, and ten years at Deshima. For all the preceding stations monthly extremes and means are given, and the whole paper is rich in description of interesting phenomena. Especial description is given of several typhoons. This paper appears to have been originally presented in German, and is translated by E. Satow. A large portion of it is devoted to the distribution of plants and trees, and their relation to the climate.

The Dutch Meteorological Institute has issued wind-charts of the North Atlantic, showing the frequency of the winds for each 1° square, and for each month.

Captain Hoffmeyer communicates to the Vienna *Zeitschrift* a paper, read before the Meteorological Convention at Paris, in August, 1878, on the Distribution of Atmospheric Pressure over the North Atlantic Ocean during the Winter, and its Influence on the Climate of Europe. After reviewing the

results of investigations by Ley, Ferrel, Mohn, Guldberg, Loomis, and Broun, as to the accuracy of Buys-Ballot's law, he proceeds to review our knowledge of the distribution of pressure over the Atlantic, as given in the works of Buchan, Brault, and Woeikoff, and then states the modifications of their views to which he has been led by his own investigations. He publishes charts of the isobars for January, 1874 and 1875, and the average of many years. He carefully avoids conclusions as to the ultimate cause of the distribution of barometric pressure and its variations, and regrets that, in the absence of observations over the Pacific Ocean, we cannot yet take a general survey of the phenomena of the atmosphere.

The Hydrographic Office of the United States Navy has published an imposing volume of charts, giving information regarding winds, calms, fogs, rain-squalls, weather, barometer, temperature of the air, of sea-water, and of evaporation—all for every 5° square, and for each month. This volume is the first of the series, and covers the Pacific Ocean between the equator and the 45th parallel of north latitude, and between the American coast and the 180th meridian. The next volume, for the North and South Atlantic Ocean, is well advanced, and the whole series, when finished, will cover the whole navigated ocean-surface of the globe. This important work was begun in September, 1876, by Lieutenant T. A. Lyons, and other officers of the United States Navy, and will by them be continued until completed. The data are supplied by log-books of the United States vessels of war, and the journals kept by merchant vessels on forms supplied by the Hydrographic Office.

In a comparison of the weather in Europe and America during May, 1878, the *Annalen der Hydrographie* says: "The notable cold epoch in the second week of May was in this year strongly marked both in Central Europe and in North America. The almost perfect simultaneity of these may be considered as a confirmation of the oft-expressed view that this cold epoch owes its origin to some cosmic cause; but in this, as in all preceding cases, the pressure was high, and the winds northerly for both continents, which conditions are those that always produce cool weather." The present writer must demur to the conclusion that a cosmic cause is indi-

cated by the simultaneity of the phenomena in Europe and America, since a study of the daily map for the whole northern hemisphere renders it probable that such simultaneity is ultimately due to peculiarities in the distribution of land and water on the earth's surface — such, for instance, as the fact that the west coast of America and the east coast of Asia, or Japan, lie in one and the same great circle, on the south side of which is the Pacific Ocean, and on the north side only land.

Among the collections of memoirs published during the past year, we note "Scientific Memoirs," by John W. Draper, containing, among other things, full accounts of studies into the radiation of heat, the refraction of light, and especially the absorption of light and heat by the atmosphere, as shown by the spectroscope.

A valuable volume of miscellaneous papers connected with physical science is found in the collected memoirs of Humphrey Lloyd, Provost of Trinity College, Dublin. Besides his numerous papers on magnetism, optics, etc., we have here a reprint of his classical Notes on the Meteorology of Ireland, which was read in December, 1853, and contains a determination of the inclination of winds to isobars, and to the bearing of storm-centres, which, in chronological order, is second only to the paper of J. H. Coffin (*Amer. Assoc. for the Adv. of Sci.* 1853).

Another valuable volume of collected memoirs is the "Recueil des Travaux Scientifiques," of Léon Foucault.

Those who have been unable to obtain copies of Fourier's "Analytical Theory of Heat" will perhaps be glad to have their attention called to a translation of this work, by Mr. A. Freeman, of Cambridge, England, although, judging from a review by Maxwell, of Freeman's translation, we should think that a second, corrected, edition would be an improvement.

The Royal Observatory at Brussels has published a catalogue of the works relating to astronomy and meteorology that are to be found in the principal libraries of Belgium. Such bibliographical works are of special value to those who wade through the increasing literature of meteorology.

A collection of translations of memoirs on meteorological subjects is published by the Smithsonian Institution in its annual report for 1877. By this method, Mr. Abbe has sought to introduce to American students the results of Hann's in-

vestigations on the distribution of moisture in the atmosphere, the influence of rainfall upon the barometer, the laws of the variation of temperature in ascending currents of air, and the relation between barometric changes and the velocity of the wind. On this latter subject he also appends the views of Colding and Peslin.

APPARATUS AND METHODS.

In a paper on the Application of Harmonic Analysis to the Reduction of Meteorological Observations, the Hon. Ralph Abercromby traces the physical and geometrical meaning of every step from the barographic record, until the tabulated results are exhibited in harmonic series; and in consideration of the failure of this series to give any clue to the physical cause of the barometric variations, and the failure in general of statistical methods to raise meteorology to the rank of an exact science, he concludes that it will be absolutely necessary to construct synoptic weather-charts for the whole northern and southern hemispheres.

In the statistical methods, phenomena are classed together that really have, perhaps, only one common property. He concludes with the sentence, "Averages, though so useful, can never make meteorology a science." In a subsequent note, he explains the method of averaging used by Bloxam in reducing his sixteen years' observations at Newport. This method, however, is not a new one, as many illustrations of its use, by Schott and others, have been published.

Angot gives in *La Nature* (p. 372) a full description of Mascart's ingenious self-recording electrometer for continuous observation of atmospheric electricity. This is essentially a Thomson collector and electrometer, combined with Mascart's self-recording apparatus. The instrument has performed satisfactorily during the Exposition at Paris, and it is understood that a number of them will be established in France, whereby the first step will be taken in the proper study of atmospheric electricity. Mascart's recording apparatus can be also applied to the registration of magnets or vibrating needles (the pendulum?), etc., and will, doubtless, find further uses.

In connection with the observation of atmospheric electricity, we notice in *Nature* the description of a very efficient and

convenient insulating stand, invented by Mascart; and an admirable memoir, by Angot, in the *Annuaire* of the French Meteorological Society.

The fourteenth volume of the "Observations at the Royal Observatory, Edinburgh," contains a supplementary chapter on meteorological spectroscopy, in which Piazzi Smyth, in his peculiar style, stoutly maintains that by means of a Browning pocket-spectroscope, he and Mrs. Smyth are able to distinctly perceive the "rain-band" due to absorption by aqueous vapor, and thereby to predict rainfall with infallible certainty, especially in summer, when the barometer frequently fails to be a guide. Although his results are at variance with Hennessy, and possibly Janssen, yet it is desirable that systematic observations be made on this matter by some of our experienced American spectroscopists. Mr. Abbe has found only a partial success in following Smyth's directions.

A. S. Herschel has described a convenient method of attaching a measuring-scale to pocket-spectroscopes, such as meteorologists use in studying the aurora, the aqueous lines, etc. His method consists essentially in substituting for the jaws of a pocket-spectroscope a disk through which is cut or punctured a vertical slit and an oblique row of small holes.

An excellent review of the investigations and literature relating to the radiometer, by W. H. Stone, will be found in the April number of the *Popular Science Review*. The idea of using the radiometer as a convenient means of measuring the solar radiation does not seem likely to lead to any results.

An important method of determining the temperature of any gas upon which the sun is shining is given by Aymonnet, in the Paris *Comptes Rendus*, which may evidently be applied to the determination of the temperature of the air by means of thermometers exposed directly to the sun, or other source of heat. Aymonnet's method consists essentially in having two thermometers, or other apparatus, side by side. It is by comparison of their readings, and after determining a certain constant depending on their instrumental peculiarities, that he computes the temperature of the air.

Intimately connected with the application of Aymonnet's method are the results of an independent investigation by Professor Villari, of Bologna, presented to the Academy, at the same meeting, by Jamin. Villari has investigated the

emissive power and the different kinds of heat that certain bodies emit at the temperature of boiling water. He has established that for each substance there is a thickness at which it has the greatest emissive power; second, that this thickness varies from 3.45 millimeters for powdered rock-salt to 0.03 for Indian-ink; third, this thickness varies with the consistency of the matter—thus, for lamp-black directly deposited, it is 0.200 millimeter, while it does not exceed 0.069 when the lamp-black has been previously mixed with bisulphide of carbon; fourth, as the same laws obtain in respect to the absorbing powers of bodies, it follows that the thermoscopes, in order to produce their maximum effect, should be covered with a shell equivalent to 0.2 millimeter of lamp-black; fifth, the different bodies present different emissive power for different portions of the spectrum—that is to say, if the heat emitted by each at the temperature of boiling water were visible, they would all appear of different colors and of different intensities; sixth, no substance whatever has a maximum of transparency for those rays which it emits at a temperature of 100° C.

Dr. E. J. Mills, of Glasgow, contributes some notices of results of a minute inquiry into the constancy of the errors of thermometers. The sets or secular change depend on the temperature. The effects of external pressure and of the alternate heating and cooling were examined, and series of standard bodies prepared, whose melting-points range from 35° to 121° (Fahr. ?), which can be used as tests for any new thermometer.

In reference to the idea of an instrument for registering the sum total and the average temperature, several contributions have appeared, and among them one from William F. Stanley (*Nature*, vol. xviii., p. 41), who describes an apparatus invented by him in 1876, and which is essentially a modification of the pendulum clock, which seems to have considerable merit. It should, however, not be forgotten that chronometers have, for the past forty years, been frequently constructed with large rates, for the purpose of ascertaining average temperatures during longitude-campaigns.

The recent publications of the Indian Meteorological Office at Calcutta, under Blanford, include, besides the "Observations," the "Memoirs," and the "Instructions" previ-

ously noted, also the "Tables" for the use of observers. In the latter Blanford gives especial attention to the tables to be used with the dry- and wet-bulb psychrometer, which tables he has compiled for the altitudes 300, 2000, 4000, and 7000 feet. So far as regards relative humidity, these can be used in other countries as well as in India; but as regards vapor tensions, they are specially adapted to the latitude 22°, in order to allow for the variation of gravity. This slight correction was, according to Blanford, first applied by Robert Dixon.

According to Markham, in 1872, Dr. Forbes Watson, the Reporter on the Products of India to the Secretary of State, prepared an elaborate paper on the Conditions under which the Wet- and Dry-bulb Barometers should be Exposed, in order to give Accurate Results as a Hygrometer. This paper represents a vast amount of laborious work and careful thought, and the tables of observation that accompany it tend to show that the results hitherto obtained by the use of the wet and dry bulbs are nearly worthless. Dr. Watson suggests steps that should be taken to ascertain the conditions under which it may be possible to obtain reliable results. Mr. Buchan has expressed his sense of the great value of Dr. Watson's memoir, and that it ought to be in the hands of every meteorological observer, but it has not yet been printed.

A paper on an Improvement in the Hair Hygrometer was read by Dr. Nippoldt before the German Association at Cassel.

A modified form of hygrometer, in which the quantity of aqueous vapor is directly determined by a volumetric process, has been constructed by Schwackhöfer for Dr. Lorenz and the Agricultural High-School at Vienna. This "volume hygrometer" has of late been employed in a series of hourly observations, for which it proves to be very convenient. The accuracy attained by it is one hundredth of one per cent. of the volume of vapor. The apparatus is equally accurate at all temperatures, and in high winds or in calms. It can also be used to determine the quantity of moisture present, as fog or cloud. Its price, however, is about $100.

In the quadricentennial volume of "Meteorological Observations" published at Upsala, Rubenson gives some notes as to investigations into instruments and methods. He finds

that for temperatures above freezing, the psychrometer gives, with Regnault's tables, the same quantity of moisture as is found by chemical methods of observation. His fixed anemometer was investigated by means of a similar portable standard, and found to require corrections amounting to ten per cent. of the whole wind velocity. By placing anemometers upon different portions of a railroad train, he investigated the variations in the flow of air past the train, but could only be thereby led to a very general confirmation of the results given by other methods as to the accuracy of the anemometer.

Among the scientific papers published in the memoirs and notices of the current volume of the *Meteorologia Italiana*, we have received a timely paper, by Dr. Chistoni, on a Comparison of the Regnault Dew-point Apparatus, August's Psychrometer, and the Ventilation or Whirling Hygrometer, which was first recommended by Belli—a subject that is now very generally attracting attention; and it is probable that the demand for increasing accuracy in meteorological data will soon require that the psychrometer be left to second-class observing-stations, and that the standard observers adopt either dew-point instruments or chemical methods.

Chistoni concludes that, under a barometric pressure of about 30 inches, and at temperatures of about 50° Fahr., the *psychrometre à fronde* will give the tension of vapor to within a tenth of a millimeter, and the relative humidity precise to within five per cent.

A modification of Regnault's dew-point apparatus has been invented by Alluard, Director of the Observatory at Clermont. It is essentially a square brass tube, gilt and highly polished, containing the ether to be evaporated, and also a thermometer to indicate its temperature; the air-temperature being shown by an exterior thermometer. The dew is deposited upon a flat surface, and can be seen at a great distance, by contrast with a contiguous polished surface.

A cheap and serviceable self-recording anemometer, giving velocity and direction, is described by Nipher in the last volume of the *Transactions* of the St. Louis Academy. He also contributes a note on the discordances as to velocity as registered by anemometers only a short distance apart, which—although he does not so state—are evidently due in large part

to the deflection of currents of air by the sides of the building, which deflections vary with the direction of the wind.

A new self-registering anemometer has been described by Hervé Mangon (*Nature*, p. 316). He combines the Robinson cups and the windmill-vanes very much as in the instruments made by Beck for the London Meteorological Office; but his registering apparatus acts through the intervention of electricity, as in the apparatus devised by Gibbon for the Army Signal-Office. The record is made upon a long fillet of paper.

Dr. T. R. Robinson communicated to the Royal Society of London, in April, the results of new experimental investigations upon the constants of the cup-anemometer. He repeated, with some modifications, the experiments made by Dohrandt. His anemometers had cups of 9, 4, 9, and 4 inches diameter, and arms of 24, 24, 12, and 12 inches in length respectively; but hemi-cylindrical cups 9 inches square, with 24-inch arms, gave decidedly the best results.

Hipp's self-recording anemometer, which is being widely adopted in Switzerland, is described by him in the *Bulletin* of the Society of Neuchatel, vol. x. The Robinson cups record their revolutions by means of electricity, so as to give the velocity by minutes or by hours, as may be desired. In the same volume, Professor Schneebeli continues his annual reports of the Variations in Level of the Swiss Lakes.

A contribution to anemometry is to be found in a short memoir, by G. A. Hagemann, in the Introduction to the Meteorological Annals for 1876, in the Danish Meteorological Institute. Hagemann compares the siphon-anemometer—known as the Lind anemometer in England and America—with a modification of it by Captain Magius. His conclusions are in favor of the siphon or Pitot tube, and not in favor of Magius's invention.

The ninth volume of the *Transactions* of the New Zealand Institute contains, among other articles on meteorology, one by Captain Marten on Anemometry. He considers that the extraordinary wind velocities recorded by the Robinson anemometer, such as 153 miles per hour at Sydney, New South Wales, 109 at Southland, New Zealand (and 181 at Mount Washington), are not real, but need a large correction for instrumental peculiarities, such that, as he concludes, the velocity of 153 miles corresponds to one of scarcely 100.

Wild has published a short paper in the *Bulletin* of the Academy of St. Petersburg on Control Barometers—that is to say, such as are to be used in comparing station-barometers with the standard one at the Central Station. He states that his first experiments in this line were made with a new siphon-barometer, constructed, according to his directions, by Turretini, of Geneva. Several improvements have been suggested in the course of his work; and two instruments were constructed, with slight changes, by Brauer, of St. Petersburg, and C. H. F. Geissler, of Berlin; and, lastly, one by R. Fuess, of Berlin—all three of which, he states, have given such eminent satisfaction that we are finally in possession of a thoroughly reliable and invariable portable mercurial barometer—one whose indications may be relied upon to the twentieth part of a millimeter or the five-hundredth part of an inch.

In a memoir upon Atmospheric Pressure, Ragona gives some important measures of the corrections due to capillarity and of the meniscus form of the top of the mercurial column. In a siphon barometer the height of the meniscus in the two legs is seldom the same. In comparing any barometer with a standard, he finds the relation of the former to the latter to vary with the pressure, temperature, and diameter of the tubes.

Goldschmid invented before his death a very delicate self-recording attachment to his form of aneroid barometer. A test series of observations at Zurich shows that his apparatus gives quite as good results as ordinary readings.

The Goldschmid aneroid, whose introduction during the past ten years has extended throughout Germany and Switzerland, has been materially improved upon by Professor A. Weilenmann, of Zurich. These improvements were proposed by him in 1872, and in the twentieth volume of the *Quarterly* of the Zurich Association he gives the results of an extended study of the merits of his improved aneroid. The analytical investigation of the errors to which the aneroid is, in general, subject, is, we believe, fuller than any hitherto given; and the formulæ thence deduced for his own instrument show that, after determining the four instrumental constants—or the corrections for temperature, pressure, errors of scale divisions and micrometer screw, and gravity—his instrument during a year, and for a range of 60° temperature

and 8 inches pressure, shows no greater discordance than between two standard mercurial barometers.

Among other works relating to the Goldschmid aneroid, we will note one by A. Dorna, of Turin, "L'Aneroide a vite Micrometrica." He used one made by Hipp, of Neuchatel, and derived very satisfactory results.

"A Contribution to our Knowledge of the Practical Value of the Naudet Aneroid in Hypsometry" is the title of a work by Dr. M. Schmidt, of Munich, who states that extensive investigations were made by him in 1873, etc., which are partly reported in a work by C. Hetting, and that he hopes now to further testify to the value of the instruments. His aneroids were made by the firm of Naudet & Hulot; their temperature and pressure errors were carefully determined. The error introduced by the irregular variations of the constant term was only ± 0.11 meter in the most unfavorable case, and the total uncertainty of any altitude is 0.78 meter.

A Summary and Critical Comparison of Recent Works on the Improved Aneroids is given by Ricco, in the memoirs of the Italian Spectroscopical Society, February, 1877. He especially considers the forms known as Goldschmid's (1), with lever; (2) without lever; (3) Weilenmann's, with microscope; (4) Goldschmid's self-registering; (5) Redier's aneroid for French agricultural stations. Ricco is also the author of L'Aneroide Rivista, published in the *Annuaire* of the Society of Naturalists, Modena.

The seventh volume of the *Proceedings* of the Scientific Association at Carlsruhe contains numerous notices of the papers read before the Society during 1872 to 1875, among which we notice: Jordan, on the Use of the Aneroid in Hypsometry, especially in Southwestern Germany; and Wiener, on the Radiation received by the Earth from the Sun—an important memoir, printed in full.

In the "Results of Meteorological Observations in 1873 in New South Wales," the Government Astronomer, H. E. Russell, describes his new electrical barograph. The record is made of natural size, and the time-scale, as well as the pressure-scale, are drawn by the instrument itself, so that the moments of records are not subject to any doubt, as in many self-registering instruments.

Professor Nipher, at the last meeting of the St. Louis Acad-

emy, read a paper on the rainfall measurements as affected by placing the gauges upon the roofs of buildings instead of on the ground—a very complicated question, and already much elucidated by the experiments at Mr. Symons's experimental stations. As is generally conceded, the inaccuracy of gauges increases when they are subject to brisk currents of air. "Any obstacle placed in a stream of air causes the air to sweep over the top and around the sides with an increased velocity." As a result, the drops of rain are deflected from their paths and drift to leeward. Mr. Nipher has endeavored to construct a rain-gauge so as to make it correct this tendency of the drops. His idea is the same as had already occurred to his colleague, Professor Woodward, and he accomplishes it by surrounding the gauge with a shield which deflects the wind downward. These shields are adjustable, and have been placed on several gauges whose indications were, at first, very discordant, but which now are brought in perfect accord with each other.

The influence of altitude on the records of the rain-gauge has been investigated by Dines, who observed gauges at altitudes of 50 feet and 4 feet. On the average the lower one caught 57 per cent. more than the upper one; in cases of light, fine rain, with strong wind, the lower gauge gave two or three times more than the upper one; occasionally, in heavy rains without wind, the records were alike. Dines concludes that the differences are due to the wind.

The observations made by Mr. Dines on the rainfall, the direction and force of the wind, and the shape of the tower in which the gauges are placed, are published in Symons's "British Rainfall for 1877." Mr. Field discusses these observations in Symons's *Meteorological Magazine*, for August, 1878, and concludes: first, that the ratio of the rainfall on the tower to the rainfall on the ground depends on the force and direction of the wind; second, that when there is no wind the amount of rainfall on the tower is about the same as that on the ground; third, that when there is wind, the amount of rain falling on the tower will vary on the different portions of the tower; the portion nearest that point at which the wind strikes the tower receives less rain than falls on the ground, and the portion farthest from that point receives the same or more rain than falls on the ground;

fourth, that the excess of rain falling on the latter portion of the tower will, to a large extent, compensate for the deficiency on the former portion.

An appendix to the "Washington Observations for 1874" contains an investigation by Professor Eastman into the comparative results obtained by using rain-gauges of different sizes and patterns. Fourteen gauges were set up in two groups, and established respectively on the southwest corner of the roof, and at the surface of the ground on the lawn. The seven gauges in each set were of similar sizes, and he found but little difference in the quantities of rain caught by gauges two inches or more in diameter. On the other hand, the average quantity received by the set that was established on the southwest corner of the roof was but 90 per cent. of that caught by the set on the lawn, 34 feet below. The readings for the roof during steady drizzling rains were 80 per cent. of those for the lawn; but during sudden showers, generally accompanied by high wind, the percentage was 92. He concludes that wind has little, if any, influence.

CHEMICAL AND PHYSICAL PROPERTIES OF THE AIR.

Thiesen publishes an interesting memoir on the extent of our atmosphere. Having regard to all that at present is known of the physical properties of air, he finds that contradictions arise at almost every step, and that we are not as yet able to indicate the limit of our atmosphere. He has sought to determine how far the circumstances that are ordinarily neglected—such as the individual gravitation and the movements of the gases—can affect our views as to the extent and density of the atmosphere surrounding each planet.

Ebermayer has, in connection with his work at the Bavarian Forest stations, investigated the quantity of carbonic acid in the air and in the ground, in the forests and in the open field.

The presence of hydrogen peroxide in rain-water has been investigated by Kern, in a village about ten miles from St. Petersburg. He finds that it is always present during June, July, August, and September, and that it is least in quantity when the rain falls with a northerly wind.

Schöne, of Moscow, communicates to the *Berichte* of the

German Chemical Association the results of laborious investigations on the presence of peroxide of hydrogen in the atmosphere. He finds that its percentage increases with the height above the earth's surface at which the condensation of the aqueous vapor takes place.

Guttmann publishes in Virchow's *Archiv* some researches on the physiological action of peroxide of hydrogen. May not the excess of this gas at high altitudes partly explain the dyspnœa and other effects of altitude upon the human system?

Russell, at Sydney, has observed the atmospheric absorption lines between the D lines of the solar spectrum. He finds only seven; while Huggins, in Kew, sees twelve; and Campbell, in London, sees nineteen. He concludes that in the atmosphere of Europe, and especially of London, some gases must exist that are not present at Sydney.

Mr. J. P. M'Clear communicates to *Nature*, vol. xvii., p. 1, some observations of the spectrum of the aurora australis made on board the *Challenger*, 1874, February 9, 21, March 3 and 6. He seems, in two cases, to have observed three lines frequently seen in the northern hemisphere, and on March 3 also observed, in addition, a fourth line, but the red line was not seen.

Cornu has communicated to the Paris Academy some remarks upon photographs of the ultra-violet portion of the solar spectrum which go far to supplement the views we have often expressed on the importance of the spectroscope as an instrument for ascertaining the quantity of aqueous vapor present in the atmosphere. The purest sky of summer cuts out much more of the ultra-violet rays than the purest sky of winter does. The absorption at the violet end is general, or in broad bands, while at the red end it is selective, or in narrow bands; the absorption by vapor which is but just beginning to condense affects the violet end, while the red end is specially affected by vapor in a state approaching that of fog or cloud; the smaller the particles, the less do they affect the red end of the spectrum. Such are some of the principles deduced or suggested by recent investigations.

Gully communicates to the Paris Academy a memoir on the relation between the manifestations of ozone and the cy-

clonic movements of the atmosphere. He seems to conclude that every time that a barometric depression is central to the south of his observing station at Rouen, the sensitive paper always turns very strongly blue. He thinks that near such a depression the coloration of the paper is increased, but remarkably so only on the north side, and is attributable to the unequal electrization of the air.

The showers of dust that frequently fall on ships traversing the Atlantic Ocean have been investigated by Hellmann, who finds that the limits of the area of dust-showers are 6° S. and 3° N. lat., and from the coast of Africa westward to 38° W. long. They are most frequent in winter near the African coast, but in spring at points farther west. The sand and dust evidently come principally from Africa and the Sahara, and the coarser deposits occur in the east portions of the region of dust-showers, while as we go west, or away from Africa, the deposits are finer. These, therefore, give us some idea of the annual change in the atmospheric currents.

E. Yung, microscopist to the University of Geneva, communicates to *La Nature* a chapter on the atmospheric dust and germs collected in Switzerland.

Miguel sends to the Paris *Comptes Rendus*, for June, the results of an investigation into atmospheric dust. His work relates only to the number of corpuscles whose diameter exceeds two thousandths of a millimeter. He finds the average number small during the winter months; it increases rapidly during the spring, remains stationary throughout the summer, and speedily declines in autumn. A fall of rain is at all seasons followed by an increase—sometimes a very remarkable one. Temperature and moisture appear to be the controlling conditions influencing their numbers. The ova of large infusoria were comparatively rare. The spores of moulds were very abundant.

The liquefaction of oxygen, nitrogen, and hydrogen, under the low temperatures and high pressures attained by Pictet and Cailletet, important as they are from a physical point of view, can hardly be said to be of much practical importance to the meteorology of our atmosphere under existing conditions.

The work of Professor O. E. Meyer, of Breslau, "Die kinetische Theorie der Gase," treats, in a manner as elementary

as is practicable, of the physical properties of gases that find their grandest exemplification in the atmosphere.

The second volume of Lord Rayleigh's "Theory of Sound" has been published, and a third is promised. This work contains a discussion by the master-hand of the theory of sound in air, the mechanics of fluids, the influence of viscosity or fluid friction, etc.

The mathematical theory of the resistances and motions of fluids is of such difficulty that only rarely do we have occasion to note any real progress in our knowledge of this subject. A valuable article on the resistance of fluids has, however, been published by Lord Rayleigh (*Philosophical Magazine*), in which many important results are given, with some account of the processes by which he arrived at them. The expression for the resistance of a meteor or other rapidly moving body will interest meteorologists. In a subsequent note Lord Rayleigh discusses the subject of the *Vena Contracta.*

A large collection of formulæ and data relative to the movement of air in pneumatic tubes is contained in a series of papers on this subject by Culley, Sabine, Bontemps, Unwin, etc., in Vol. XLIII. of the *Proceedings* of the Institute of Civil Engineers.

Of mechanical problems whose solution offers something of interest to meteorologists, we note the papers on Vortex Motion and on Waves presented to the London Mathematical Society at their meeting on the 8th of November. In the former paper Professor Clifford gives a simple solution of the problem so profoundly handled by Stokes, Rankine, and Helmholtz. The paper on Waves, by Lord Rayleigh, communicated some results, also published in his work on "Sound:" the phenomena attending the advance of a group of waves into still water, and those attending a group of deep-water waves, as also the formation of the system of diverging waves that precedes any body moving along through the water, are all explained as due to the existence and superposition of two infinite trains of waves of nearly equal wave lengths and amplitudes.

Those interested in the flow of water in rivers will find in Vol. VI., No. 23, of Indian Engineering, a translation by Cunningham of Bazin's "Discussion of Experiments on Velocity

in a Channel." A few notes are added by the translator, highly appreciative of Humphrey's and Abbot's work on the Mississippi.

The action of frictional resistance and loss of energy upon water when flowing at various velocities through a nozzle with a converging entrance and diverging outlet has been carefully treated experimentally by James Brownlee, whose memoir thereon is published in Vol. XIX. of the *Transactions* of the Institute of Engineers and Ship-builders in Scotland; following this paper, Mr. R. D. Napier, Professor J. Thomson, and others gave some valuable theoretical expositions of the subject. The same volume contains a careful paper by Mansel, in which are deduced several propositions on the motion of steam-vessels.

P. D. Heen, in the Brussels *Bulletin*, 1878, p. 798, communicates an investigation into the laws of the fluidity of liquids. He defines the coefficient of fluidity as the relative time required for the molecules to be displaced or to slide over each other to an equal distance in different fluids. He determines this coefficient experimentally for numerous fluids and saline solutions, and applies the results to determining the velocity of flow of the liquids through small apertures.

The resistance of the atmosphere to the oscillations of the torsion pendulum has been investigated by Cornu and Baille as one of the preliminaries to their proposed accurate measurement of the earth's density. They find this resistance appreciable, and that in consequence of its existence the amplitude of the successive vibrations diminishes in geometrical progression, while the times of the elongations diminish in an arithmetical progression. It is hence inferred that the resistance of the air is proportional to the first power of the angular velocity of the balance.

Mr. David Trowbridge, of Waterburgh, N. Y., publishes a paper on the atmospheres of the sun and planets, in which he takes account of the temperatures of the surfaces of the planets and various modifying circumstances, and shows that if the earth were 490° warmer than it now is, the height of its atmosphere would be more than doubled. He shows that *Jupiter's* atmosphere at his surface is either very dense or else the temperature at the surface is greater than 1000° Fahr. The height of the barometer at the sur-

face of *Jupiter* is, on the most reasonable supposition, 82.5 inches, and the pressure to the square inch 93¾ pounds. For *Saturn*, he finds the atmospheric pressure to be 18 pounds. The heights of the atmospheres in miles, and pressures in pounds per square inch, resulting from certain very reasonable suppositions, are as follows:

	Height. Miles.	Pressure. p'ds per sq. in.		Height. Miles.	Pressure. p'ds per sq. in.
Mercury....	719	3	Jupiter.....	146	88
Venus.....	392	11	Saturn	313	18
The Earth..	343	15	Uranus.....	515	8
Mars.....	1095	1	Neptune.....	436	9

He remarks that the peculiar figure Sir William Herschel found *Saturn* to present—which Bessel and others could not discover, and which Airy could not explain—is accounted for without difficulty by the currents in his atmosphere, as will be seen by consulting Mr. Ferrel's treatise. With reference to the solar atmosphere, Mr. Trowbridge assumes that its temperature is about 9,800,000°, and that its density at the surface of the sun is not greater than half the density of hydrogen at the surface of the earth. On whatever assumption we make, Mr. Trowbridge finds the solar atmosphere so rare that we easily explain the rapid movements of the red hydrogen flames that have been observed by the spectroscope.

Meteorology, as well as Astronomy and Natural History, has a common interest in the questions of cosmogony; and upon the fundamental question as to the origin of the rotation of the earth, sun, and planets, considerable light is thrown by an investigation (published in the *Bulletin* of the Royal Academy of Belgium) of C. Lagrange, on the influence of the form of bodies on their attractions. He concludes that the revolution of the satellites in their orbits about their primaries has determined the direction and velocity of rotation of the latter, and similarly the planets have determined the rotation of the sun. Should these results be generally accepted, they must prove to be a very material contribution to a modified form of Laplace's nebular hypothesis.

TEMPERATURE.

A very complete memoir, by Chr. Wiener, on the radiation received by the earth from the sun, is published in the

seventh volume of the *Verhandlungen* of the Scientific Association at Carlsruhe. Wiener develops only the purely mathematical portion of the problem, and carries the investigation into some details that have been treated of only in a general manner by Meech and others. His attention is especially directed to the total radiation received in one day in various latitudes and seasons. He finds, as others have done, that during the hottest quarter of the year the heat received at the poles exceeds that at any other portion of the globe. The absorption by the atmosphere and the radiation from the earth are not considered by our author. Certain graphic methods of computation employed by him are shown to agree sensibly with more refined processes of calculation.

The new scientific journal, *Archiv für Mathematik og Naturvidenskab*, published at Christiania, contains an article, by H. Geelmuyden, on the influence of the eccentricity of the orbits of heavenly bodies upon the quantity of heat they receive from the sun.

J. Violle communicates to the Paris Academy of Sciences the results of actinometric observations made in the desert of Sahara and in Algiers. He finds the constant of solar radiation received by the earth to be 2.40 or 2.42, and less than the 2.54 obtained from his observations on Mt. Blanc. Violle's work is reviewed in the *Revue Scientifique*, 1878, p. 944, and in Hann's *Zeitschrift*.

Crova has continued his investigations into the calorific intensity of the solar rays. He states that his observations during 1877 completely confirm those of 1875 and 1876. The intensity measured at noon increased steadily up to the 15th of March, then diminished up to the 28th of June, and again increased to the 16th of October. The observed radiation was feeblest with south or southeast winds and high temperatures, and strongest for north or northwest winds and low temperatures. He has also observed the telluric bands in the solar spectrum, and has established the fact that their intensity is greater in proportion as the solar radiation is feebler. He has also measured the radiations transmitted through a layer of water. He concludes that the absorption produced by the vapor of atmospheric water has an influence upon the transmission of solar radiations, but that

a preponderant part is due to the absorption to which they are subjected before traversing our atmosphere; that in fact the absorption which they experience in traversing the solar atmosphere itself has deprived them of a large part of the rays that are absorbable by water.

We have in former summaries omitted to call attention to an elaborate historical and critical memoir, by Crova, in the *Annales de Chimie et de Physique*, for August, 1877, on solar radiation and absorption in the earth's atmosphere. A short but suggestive article on the same subject, by Govi, will be found in a recent number of the Paris *Comptes Rendus*.

The ultra-violet spectrum has been studied by Cornu. By employing quartz object-glasses, he is able to show that the spectrum varies with the time of day, having a maximum about mid-day; it is also longer in winter than in summer.

On the subject of solar radiation, the work of Radau, "Les Radiations Chimiques," is to be commended to those who extend their meteorological investigations to the fundamental question of the absorption by the earth's atmosphere of the solar radiations.

Mr. G. M. Whipple, of the Kew Observatory, communicates to the British Meteorological Society a memoir on the Relative Duration of Sunshine at Greenwich and at Kew. He finds that at Greenwich the sunlight is cut off by fog or smoke when the wind blows from west-northwest or north, but by east and southwest winds the fog or smoke is blown over Kew, cutting off its sunlight.

Rubenson has examined the diurnal variations of temperature at Swedish stations, and finds (1) the non-periodic variation is throughout the year greater than the periodic; (2) the difference of these two variations is greatest in winter; (3) during the remainder of the year the difference is nearly constant; (4) the difference—2.66 in spring, 2.82 in summer, 3.03 in autumn—can be assumed to hold good apparently for the whole of Sweden. The difference in question is greater for a maritime climate, and least for one of a continental type.

In a communication to the French Association at Havre, Glaisher gives the results of all his observations in balloons upon the decrease of temperature of air with altitude. He finds an increase during the night-time, and a more rapid decrease during the day-time than is usually accepted. Eleven

years of observations upon thermometers placed at altitudes varying from four to twenty-four feet conduce to the same result. The greatest irregularities are, however, met with in ascensions to considerable heights, and much more knowledge on this subject is greatly to be desired.

Guldberg and Mohn have published two articles on the Vertical Diminution of Temperature in the Atmosphere. Their essay goes over a ground already pretty fully traversed by Thomson, Reye, Hann, etc., but presents some features of the subject in a rather new aspect. Their formulæ relate to a stationary atmosphere and to ascending and descending currents.

Alluard communicates to the Academy at Paris the results of observations, on the Puy-de-Dôme, on the Nocturnal Variations of Temperature at Different Altitudes. He has studied the minimum, maximum, and mean temperatures, from January to August, 1878, at the summit and at Clermont. During these months he finds 49 cases in which the minimum temperatures at the summit are decidedly warmer than at the base, and he concludes that during the night-time the temperature varies with altitude in an entirely different manner from what it does by day.

The most important work on atmospheric temperatures received during the year is the first part of Wild's "Temperatur-Verhältnisse" for the Russian Empire, which great work will eventually include all questions relating to the distribution of temperature throughout Asiatic and European Russia. The present volume is confined to the preparatory work of collecting and criticising the material at hand, and especially to the investigation of the diurnal temperature periods, as shown by series of hourly or other frequent observations. Wild declines to present the laws of diurnal variations in the form of the Lambert formulæ, and confines himself to the graphic method of plotting and interpolation by means of free-hand-drawn curves. The reasons for this important step are fully and forcibly given, and consist in the utter insufficiency of the Lambert formulæ to represent the observations unless from eight to sixteen terms are employed, which leads to great and unnecessary labor, and even then introduces erroneous times of maximum and minimum.

Wild concludes this portion of his work with a series of

twelve generalizations in reference to diurnal temperature changes. Among the conclusions he deduces from these, we note that he deems it entirely premature to elaborate any formula for the connection between the diurnal period and its apparent physical causes, the solar radiation, atmospheric diathermancy, soil, winds, clouds, etc. Elaborate tables for the reduction of observations made at various hours to the true daily and annual means conclude this first portion of Wild's important work. The expense of compiling these tables has been borne by the minister in charge of the crown lands.

Tables of mean annual temperatures for numerous points in Colombia and Ecuador are published by Reiss and Stübel in the tables of altitudes determined by them in those countries.

The twenty-five years of unbroken observations from 1848 to 1872, at twenty-nine stations in Germany, have been, by Hellmann (*Zeitschrift K. P. Statistischen Bureaus*, vol. xv., p. 405), made the basis of an inquiry into the Variability of the Temperature in Northern Germany. The highest mean variability occurs in Eastern Prussia; the least variable climate is that of the northern coast of the Baltic. The average variability of the summer months is only half that of the winter months. The most variable month is February; the reason of which is found, by Hellmann and Dove, in the fact that at that time the waters of the Arctic regions are still frozen up. A highly suggestive table gives the number of years necessary to be employed in order to obtain a mean that shall have an accuracy of one tenth of a degree, whence it appears that three hundred years of observations would be needed to obtain this accuracy in the mean for the most variable month, or February.

Hann has communicated to the Academy of Sciences of Vienna a memoir on the Temperature of the Air observed at that place during the last hundred years, in which work he has simply completed a task left unfinished by Jelinek. He investigates the secular change and the annual changes, and especially the relation between the temperature and the sun-spots, in reference to which latter subject he concludes that the influence of the sun-spots upon the mean temperature is so slight that within any given eleven-year cycle it is

completely obscured by other influences, and that even in the mean of nine cycles there is no certain evidence of any definite relation; to which conclusion Celoria had also come in 1874, in reference to the temperatures of Milan. Hann has also investigated the possibility of predicting the temperature of any given season of the year from the known temperature of the past season. He concludes that, on the whole, when the temperature of any season is decidedly greater or less than the normal temperature, it is more probable that the following season will deviate in the same direction from the normal. Similar results have been obtained by Quetelet and Eisenlohr. In conclusion, he reduces the temperatures hitherto observed in Vienna to the locality of the new Meteorological Institute, on the Hohewarte, near Vienna. In a subsequent paper on this same subject, Hann revises his method of determining the mean temperature, inasmuch as he considers that he may have been led into error by having given too great weight to the long series of observations made unfortunately with somewhat less perfect instruments and under an objectionable exposure.

The direct utilization of the solar heat for industrial purposes—a subject which has been diligently pursued for many years by Mouchot—forms the subject of a note by him read before the Academy of Sciences, September 30, 1878, in which he says that his smaller pieces of cooking apparatus have never failed to work during sunny weather. Some mirrors of less than half a square meter, constructed with all desirable perfection, have sufficed to roast half a kilogram of beef in twenty-two minutes, and to cook, in an hour and a half, stews which required four hours of an ordinary fire of wood; and in half an hour to bring three fourths of a liter of cold water to the boiling-point, which latter corresponds to the utilization of 9.5 colories per minute per square meter—a remarkable result in the latitude of Paris. The solar alembics have also furnished equally excellent results. Assisted by Pifre, he had completely set up, on the 1st of September, a solar receiver, whose mirror presents an aperture of about twenty square meters.

Of the innumerable inventions of the venerable John Ericsson, he is, we believe, most fond of his inventions and researches relative to caloric and solar engines, and the direct utili-

zation of solar heat. A work published by Mouchot, in 1869, "La Chaleur Solaire et sur Applications Industrielles," gives a rather complete exhibit of all that had been done up to that time in France, and some notice of the life-work of Ericsson. But the Centennial Exhibition gave Ericsson himself a proper occasion to collect and review his imposing array of works in this department, beginning, we believe, with 1825 or thereabouts. These he has published, at his own expense, in a luxurious work, in which he reproduces much of what he has elsewhere published, and adds much more new and critical matter. The work is invaluable to one who would follow the author in his long career, and would understand the merits of the questions at issue between him and many other investigators.

MOVEMENTS OF THE ATMOSPHERE.

In a mathematical discussion of the movements of the wind, M. Finger, of Vienna, finds that, in consequence of the earth's rotation, any movement of air along the surface must affect the barometric pressure. Easterly winds increase the pressure, and westerly winds diminish it.

Eugene Suttor, honorary engineer, of Belgium, contributes to the Royal Institute of Luxemburg, vol. xvi., a memoir on the Movement of Bodies on the Surface of the Earth, taking into consideration the diurnal rotation of the latter. His work is apparently independent of those which have been published the past few years by several investigators; and he applies his formulæ simply to explain the phenomena of the Foucault pendulum, and the observations, by Reich, on falling bodies, at Freyberg.

An inaugural dissertation of T. Bertran, at the University of Marburg, 1876, has come to hand rather late in the day, on the subject of the Motion of a Material Point, under the Influence of Gravity, upon a Surface of Rotation having a Vertical Axis. After the general equations of motion have been given, he considers especially cylindrical, spherical, and paraboloid surfaces.

Attention should be called to an article, by J. Aitken, in the *Philosophical Magazine*, on Rigidity produced by Centrifugal Force. This subject has been treated of by Sir William Thomson theoretically, and by Osborne and Aitken ex-

perimentally. The latter illustrate the subject by investigating the movement of a chain hanging loosely over a pulley, around which it is rapidly running. The various curious curves into which it twists itself are fairly explicable by a proper application of the laws of centrifugal force, and the elasticity and rigidity that are imparted to the chain by its motion remind one of the properties of vortex rings of air or water. The allied mechanical principles here involved will, it would seem, also find an application in some phenomena of meteorology, especially those of tornadoes. These views were first communicated two years ago by Aitken to the Royal Society of Edinburgh, but have only recently been published.

The students of vortex motion will find some valuable chapters in the last volume of the *Proceedings* of the Royal Society of Edinburgh, which, although delivered in 1875, have only come to hand the past year. The first paper, on Vortex Statics, by Sir William Thomson, concludes with a brief statement of the general propositions, definitions, and principles. The paper itself deals with the steady motion of vortex rings. The cases are considered in which one circular vortex ring is linked with another, and where three or more rings are mutually interlinked; the cases of trefoil knots, nine-leafed knots, and much more complicated figures are also considered. Further papers on the same subject are also promised.

At the reunion of French scientists at the Sorbonne, Professor Hebert, of Mulins, read a paper on the General Movements of the Atmosphere. From the Signal Service tri-daily weather-charts he concludes that the Atlantic storms have their origin in the Rocky Mountain district, being produced by the friction of the equatorial current against the mountain-tops. These tourbillions follow the river-courses to the Gulf of St. Lawrence, and there form the great depressions which start across the Atlantic; and we need hardly say that Mr. Hebert's conclusions differ widely from the views held by American meteorologists.

A contribution to our knowledge of the effect of winds on the gradient of rivers (and inversely to the friction of wind over water) is given in a paper, by W. H. Searles, on the Levels of Portions of the Erie Canal. He finds the probable error in 136 miles of most careful levelling to be ± 0.103 foot.

The Science Observer, the organ of the Boston Amateur Scientific Society, contains notes by Henry White, calling attention to the importance of observing meteor trains as a means of learning something about the air-currents at high altitudes. The importance of such observations is not to be denied; but unless several observers at well-located positions unite in such observations, we fear that but little can be deduced relative to air-currents. Were a few persons, located within fifty miles of each other, to systematically observe and compare notes on the motions of cirri, polar bands, and meteor trains, they would soon be in position to materially contribute to meteorology.

Observations on the direction of the motions of clouds continue to attract increased attention. Besides the apparatus invented by Goddard, Braun, Linss, and others, Marié Davy describes the following, which he has established in the garden of the observatory at Mont Souris. It consists essentially of a horizontal mirror upon which the sixteen principal compass points are engraved. The observer places his eye so that the image of the cloud appears in the centre of the mirror; he then sets a small cone upon the mirror in such a position that the point of the cone covers the same centre. A few minutes afterwards he brings his eye to the same position, and easily sees in what direction the cloud has moved.

Linss has observed the motions of the clouds at Darmstadt with his improved form of Braun's nephoscope. He finds that the apparent velocity of cumuli, pallio-cirri, and cirro-cumuli is greater at 8 A.M. than at noon or 4 P.M. He finds a constant relation between the directions of the higher clouds as compared to cumuli, and that the changes in the upper strata of air occur at least four hours earlier than in the lower ones.

The first publication of Dr. Hildebrandsson on the Movements of the Upper Currents has been followed by the publication, at Upsala, of an "Atlas des Mouvements Supérieurs."

Besides this, Rev. Clement Ley has published a series of maps for each day of March, 1876. His studies make it probable that the stratum of air in which cirrus-clouds occur is at a much higher level over the advancing portion of the cyclone than over its rear.

In addition to their memoir on the Distribution of Tempera-

ture in the Air, Professors Guldberg and Mohn have also published a short elementary essay on Vertical Currents in the Atmosphere. They treat of ascending and descending currents, and illustrate their formulæ by numerous examples, and especially urge the importance of knowing more than we do about the condition of the outer, or higher, atmosphere with reference to temperature and moisture.

The relative force of the wind at the ground, and at a considerable elevation above, has been studied by J. Stevenson, C. E., of Edinburgh. The observations give in each case a great increase in velocity, but hardly allow of further definite generalization. The experiments on the velocity upon different sites of a round tower, and between various screens, are very interesting, and show how very local are the indications of an anemometer, and how carefully its site should be selected.

BAROMETRIC PRESSURE.

In order to determine the mean barometric pressure at the new Meteorological Observatory at Vienna, Hann has investigated all the barometric observations made in that city since 1775, but finds the uncertainty of the instrumental errors and the altitudes such that it is not advantageous to combine them with the recent observations; and therefore relies entirely upon those made since 1852. He closes his paper by deducing the diurnal and annual periodical changes in the pressure.

Buys-Ballot communicates a highly important memoir containing tables of monthly mean pressures at the stations for which the departures are given daily in the *Meteorological Bulletin* of the Netherlands. The large number of stations, and the careful revision of the data, render this a very welcome addition to our knowledge of the distribution of atmospheric pressure in Europe. He has also published, in the *Austrian Meteorological Journal*, a table showing the annual barometric variations for 108 stations throughout Europe, as resulting from long series of observations, and reduced to a uniform decennium. The discussion of his results he reserves to himself in a future number of his *Jaarboek*.

Carpmael, of Toronto, gives a formula for the reduction to sea-level of the readings of the barometer. His formulæ are convenient, and quite as accurate as the conditions of the

problem admit of; they differ, however, very much from those of the method adopted by the Army Signal-Office. His table is especially adapted to be used with the arithmometer of Thomas de Colmar.

Dr. Woeikoff communicates to Petermann's *Mittheilungen* some of the most recent results of the Russian Levelling Expedition into Siberia, under the command of General Von Stubendorf. His results are considerably higher than those previously accepted, and show us that the mean pressure in the interior of Asia, when reduced to sea-level, is decidedly higher than has been generally supposed. These results confirm his previously announced generalization that in northern latitudes the atmospheric pressure is higher over the continents than over the sea. This excessive pressure over the continents he refers to the well-known fact that the continents are especially cold in winter, and, on the average, colder throughout the year than the ocean; whence follows an anti-cyclonic movement of the winds, and an excess of clear sky and barometric pressure.

The diurnal variation of the barometer, as deduced from twenty years' photographic records, at the Royal Observatory, has been communicated to the Meteorological Society of London.

Rykatcheff announces the existence of a third diurnal barometric maximum, which is especially evident between latitudes 40° and 45° N. and in the month of January; it occurs at about one or two o'clock in the morning. In order to detect its presence at any station, it is necessary to have actual hourly observations throughout the night. It seems to be equally obvious at stations in Europe, Asia, and North America, and does not exist in the tropics.

In reference to a third daily barometric maximum, Karlinski writes that his twenty-five-year record at Cracow confirms Rykatcheff's announcement, but only for the month of January, and even then only in the faintest trace. He adds that from 52 to 87—averaging 70—barometric waves annually pass over Cracow.

Linss, of Darmstadt, calls attention to the importance of considering the inertia of the atmosphere (Lamont's theory) in explaining the diurnal barometric variation. In studying the direction of the motion of the clouds, he finds that the

barometer rises less in proportion as the angle is larger which the direction of the lower clouds' movement makes with the direction of the barometric gradient.

Dr. W. Köppen, of the Deutsche Seewarte, calls attention to the fact that Professor Erman, in 1853, in Poggendorff's *Annalen*, vol. lxxxiii., proved that the direction of the wind was inclined to the barometric gradient in accordance with the law now frequently, but wholly erroneously, called Buys-Ballot's law. Furthermore, he shows that Dr. Dippe published in 1860 a still more elaborate investigation into the relations between isobars and winds, and determined the angular deviation, and also the strength of the wind, in terms of the gradient. The present writer has previously called attention to the fact that Buys-Ballot's law, as enunciated by him, is simply a rule for predicting the winds in Holland, and is not at all a general physical law of storms. The inclination of the winds to the isobars was elaborately worked up by James Henry Coffin, and published in the *Proceedings* of the American Association for the Advancement of Science, 1853; while in the same year Rev. Humphrey Lloyd deduced the angle between the winds and the radius drawn to the centre of the system of winds. The physical explanation of the laws of the winds is due to Ferrel, whose first publications date 1856, although he had then for some years perceived and taught the correct views.

An important memoir, by Hoffmeyer, is published in the *Zeitschrift* of the Austrian Meteorological Society for October, on the Distribution of Atmospheric Pressure over the North Atlantic Ocean during the Winter, and its Influence on the Climate of Europe. He prefaces his remarks by reference to Buys-Ballot's law, and to the researches of Ley, Ferrel, Mohn, Guldberg, Loomis, and Broun. As an improvement on the charts of isobars published by Buchan and Woeikoff, he gives tables and charts based upon a much larger number of observations, which, he thinks, must be recognized as the most reliable that can be produced at present.

According to this new chart, for January, the principal minimum for the North Atlantic is to the southwest, and not to the northeast of Iceland; while a partial minimum extends from this point towards the North Cape on the one hand, and towards Davis Strait on the other hand.

In order to improve on these charts, he proposes to extend his daily weather-charts by extra- and interpolation over those portions of the ocean from which he has no direct observations, and to combine into monthly means the readings taken from his daily charts. At present he has charts for only two years—1874 and 1875—which he gives, and which, of course, show a distribution of pressure decidedly different from that given in his general chart. The charts are also given for December, 1874, and February, 1875; that for December showing a very remarkable departure from what would be considered a normal distribution.

He seems to consider that three minima—namely, that of Davis Strait, that northeast of Iceland, and that southwest of Iceland—by varying their position and relative development, alternate in their control over the winds and weather of the Atlantic.

The character of the weather which prevails over Northern Europe depends, therefore, entirely upon the predominance of one or other of the barometric minima of the North Atlantic Ocean. While recognizing the fact that, theoretically, the wind affects the distribution of pressure, he seems to only partially appreciate the importance of the law established by theoretical mechanics—namely, that it is not so much the barometric pressure that determines the wind, as it is the wind that determines the pressure.

He recognizes the fact that the area studied by him is but a very small portion of the northern hemisphere, and that the causes of the important variations in the distribution of pressure must be, at least in part, looked for outside of the region covered by his maps. In this respect, certainly, the monthly maps published by Ferrel in 1877, and the daily weather-maps of the northern hemisphere published by the Signal-Office in 1878, must be recognized as the first steps in the proper treatment of this subject.

EVAPORATION AND PRECIPITATION.

Weilenmann, in the *Schweizerischen Met. Beob.*, 1877, vol. xii., gives the development of a formula for the quantity of evaporation, which agrees, in the most remarkable manner, with observations at Vienna, St. Petersburg, Mont Souris, Pola, and Tiflis. This memoir and his essay on Atmospheric

Temperature constitute two important contributions to deductive meteorology.

Professor Nipher sends us, among the publications of the Missouri Weather Service, a valuable table of monthly, annual, and seasonal amounts of rainfall observed at St. Louis, principally by Dr. George Engelmann, from 1834 to 1877. There are but few stations in the world that can present an unbroken homogeneous series like this, and it is to be hoped that similar tables may be published for such other long series of observations as we may have in the United States. Such a collection, supplementary to the Smithsonian Tables, would be useful in many investigations.

A paper, by Otto Krümmer, on the Distribution of Rainfall in Europe, is published in the July number of the *Journal* of the Berlin Gesellschaft für Erdkunde.

Dr. G. Hellmann has published, in the Netherlands meteorological *Jaarboek*, a work on the Humidity and Cloudiness of Spain and Portugal. He gives the hourly variations for 4 stations, and the monthly and annual means for 18 stations, for 12 years. The average number of cloudless days during the year is, for Obiedo, 50; Saragossa, 199; and Valencia, 260.

The distribution of rain over Germany, according to the four seasons, is almost exhaustively treated of by Dr. J. Van Bebber, in Petermann's *Mittheilungen*, and is accompanied by four charts, showing isohyetals for each 25 millimeters. He distinguishes, for Germany, three well-marked regions: first, the west coast, or region of heavy autumnal rains; second, Alsace, the region of heavy winter rains; third, the region of summer rains, which includes pretty much all the rest of Germany.

An investigation, by Dogiel, published in Vol. XX. of the *Bulletin* of the St. Petersburg Academy, into the innumerable forms of the hexagonal crystals of iodoform (CHI_3), affords additional reasons for careful investigation into the circumstances that determine the formation of the varieties of snow-crystals. It is highly probable that definite temperatures and pressures may be indicated by these forms.

The large number of observers of rainfall in India will surprise every one who has not especially looked into this matter. The government supplies rain-gauges to all districts and

subdivisions. They are also generally placed at every planter's station, and at the tea-gardens, under the control of the various tea companies. Several provinces have more than 100 gauges each, and in all India there are estimated to be at least 1500 rainfall stations.

This subject was brought to notice by the reading of a paper, by C. N. Pearson, on the Meteorology of Mozufferpoor, Tirhoot, India (*Quarterly Journal* of the Meteorological Society, 1877, p. 410). An extraordinary rainfall of 14 inches in 12 hours occurred between midnight of the 22d of September, 1876, and the following noon, and measures at seven neighboring places showed the local nature of the rain.

Returns from 900 rainfall stations in France are published quarterly by the Association des Sciences de France and the Département de Ponts et Chausses under Belgrand.

Mr. Nathan Butler communicates to the *Bulletin* of the Minnesota Academy some notes on a hail-storm which he experienced in the western part of Minnesota on the 18th of August, 1858. The sky was generally clear, the weather quite warm, and the clouds overhead very light and fleecy. Immediately following a flash of lightning, large hailstones began to fall, and continued for perhaps two or three minutes. They buried themselves for about half of their diameter into the sod of the prairie. When the shower was finished, the stones were sprinkled into the ground about fifteen feet apart, and the larger ones were about the size of a man's two fists. In shape they were spherical on one end, made up of hexagonal crystals, like crystals of quartz; the other end was conical, made up of white ice. They were quite solid, and did not break in falling. They were found to weigh a pound each.

The abnormal character of the weather of the winter of 1877–78 is strikingly seen in the immense floods of the Sacramento valley. It is probable that such floods may occur every century. The enormous erosions west of the Rocky Mountains may be due to such occasional floods quite as much as to any regular annual rainfall.

A very complete synopsis of the various theories with regard to the formation of hail is given by Dr. T. H. Bauermeister in successive numbers of Dr. Klein's excellent popular scientific journal *Gaea*. He reviews the history of the subject from the time of Musschenbroek, and gives especial at-

tention to the views of Volta, Leopold Von Buch, Muncke, Mohr, Reye, Lucas, Baumgartner, and Dellmann. He concludes, however, by saying that previous to any critical discussion of these different theories, it is, above all, necessary that there should be as full as possible a collection and short description of all hail-storms that have been scientifically observed with reference to the form of the clouds, the direction of the wind, the atmospheric electricity, the topographical distribution, as well as a collection of the results of scientific balloon voyages, and as many as possible observations on high mountains. He hopes in a short time to collect such material, and will gladly welcome any contribution.

Reynolds has considered the formation of hail-storms, and has artificially reproduced them in great perfection.

STORMS.

Professor Loomis has published his eighth contribution to meteorology, January, 1878, and his ninth paper in July, while the tenth paper is understood to be in press, having been read before the National Academy in October, 1878. The eighth paper deals with the origin of areas of low pressure, and the ninth paper considers especially those storms that come from the Pacific coast eastward to the Mississippi valley. He then takes up the areas of high barometer. Combining the two studies with the observations of the clouds, he arrives at a general circulation of the atmosphere similar to the views published by Ley, Hildebrandsson, etc.

The important memoir of Captain Henry Toynbee on the Meteorology of the North Atlantic during August, 1873, has been published by the Meteorological Council. This work relates especially, of course, to the history of the great hurricane of that month, and does not appear to have been prompted by the report of Mr. Abbe on the Nova Scotia hurricane, but to have been begun in December, 1873, quite independent of, and before the publication of, that work. Captain Toynbee has collected some 280 ships' logs, and has utilized all other sources of information; so that his work is undoubtedly the most valuable collection of facts relating to any hurricane which has ever yet been published, and is really a monument to his patience in collating material which, judging from our own experience, must have offered very many

perplexing discrepancies. His work includes 31 daily charts of the North Atlantic and a concluding synoptic-chart, while his text presents us with a review of each daily chart in succession, followed by a series of chapters on the hurricane, and conclusions that can be drawn from the study.

He states that from the 1st to the 10th, the northeast trade and southwest monsoon were often in close proximity over that part of the sea which lies to the southwest of Cape Verde. It seems most probable that the hurricane was forming on the 12th in about 11° N. and 20° W. From that time on, the track of the centre of the hurricane is occasionally indicated until the 17th, from which date until the 25th its track is very clear as it passed westward between the West Indies and the Bermudas, and then turned northward, and finally northeastward, near the southern coast of Nova Scotia. On the 26th he concludes that the centre of the hurricane was south of Newfoundland, but that it was broken in force, and that contact with land broke up the great eddy, which had shown no signs of breaking up so long as it was over the open sea. From the 27th to the 31st there appear areas of slight barometric depression between Labrador and Europe, attended occasionally by strong gales but no hurricane. By means of these depressions, which represent the breaking-up of the hurricane, the meteorologist would continue the track of the hurricane eastward to Great Britain; but the practical seaman would say that the hurricane, as such, died out in Newfoundland. He shows that had we telegraphic communication with the Bermudas and St. Thomas, timely warnings might have been sent to Nova Scotia and the United States. The law according to which areas of low pressure in Europe pass outside of, instead of advancing into, areas of high pressure seems to have also prevailed in the progress of this hurricane.

The important question with regard to the direction of the wind and the bearing of the centre of the hurricane is elucidated by diagrams, and especially by measures made on three different charts, and at distances from 100 to 800 miles from the centre. On these charts the angle between the bearing of the hurricane-centre and the direction of the wind has been carefully measured for 108 different ships' positions, the average of all of which shows that the wind does not

make an angle of 90° with the bearing of the centre, but that there is an indraft of from 25° to 31°, being on the average 29°, or 2½ points. It is probable that there is really a great range in the amount of indraft, so that this mean is a rough approximation to the truth. The best rule for navigators is, he thinks, about as follows:

In the northern hemisphere with the wind

North,	the	hurricane	centre	probably	bears	E.S.E.,	or more	southerly.
East,	"	"	"	"	"	S.S.W.,	"	westerly.
South,	"	"	"	"	"	W.N.W.,	"	northerly.
West,	"	"	"	"	"	N.N.E.,	"	easterly.

The only modification of the ordinary instructions for handling ships in hurricanes which these facts suggest is, that when the circular theory states that a ship ought to run before the wind, these facts show that, if possible, she ought in the northern hemisphere, to keep the wind well on the starboard quarter. He also shows that the indraft is greater in one quarter of a hurricane than another, and greater near the centre than farther from it. The mean of the three charts just mentioned gives an average wind force of 10 on Beaufort's scale, at a distance of 90 miles from the centre, and a force of 6 at a distance of 425 miles from the centre.

In the chapter on the normal circulation of air during August, 1873, he introduces a very suggestive letter from Clement Ley, with reference to the relations between the upper and lower currents of the atmosphere circulating round areas of barometric depression. Mr. Ley has evidently established inductively, from the consideration of a great number of observations, certain laws of atmospheric circulation which have been theoretically and more or less vaguely guessed at by several meteorologists of the past generation. His diagram represents two low areas, with a high between, all advancing due eastward. The lows are preceded by southwest to southeast and northeast surface winds, which are also ascending winds, and are accompanied by clouds, either cumulus, stratus, or cirrus, above which he represents descending currents from the northwest and southwest, which feed the preceding area of low pressure, and produce an area of clear sky. The advancing edge of a bank of cirro-stratus cloud is very well marked, and he states that he has in his diagram given its mean position in relation to the isobar and

the upper and lower currents, as deduced from a great number of distances.

He concludes with a strong appeal to owners, captains, and officers of vessels to assist him in further studies of ocean meteorology. In an appendix he gives a comparison of wind observations at Pike's Peak and Mount Washington.

Mr. H. F. Blanford communicates to *Nature*, July 25, a short chapter on the Genesis of Cyclones, in which he distinctly combats the idea that these may originate between parallel and opposite currents of air. He regards the torrents of rain over the cyclone cradle as furnishing the energy of the incipient storm.

Lieutenant J. Spindler publishes, in an appendix to the St. Petersburg *Daily Meteorological Bulletin*, a valuable collection of the Paths of Storm-centres that have passed over Northeastern Europe during 1873 to 1877. The tables and results will afford material for testing future theories of storm movements. An abstract of this valuable paper is also given in Hann's *Zeitschrift.*

The hurricane of the 23d of September, 1877, on the coasts of Venezuela, is briefly described in the November number of the *Gazeta Cientifica.* This hurricane formed in the immediate neighborhood of the island of Trinidad, moved nearly northward to Cuba, and reached the central portion of the United States.

The article on the West India Hurricane of September 12 and 13, 1876, by Tejeda, of Porto Rico, which was referred to by us in the *Annual Record* for 1877, has, we learn, been reprinted in the *Annuaire*, for 1877, of the Spanish Navy Department, with apparently considerable additions. The cyclone moved from St. Christopher over Porto Rico, and finally reached Florida.

In the Paris *Comptes Rendus*, Faye claims that Hirn has favorably considered the theory according to which the air in a cyclone is descending instead of ascending, and that he allows two kinds of descending cyclones—the ordinary whirlwind and the tornado.

In April, Professor Ferrel read before the National Academy at Washington a memoir on the Theory of the Tornado and Water-spout, in which he gave the formulæ connecting the pressure in the interior of the whirl with the elevation

above ground, the temperature, humidity, and velocity of the air, and the dimensions of the moving mass. His formulæ were illustrated by numerous examples, and are believed to present us with the first satisfactory deductive investigation of the subject that has as yet been published.

The famous squall of March 24, 1878, in which the *Eurydice* was capsized, has been made the subject of a short study by W. Clement Ley, who thinks that this squall may be regarded as a typical one, in that the longest diameter of its barometric depression was nearly at right angles to the direction of the wind, and very much exceeded its shortest diameter. In one respect it was decidedly exceptional—namely, in the backing of the cirrus current by about 112° during its passage.

Mr. Ley concludes that the principles of cloud observation should occupy a very large place in the education of seamen, and, we may add, of all other meteorological observers. It does not seem possible for a central meteorological office to predict such local squalls as this, but it is allowable to infer from Ley's article that experienced navigators can themselves foresee them a few minutes in advance, sufficient to prepare their vessels to meet them.

Bucchich communicates to the Austrian Association results of numerous observations at Lesina on water-spouts. He states: first, their cause is to be found in opposing wind-currents; second, at Lesina they always move from east to west; third, the direction of rotation of the whirl is opposed to that of the hands of a watch; fourth, for one water-spout he was able to determine its time of rotation—namely, twelve seconds.

An account of the tornado of the 15th of May, 1878, in the Department of Vienna, is given by Touchimbert in the Paris *Comptes Rendus.*

While making magnetic observations at Kirksville, Mo., Professor Nipher had occasion to carefully observe several dust-whirls, or small whirlwinds. One of these whirls crossed a pond of water, and immediately a depression was formed, extending to the bottom of the pond; the top of the depression was about six feet in diameter. The water all around this depression was whirling rapidly.

K. V. Riecke has collected and studied the statistics of

hail-storms and resulting damages in Würtemberg during the thirty years from 1828 to 1857, the work being a continuation of that previously published by Camerers. He gives interesting quotations from early chronicles dating back a thousand years, which have, we understand, been reprinted in previous *Jahrbuchers* published by the Würtemberg Statistical Bureau. The average number of hail-storms is 14.8 per year during the first half of the period investigated by Riecke, but only 12 in the latter half of that period. The years of most frequent hail-storms were, 1852 (? 26), 1847 (24), 1834 (23), 1835 (23), 1873 (22), 1839 (20). The average area covered by the hail that fell from these storms is 2525 morgens, or 796 hectares, or 1967 acres.

By summing up the areas covered by hail, it is found that the years of maximum area were, in regular order, 1873, 1872, 1853, 1852, 1869, 1856, 1830, 1846, and 1832; and the years of minimum area were, 1833, 1851, 1858, 1844, 1857, 1874, 1835, 1848, 1842, and 1840. A strong indication is given of an increase in the intensity of thunder-storms. Besides numerous interesting historical notices dating back to the year 855, Riecke gives detailed tables of the hail-storms and of the property destroyed during the last fifty years.

The summer of 1878 was remarkable for numerous hail-storms in Great Britain. The severest occurred on the 4th of August in Leicestershire, and is well described by W. Clement Ley, who states that about two inches of hail fell in his neighborhood in fifteen minutes, the stones averaging about five inches in circumference, as measured two hours after they fell.

In the *Bulletin* of the Natural History Society of Colmar, G. A. Hirn supports in part the theory of Faye as to the nature and origin of cyclones and tornadoes.

Among the terribly destructive storms of modern times must be included that of April 12, on the Chinese coast. This storm passed directly over Canton, causing indescribable destruction and an immense loss of life, estimated at between 6000 and 7000 persons: it appears to have been, at least in Canton, of the nature of a tornado, having a diameter of about 300 yards, and a path of destruction only 3 miles long.

General T. L. Rosser gave a short address in December, 1877, before the Minnesota Academy of Social Science at

Minneapolis, on Tornadoes and Cyclones, in which he endeavors to explain the phenomena of a shower of flesh, or batrachian spawn, that occurred on the 3d of March in Bath County, Ky., and concludes by propounding a theory of the general movements of the atmosphere. He states that on the line of the Northern Pacific Railroad between Bismarck and Fargo, a distance of about 200 miles east and west, the storms of severe north or northwest winds, with snow, advanced eastward at an average rate of about 12 or 15 miles per hour. When a storm is reported as beginning at Bismarck, the weather at Fargo would often be bright and beautiful, but as the storm approached, scattering clouds here and there appeared, and considerable agitation would be manifest in the upper regions of the atmosphere. As the storm rose from the west, the winds would suck in from the east, exhibiting the remarkable (?) phenomenon of a storm coming up in the face of the wind.

Professor S. A. King has furnished the daily press with a graphic account of his balloon ascension in August, 1875, at Burlington, Iowa. He started at about half-past four, at which time there was a terribly ominous-looking thunderstorm approaching. His balloon had been filled at the gasworks, two miles distant from the place of ascension, and had lost so much of its gas that its diminished buoyancy obliged him to start alone. His balloon, from the moment it left the ground, was rapidly carried towards the coming thunderstorm, and its ascent was also rapid until, in about seven minutes, he entered the cloud. Going up through this, just as he expected to reach the top there came right down in front of him, and apparently not more than fifty feet distant, a grand discharge of electricity. In an instant, almost, he felt the car lifted, the gas in the balloon suddenly expanded to overflowing, and the balloon was hurled through the cloud with inconceivable velocity, the car swinging back and forth at a terrible rate. All this was suddenly accomplished, and would have been quickly over, but before the car had time to stop oscillating, another discharge of electricity occurred, and the same thing recurred again and again, until it seemed as though he should never escape. Each time the balloon would be extended to its utmost, until, finally, it was thrown into the midst of the tremendous rain, and was carried down rap-

idly. Gradually the gas was forced out, and the lower part of the bag doubled up into the upper part, forming a sort of parachute. He landed just twelve miles from his starting-place, having evidently retraced a portion of his track.

ATMOSPHERIC ELECTRICITY.

An important work of Edlund on the Origin of Atmospheric Electricity is published by the Swedish Academy, and also in the *London, Dublin, and Edinburgh Philosophical Magazine*, and in Hann's *Zeitschrift*. He shows that the rotating magnetic earth, being a good electric conductor, must, by unipolar induction, give rise to a nearly uniform charge of negative electricity throughout its own whole mass, but to a variable charge of positive electricity throughout the atmosphere. The discharges, of course, give rise to aurora and lightning. He deduces, with comparative accuracy and simplicity, the diurnal and annual periods, and the geographical distribution of these phenomena.

Important papers by Angot in the *Annuaire* of the Meteorological Society of France, and by Everett in the report of the Permanent Committee of the Vienna Congress, present the best connected accounts of modern methods and theories that are at present accessible to ordinary readers.

In a note on the Origin of Thunder-storms, Professor Tait explains how a pair of vertical rotating columns revolving in opposite directions can be produced out of one column in the upper regions of the atmosphere revolving about a horizontal axis. He also suggests that the source of the electricity specially developed in thunder-storms may probably be found in the contact of air with the surface of the warm drops of water.

A general review of the subject of Atmospheric Electricity is given by Dr. Margules in the Vienna *Zeitschrift*, wherein he expounds the electrical principles that occur, and enumerates some of the questions that first demand investigation.

The phenomena of Globular Lightning are described by M. Fitzgerald, of Donegal County, Ireland, who saw a globe of fire in the air descend gradually along the crown of a ridge, and down into the valley, where it drifted along a boggy surface, occasionally disappearing in the soil, but reappearing farther on. It finally flew across the stream, and buried it-

self and disappeared in the peat bank. Its total duration was about 20 minutes. It appeared about 2 feet in diameter at first, but gradually diminished to 3 inches. The sky was clear at the time. Wherever it touched the ground in its course, it ploughed up the earth to a depth of several feet. In the discussion on this report, Mr. Symons stated that forked lightning and globular lightning were, he thought, the same.

The *Scientific Gazette* for Venezuela publishes a communication to the Physical Society of Caraccas, by J. M. Tebar, on an Electric Phenomenon peculiar to Lake Zulia, called the *Farol de Maracaibo.* He explains this light as being an electric phenomenon due to a quiet discharge of a large extent of atmosphere of the negative electricity with which ascending currents of air are saturated, while the descending currents are charged with positive electricity. The same journal contains an original theory, accompanied by some mathematical demonstrations, relative to the Nebular Hypothesis, by E. Ricard.

Hildebrandsson has published an Investigation into the Thunder-storms of Sweden, based on observations at about 250 stations, from 1871 to 1875. He distinguishes between the thunder-storms that attend the advancing sides of extensive storms (the *Wirbelgewitter*) and those that originate in overheated districts (the *Wärmegewitter*). Similar classifications have been made by Mohn in Norway and Fron in France, and are occasionally alluded to in the weather reviews of the Army Signal-Office. Scarcely a single instance was recorded in the five years in which it could not be shown that the so-called "heat" or "sheet" lightning was simply the reflection of lightning so far distant that the thunder was inaudible, or possibly refracted above the observer's ear.

Dr. Pissis publishes in his "Physical Geography of the Republic of Chili" some notes on thunder-storms in that state. Destructive thunder-storms are unknown in the inhabited portions of the state, but are of daily occurrence among the mountains. In the morning a small cloud forms around each summit, which soon increases to a large cumulus, and eventually extends over the whole range of peaks. In the afternoon fearful thunder and lightning occur; and, high up the mountain-sides, snow and hail. The hail and snow are phosphorescent, as it were, with electricity. The storms on the

eastern slopes of the Andes and on the pampas are of shorter duration than on the west side. The lower horizontal surface of the clouds, which is at an altitude of 1500 or 2000 meters, sometimes extends from the coast eastward to far beyond the Andes. The greatest thunder-storms in Chili last three or four days, but the electric discharges all occur in the first hour.

Carl Weyprecht has published the "Magnetic and Aurora Observations of the Austro-Hungarian Arctic Expedition of 1872 to 1874," with which he also gives an excellent analysis and *résumé* of our knowledge on the subject. Among other things, he strongly inclines to the opinion that the auroral light belongs to the lower portion of the atmosphere. He fails to establish any connection between the aurora and the weather. He concludes that the zone of maximum frequency moves northward during the winter, and again southward during the spring.

Thalen has a memoir on Exploitation for Iron Ore by Means of the Magnetic Needle. He gives full and strictly accurate methods, and his formulæ may possibly be applicable to the search for the seat of the disturbances that accompany auroras.

An elaborate paper on the Protection of Buildings from Lightning, by Dr. Mann, is republished, with additional notes, in the sixth volume of the "Professional Papers on Indian Engineering."

The American Academy of Sciences of Boston has instituted an inquiry with reference to the general phenomena of lightning, and, among other things, has requested the Chief Signal Officer of the Army to collect, as far as possible, all notes and observations upon accidents caused by lightning. All who may read this note are cordially invited to record such facts as may come to their knowledge.

The Proper Method of Protecting Buildings by Lightning-rods is discussed, in a fifth note, by Melsens, in the Brussels *Bulletin*, 1878, p. 43. He gives an analysis of the conditions necessary to insure efficacy, and discusses the constructions published by the French Commission.

According to Mr. Symons, both Mishel, Secretary of the French Commission on Lightning-rods, and Jarriant, a large dealer in lightning-rods adopt as the area protected from

lightning by a given rod a circle whose radius is $1\frac{3}{4}$ times the height of the rod above the building.

An excellent paper on Lightning-conductors was read before the British Association, by Mr. R. Anderson. He states that so slow has been the march of progress since the days of Benjamin Franklin, that lightning-conductors are still wanting on at least half, and perhaps two thirds, of all the public buildings, and on 95 per cent. of all the private houses in Great Britain. The terrible losses occasioned by lightning are due to three sources of neglect: first, not providing any lightning-rods at all; second, not placing them in the right position; third, not having them regularly tested, so as to ascertain their constant efficiency. Lightning-conductors, he says, ought to be tested at least once a year. Between three and four thousand pounds sterling were spent in protecting the Houses of Parliament some twenty years ago. Since that time they have never been tested, and there is no guarantee whatever that a discharge of lightning may not at any time fall upon the Queen's throne. The testing should take place at regular intervals.

The wonderful sensitiveness of Bell's telephone—such that it responds to induced currents of the strength of only the one thousand-millionth part of a C. G. S. unit, or less—gives it great importance as an instrument of research in relation to atmospheric electricity and terrestrial ground-currents. Some observations made in Providence, R. I., have led to the conclusion that by it the existence of a thunder-storm may be detected when otherwise altogether invisible at the station.

The Edison microphone has even been applied successfully to the observation of subterranean sounds produced by volcanic actions, and may evidently be further applied to whatever goes on in the earth and ocean.

Mr. Henry Goldmark, of the Laboratory of Harvard College, contributes observations upon the Effect of Temperature on Atmospheric Electricity. He used Sir William Thomson's water-dropping apparatus and his quadrant electrometer. The observations were made in a room whose temperature could be varied as desired. He found, first, that even a very considerable change of temperature does not have any great or marked effect upon the electric potential

of the air; second, that, however, a rise in temperature does produce a slight but constant increase in the potential.

OPTICAL PHENOMENA.

Montigny gives a preliminary chapter of results of his observations on the Scintillations of the Stars. The first interesting observation that he publishes is in the *Bulletin* of the Royal Academy at Brussels, 1878, p. 157. It was first noticed by Usher, 1788, at Dublin, that the stars scintillate remarkably during and preceding an aurora. In 1840 Arago says that Forbes and Neckar and himself agreed that the stars never scintillate unless there is an aurora somewhere. Montigny observed an especial increase of scintillation of auroras April 5, 1870, and June 1, 1878. He also says that the scintillation is connected with a lowering of temperature, and that this cooling occurs simultaneously with auroras and scintillation, and that, finally, the cooling causes the scintillation. In the second communication, in the *Bulletin*, Brussels, vol. xlv., p. 391, he gives the results of Seven Years' Observations with his Scintillometer on Fifteen Stars as to Color, and finds that the red colors predominate during dry weather, while the blue precedes rain. The memoir on the Connection between Scintillation and Rain, etc. (*Bulletin*, 1878, p. 598), is received too late to allow of the extended notice that it deserves.

A memoir by Wild (St. Petersburg *Bulletin*, vol. xxi., p. 312), on the Photometric Determination of the Diffuse Light of the Sky, gives the preliminary results of an investigation that for many years has engaged his attention. The instrument that he has invented and used for this purpose he designates as the urano-photometer, and it seems to combine the features of the photometers invented by Arago, Hirn, Wild, and Zöllner. A disk of ground glass illumined by the sun affords an artificial standard light, whose whiteness is turned to the required shade of blue by receiving it through a quartz plate and polarizing apparatus. Wild finds (1) the color of the diffuse sunlight, as we proceed from the sun northward on a vertical circle, changes gradually from the red to the violet end of the spectrum, and at a distance of 80° from the sun is nearly between Fraunhofer's lines C and D, or at the wavelength 0.000628 meter; from here onward to the horizon the

tint retreats to the red end; (2) the color and the polarization have their maximum at 90° from the sun; (3) the total intensity of the diffuse reflected skylight appears to be least at about 80° distance from the sun, and diminishes thence more slowly towards the horizon than towards the sun.

In some papers on Physical Science for Artists, Mr. Lockyer introduces an explanation of the color of the sky, and some criticisms on some prominent pictures in the Royal Academy, which will be generally interesting to artists.

The lunar eclipse, August 12, 1878, was studied spectroscopically by N. Maunder, at Greenwich, who observed a marked absence in aqueous lines, apparently showing that there was comparatively little vapor or cloud in that part of our atmosphere through which the sun's rays passed. The atmospheric bands were also remarkably faint.

At the Dublin meeting of the British Association for the Advancement of Science, we notice among the meteorological papers one by Professor S. P. Thompson, on the Wedge-shaped Radial Streaks of Light devoid of Color observed between the Primary and Secondary Bow of the Rainbow.

An article on the History of the various Theories of the Rainbow, by Reclam, is published in *Gaea*. He especially touches upon the theories of Newton, Descartes, and those who preceded them.

The *Bulletin* of the Geographical and Statistical Society of Mexico, vol. iv., p. 190, gives a detailed account of a Solar Halo at Zongolica on the 27th of April, 1874, a very rare phenomenon in that latitude, and on that account worthy of note.

The connection between tempests and solar spots has been studied by Zenger. He also finds that photographs of the sun taken in the Tyrol and in Switzerland are surrounded by peculiar haze and halos, which are not otherwise visible to the naked eye, indicating the presence of moisture and haze very high up in the atmosphere, and anticipating the occurrence of storms sometimes by ten or fifteen days (? hours) (see the Franklin Institute *Journal*, 1878, p. 283).

Mr. Burton has made some observations on the Spectra of the Zodiacal and Auroral Lights. He used an apparatus loaned by the Royal Irish Academy of Sciences, and Professor Stokes, commenting upon the paper as a valuable one, says

that he seems to have shown that the bright line thought by Angstrom to be identical in these two lights is really not so.

Mr. Burton has also measured the position of a new dark band in the zodiacal light, in which light he also finds distinct traces of polarization.

MISCELLANEOUS RELATIONS AND APPLICATIONS.

Sun-spot Periods.

A memoir of exceptional thoroughness and interest upon the Sun-spot Periods in our Atmospheric Phenomena is by F. G. Hahn—"Ueber die Beziehungen der Sonnenflecken-Periode zu meteorologischen Erscheinungen," Leipzig, 1877.

Dr. S. Gunther, in a work on the "Influence of the Celestial Bodies upon the Weather" (Nuremberg, 1876), gives an excellent historical *résumé* and bibliography of this subject.

The discovery by Main at Oxford that the annual mean direction of the wind fluctuates with the variation of the solar spots has stimulated Hornstein to a similar investigation for Prague. He has communicated to the Vienna Academy, June, 1877, a memoir on the Probable Dependence of the Mean Direction of the Wind upon the Period of the Sun's Spots, the study of which subject has occupied him since 1871. His results are similar to those of Dr. Gould, whom he appears to have anticipated somewhat, and with whose methods his own agree very closely. He finds an increase of 0.00133° C. for a diminution of 1 on Wolf's scale of solar spottiness.

Dr. B. A. Gould contributes to the *Ast. Nach.* a summary of his climatological researches. From the observations at Buenos Ayres and Bahia Blanca, since 1856 and 1866 respectively, he has computed for each year separately the thermal wind-roses, as also the mean temperatures and mean direction of the wind. By means of the thermal wind-roses he is able to reduce the mean annual temperatures to what they would have been if the mean annual direction of the wind were the same throughout the series of years. He thus obtains mean annual temperatures which are apparently perfectly intercomparable, and finds that these figures follow the changes in sun-spots remarkably closely. He finds that a fall of 1° C. in the mean annual temperature corresponds

at Buenos Ayres to an increase of 138 on Wolf's scale of solar spottiness, and at Bahia Blanca to an increase of 193 on Wolf's scale.

Fritz contributes to Petermann's *Mittheilungen* a memoir, in his well-known exhaustive style, on the Periodical Changes in the Lengths of Glaciers. A glacier is a very delicate meteoroscope, and the changes in its volume and length, depending upon a combination of several circumstances, enable us, as it were, to integrate the meteorological conditions of the year. Professor Fritz suggests even that through them we may find a new bond of connection between solar spots and terrestrial meteorology; and, in fact, finds most remarkable coincidences between the hundreds of cases that he has collected and the dates of sun-spot maxima and minima. With an increase of sun-spots comes an increase in the length of the glacier.

Perhaps the most interesting contribution to this subject is that given by Professor H. Fritz in his study of the periodicity of the rise and fall of the Nile, as recorded on the nilometer of the island of Rhodes. He had at his disposal only the record of the highest reading on the nilometer for each year from 1825 to 1872, and he shows that these follow Wolf's sun-spot numbers with most unexpected closeness. The years of minimum sun-spots are nearly coincident with the years of least rise in the Nile, thus confirming Meldrum's results for the southern hemisphere. It is to be hoped that it may become possible to similarly investigate the mean discharge as well as the maximum heights of the Nile. That this periodicity was known to the ancient Egyptian priests is rendered plausible when we recall Joseph's prediction of seven full and seven lean years, corresponding to the seven years of high-water and low-water, and agreeing closely with Fritz's table of periodicity.

In Vol. XX. of the *Vierteljahrsschrift* of the Natural History Association of Zurich, Fritz has an essay on the Longer Periods of the Auroral Phenomena, in which, among other things, he, as the first who, in 1863, fully demonstrated the parallelism of sun-spots and auroras, very plainly protests against having been ignored, but copied by Loomis in his famous essay of 1866. In the present work, by a new and improved method of analysis of a vastly larger collection of

data, Fritz shows that the aurora maxima occur 0.73 of a year after the sun-spot maxima, while the aurora minima occur 0.30 year before the spot minima. These small deviations from absolute coincidence may, however, possibly be due to the imperfections of our data; the auroral changes are much more energetic than those of the sun-spot frequency. There is good evidence of the existence of a period of $5 \times 11.11 = 55.55$ years, and Fritz even suspects one of 220 or 222 years' duration.

The subject of the connection between rainfall cycles and sun-spot cycles has called forth considerable correspondence, much of which is noticed in *Nature*, where articles have appeared by Dr. W. W. Hunter, Dr. E. Bonavia, C. Meldrum, A. Buchan, and S. A. Hill.

The general result of these investigations is, we think, quite decidedly favorable to the conclusion that the solar spots and temperatures change in parallel cycles, and affect every feature in terrestrial meteorology.

The subject can only be properly studied by including observations from the whole earth in an analysis, and we are not surprised to find that Mr. Hill has shown that the data for India can be twisted into proving either a maximum or a minimum of rain for each maximum of solar spots, the truth being that a change in the solar heat produces opposite effects in two regions whose geographical conditions are dissimilar.

Dr. Hunter has shown that at Madras itself the years of little rain, drought, and famine agree with the years of minimum sun-spot frequency. Messrs. Hill and Archibald have discovered that in Northern India, between latitudes 20° and 30°, the winter rainfall corresponds inversely with the period of solar spots—*i. e.*, the maximum winter rainfall coincides with the minimum of sun-spots. The failure of these winter rains causes short crops and severe famine in the subsequent season. Assuming that the sun radiates less heat at times of sun-spot maximum, it seems possible to plausibly explain the consequent slight rainfall. In general, in years of maximum sun-spot, the summer rainfall is above, and the winter rainfall below the average, and inversely in years of minimum sun-spot. The reality of this connection is endorsed by Buchan, who appeals to the British government to avert dis-

astrous famines by instituting a comprehensive system of hydraulic engineering, such that the surplus rains of one season may be husbanded for use in time of need.

Perhaps the greatest boon possible to confer upon Ceylon and India will be the restoration of the ancient system of tanks and irrigation, by which, a thousand years ago, the desolating effects of a scarcity of water were almost completely averted. Similar tanks will, at some future day, doubtless be introduced into our own western country.

Mr. Meldrum read a memoir before the British Association at Plymouth, showing that the number and severity of the cyclones in the Indian Ocean during 1875, 1876, and 1877 had been much below the average, and entirely confirmed the hypothesis of an eleven-year cycle.

Mr. O. A. Derby, of Rio Janeiro, communicates to *Nature* for August 8 a table of Rainfall in Tropical Brazil, showing that the relation between rainfall and sun-spots, as deduced by Dr. Hunter for India, holds good also for Brazil.

In *Nature* for September 26 are two important papers by C. Meldrum and F. Chambers respectively; the former discusses Rainfall at Madras, Edinburgh, and Paris, and the latter discusses Barometric Pressure at Bombay. Both make out a series of remarkable parallels between sun-spots and terrestrial meteorology.

The latest communication on this subject is from J. A. Broun, in *Nature*, November 7, where he enumerates several conclusions bearing on the researches of Chambers and others. With regard to the question of the generality of their results, he concludes—first, years of greatest and least mean pressure are the same for all India; second, the apparent relation to the decennial period, found by Mr. C. Chambers for Bombay, holds good for all India.

Professor M. Williams, in a letter to the London *Times* of November 7, states that "from his observations of the present condition of the disk of the sun, in connection with various atmospheric phenomena, the Madras astronomer Pogson prophesied, in 1876, a recurrence of the drought and famine that occurred in 1877."

Mr. C. Meldrum has distributed some copies of his article on Sun-spots and Rainfall, extracted from the *Mauritius Almanac and Register*, in which he gives a connected account

of his own and other researches into this subject. These researches now include every portion of the world, and, according to Meldrum, the rule is almost universal that the years of greater rainfall are the years of greater sun-spot area. In India the irregularities seem to be very great, partly owing to the imperfections of the observations and to the great climatic variations, and possibly in part to the empiric and obscure nature of the theory. However, the parallelism is comparable in regularity to the diurnal variation of the barometer or the periodicity of the aurora.

Professor G. F. Becker contributes to the *Mining and Scientific Press*, of San Francisco, of February 2, some tables and diagrams illustrating the periodicity of the rainfall at San Francisco, Sacramento, and Stockton since 1849. He finds evidences of a well-marked thirteen-year period for each place.

The Variation of the Zodiacal Light in Sympathy with the Sun's Spots is the subject of a short note by Hind, who quotes a letter of Olbers, published in 1839, wherein the variation of the zodiacal light is mentioned. Modern observations seem to confirm the statement of Cassini, that the zodiacal light is much more brilliant when numerous and large sun-spots are present.

The *Annuaire* of the Bureau of Longitudes for 1878 contains, as an appendix, a memoir by Faye, on Cosmic Meteorology, in which the distinguished author seeks to give a strong proof of the influence of solar spots and other cosmic influences. A criticism of this work, by John Allan Broun, is published in *Nature*, vol. xviii., p. 128.

Health.

An excellent address of Dr. Schreiber, on Meteorology in Medicine, has been translated by Dr. W. H. Geddings, and published in the *Richmond and Louisville Medical Journal.*

Some Notes on the Climate and History of New Mexico, by Dr. Thomas A. McParlin, are published in the "Smithsonian Report for 1877." He gives the views of numerous authors on the theory of the influence of high altitudes on human life, and his memoir is full of miscellaneous interesting statistics, including also a letter from J. M. Gough on Electric Disturbances on Telegraph Lines. In reference to the

effect of altitude, he states that his own experience has been that he has never detected any quickening or other disturbance of respiration, and that at the greatest altitudes as yet attained by man it is evident that there is an abundance of oxygen to supply the needs of the blood at every inspiration, while at low altitudes there is great excess of oxygen. This consideration deprives of its force the argument of those who say that the quickened respiration and pulse experienced by most observers is an involuntary effort of the system under the control of the sympathetic nerve to furnish a sufficient supply of oxygen to the blood. He considers that the human race degenerates by dwelling in low and unhealthy places, and that in such places it is decimated by such pestilences as the cholera, yellow fever, remittent fever, and plague.

Mr. Buchand has communicated to the Philosophical Society of Glasgow some more recent deductions with reference to the relations of meteorology to public health, as deduced from the study of weekly mortality and weather returns for all the large towns in the British islands. He shows that diarrhœa and British cholera on the one hand, and dysentery and Asiatic cholera on the other, form themselves into two distinct groups. The prominent phases in the annual progress of whooping-cough and scarlet fever agree even to minute details year after year for thirty years. He infers that there is something connected with the weather of spring which tends to reduce the mortality from scarlet fever, but something connected with late autumn weather under which this disease attains its maximum fatality. In the case of whooping-cough, its maximum severity occurs in early spring, and its minimum severity in autumn.

In commenting on Mr. Buchand's paper on the Relations of Meteorology to Public Health, Mr. E. M. Dixon stated that, according to the analyses that had been made daily at six points in Glasgow, it appeared that a steady increase in the amount of organic matter in the atmosphere took place along with the increase of temperature in the spring and summer, but that the amount of organic dust decreased as the temperature fell in the autumn.

In the *Journal* of the Franklin Institute for January, February, and March will be found a rather lengthy article, by Professor Briggs, on the Relation of Moisture in Air to Health

and Comfort, in which he maintains that the delightful summer condition of temperature, 62° to 68°, and relative humidity, 80 to 85 per cent., is not desirable, or even attainable, at other seasons in the heating of dwellings, etc. The dry air of America possesses both curative and preventive qualities of great value; moist air that promotes vegetable growth is, on sanitary grounds, not desirable for breathing. The author has found the dew-point far below the freezing-point of water in well-warmed and ventilated rooms where there was nothing of that sensation of dryness that is usually held to accompany the heat of a furnace when not supplied with water for evaporation. New houses, that are accounted unhealthy in Europe, are not so in America. Gas burned in rooms produces much less unpleasant effects in America than in England. What is needed is an equality in relative humidity between the interior and exterior air. Thus, if the outer temperature be 0 and relative humidity 40 per cent., and the interior temperature be 70°, we ought to raise the interior humidity to 40 per cent. by adding a little water, and not to 80 or 90 per cent. by adding too much.

The effect of diminished atmospheric pressure upon the human body was discussed by Mermod in the *Bulletin* of the Switzerland Society of Natural Sciences. His observations extend through three years, and relate mostly to himself: first, he finds that the systematic residence in higher regions is attended by an increase in the pulse, but not in the frequency of breathing; second, therefore the ratio between the frequency of respiration and heart-beats grows smaller as we ascend to higher stations; the temperature of the body, however, was unchanged; third, the absolute and relative amounts of carbonic-acid gas can be regulated by moving the patient to a higher or lower level.

From an inaugural dissertation, by M. Schyrmunski, of Wilna, on the Influence of Rarefied Air on the Human Body, we extract the following notes as interesting to the invalids who resort to Colorado and other high regions: The first accurate observations on the subject were made by Saussure on the occasion of his ascent of Mont Blanc in 1787. The principal subsequent observations and publications on this subject have been A. von Humboldt's ascent of Chimborazo; Boussingault's ascent of Chimborazo in 1831; R. von Schlaginweit's

ascents of peaks in the Himalayas in 1862; and Lortel's "Physiologie du Mal des Montagnes" (1870). The preceding observers ascended mountains. The following relate to balloon ascensions: Gay Lussac and Madame Blanchard in 1804, both of whom ascended to 7000 meters; Coxwell and Glaisher in 1862 ascended to over 9000 and probably 11,000 meters; and Croce-Spinelli, Sivel, and Tissandier in 1875 ascended to about 8600 meters.

From all of these observations, Schyrmunski thinks best to draw but few physiological conclusions, and prefers to rely on experiments made by means of the air-pump. Of similar experiments he knows only those of Henslaw, Tabarié, Junod, and Vivenot; but in the memoir of the latter on the Physiological Effects of Condensed Air, only two observations are quoted on the influence of rarefied air. He has, therefore, conducted a rather extensive series of experiments upon himself. In each experiment, he or his friends remained in the pneumatic cabinet for two full hours. During this time the rarefaction proceeded uniformly until, in forty minutes, the greatest rarefaction was produced. The pressure then remained constant for an hour, and was then, in about twenty minutes, gradually restored to the prevailing atmospheric pressure. The pressure was ordinarily reduced to about 300 millimeters, corresponding to an altitude of about 14,000 feet.

He divides his observations into two classes: first, in so far as they relate to the general effect on the system, they agree with the observations on mountains and in balloons. The first symptom is a sensation of pressure in the ears; the second symptom relates to the voice, which becomes husky and feeble; but whether this is an effect of the rarefied air on the vocal organs or the ear he cannot decide. Whistling becomes very difficult, due to the altered expiration and inspiration; headache was very severe in the first experiments, and continued for some hours after leaving the cabinet; lassitude and inclination to sleep, and a sensation of heat in the face; the lips turned bluish, the eyes burned; flickerings and difficulty in fixing the sight; the respiration became more and more frequent and superficial, until finally the difficulty of breathing became very great, and the pulse rose from 84 to 104 per minute. All these general symptoms were most decided in the first experiments, and afterwards

gradually diminished in intensity; the most persistent was the effect upon the hearing.—Second. In regard to the special effects upon human organism, Schyrmunski considers first the change in the capacity of the lungs, or the quantity of expired air. Having had considerable experience with the spirometer, his observations appear worthy of full credit, and he concludes that, in artificially rarefied air in the pneumatic apparatus, the vital capacity of the lungs, or the quantity of expired air, diminishes. Its diminution during the process of rarefaction and its subsequent increase appear to be quite regular; the average amount of the diminution is about 2 per cent. He next considers the influence of rarefaction upon the temperature, and finds that there is a slight increase, followed by a steady diminution of the interior temperature of the body — a phenomenon which may, perhaps, be explained by the changes in the circulation and respiration; for at the beginning there is an increase in the frequency of breathing and in the pulse, and a rush of blood to the extremities, causing an increase of temperature, which is soon followed by slow reaction.

From the inaugural dissertation from L. Stembo, on the Physiological Effect of Compressed Air, we take the following notes: After alluding to the contradictory opinions and results of observations of Knauthe, Vivenot, Panum, Lange, and others, he states that his attention was first directed to the vital capacity of the lungs as depending on the barometric pressure. He finds a steady increase in the capacity while the pressure increases, and, on the other hand, obtained a similar result outside of the pneumatic cabinet. He then investigates any possible source of error affecting his observations, and finds that the increase in lung-capacity is certainly confirmed. The explanation given by him leads to the conclusion that compressed air will have a healing tendency in inflammations of the mucous membrane of the bronchial tubes; also in acute catarrh of the smaller bronchiæ, and in bronchial asthma. With reference to the temperature of the skin under compressed air, he finds that with increasing pressure the temperature invariably sinks.

Hypsometry.

At the end of an investigation into the accuracy of his new barometer (Zurich *Vierteljahrsschrift*, vol. xx., p. 385), Weilen-

mann introduces an essay on the Best Time for Determining Altitudes by the Barometer. In continuation of the labors of Ruhlmann, Bauernfeind, Plantamour, and others, he shows that the correct altitude can be deduced from observations on summer afternoons, and that, too, without using the temperature of the upper stations, and even when the stations are at considerable horizontal distances. His method depends on the assumption that the equilibrium of the ascending currents is maintained and expressed by the known laws of thermo-dynamics (as developed quite independently by Thomson, Reye, Hann, and others), and assuming that the ascending currents neither give any heat to surrounding air nor receive any from it or from the sun, or other source. His formulæ thus deduced, and employing for all his physical constants the numbers ordinarily accepted as resulting from laboratory experiments, enable him to compute altitudes up to 7000 feet, with an extreme error of 15 feet when he uses monthly means of observations in July at 1, 2, or 3 P.M.

Lieutenant-Colonel R. S. Williamson, U.S.E., has published a compendium of his paper on the Use of the Barometer on Surveys, which is followed by a comparison of his method with that of Professor J. D. Whitney, as described in his work entitled "Contributions to Barometric Hypsometry." Colonel Williamson claims to have shown conclusively that Whitney's method gives over 40 per cent. more of maximum and mean errors than does his own.

Major Powell states, in reference to the hypsometric work of his survey in Southern Utah in 1877, that it rests on a primary base established at Mount Pleasant, at which barometric observations were made four times daily, and were also made hourly for eight days of each month. All his camps and observing-stations were connected with the base by barometric observations; but it is recommended that a special series of hourly observations be conducted for a few years upon some of the Rocky Mountain peaks for the purpose of correcting the barometric formulæ now in use. For topographic details much use has been made for some years past of the orograph — an instrument devised by Professor A. H. Thompson, and which seems to have been lately reinvented in France.

Physical Geography and Geology.

The influence of meteorological phenomena, especially rainfall and rivers, in altering the physical geography, is well illustrated by the following extract from Markham's chapter on the "Physical Geography of India:" "The basin of the Ganges has been minutely examined by the officers who have constructed the works of irrigation, and the physical laws which regulate the great Indian river-systems have been discussed by Mr. Ferguson. The latter shows that all rivers oscillate in curves whose extent is directly proportional to the quantity of water flowing through them. Water resists water far better than earth does, so that a river can attack its banks in detail and carry the bits away; but still water, by producing a state of rest, forces a river to deposit its silt. Mr. Ferguson concludes, with regard to the Ganges, that from 4000 to 5000 years ago the sea, or at least the tide, extended as far as Rajmahal, and that Bengal proper was a vast bay or lagoon." The gradual raising of the delta is indicated by the positions of the capital cities: thus, 3000 B.C., the only practically habitable part was the water-shed between the Sutley and the Jumna. The first cities really in the plains were Hastanapura, on the Ganges, and Ayodia, on the Gogra, which flourished from 2000 B.C. to 1000 B.C. Then followed in succession Canonj, afterwards Palibothra, or Patna, then Gour, and, finally, A.D. 1604, Dacca.

A magnificent chart of Europe during the two glacial periods is published by Petermann, in the twenty-fourth volume of the *Mittheilungen*, in continuation of his earlier paper on the same subject.

Abich contributes a paper on the Glaciers and Snow-lines of the Caucasus. The latter vary from 8000 to 10,000 feet, according to locality. Observations on the movement of the glaciers seemed to give negative results.

T. Sterry Hunt communicates to the Academy of Sciences at Paris some remarks on the Geological Relations of the Atmosphere. He says: "I have been led to see in the carbonic acid discharged from volcanoes and from some springs of gaseous waters, only a product of the decomposition of the carbonates which were previously formed at the surface of the globe, at the expense of the carbonic acid of the atmos-

phere. I have shown, moreover, that the formation of the carbonaceous and bituminous matters in the strata of the earth, all which seem to me to have an organic origin, have required a weight of carbonic acid which far surpasses that of our atmosphere, and moreover would have given place to a very considerable disengagement of oxygen resulting from the deoxidation of carbonic acid and water. It is necessary to admit that this carbonic acid had an extra terrestrial origin. I think we ought to consider our atmosphere as a cosmic and universal medium, condensed around certain centres of attraction in proportion to their masses and their temperatures, and occupying the whole of interstellar space in a state of extreme rarefaction. From this it will result that the surplus of carbonic acid will be absorbed in equal proportions in the atmospheres of all the celestial bodies, and that at the same time any excess of oxygen disengaged at the surface of our globe will be equally divided among all the celestial bodies. This theory of a universal exchange seems to me to furnish an explanation of the origin of cosmic dust."

Botany and Zoology.

The influence of atmospheric electricity upon vegetation has been studied by Grandeau, who communicates his results to the Academy of Sciences at Paris, showing that under large trees, under massive shrubbery, and under a coppice covered with verdure, the electric tension of the atmosphere is sensibly zero, while at the same moment, at a few yards' distance from these conducting bodies, we can demonstrate notable quantities of electricity.

Berthelot communicates to the Paris Academy some interesting remarks in reference to the memoir of Grandeau on the Effect of Atmospheric Electricity. He states that he has discovered that the free nitrogen in the air unites with organic matter under the influence of electricity, not only when strong tensions are employed in the experiment, but also with very feeble tensions. He again calls the attention of meteorologists and farmers to the importance of the continued action of atmospheric electricity of feeble tension to the fertilization of the soil.

The Influence of Temperature on Vegetation was treated of by Goppert, in which he explains why it is that great ex-

tremes of cold, lasting but a short time, are less injurious than less extreme temperatures lasting for a longer time. Middendorff concluded from his observations in Siberia that the frozen stems and roots could perhaps exist in that condition for many years without injury, with which conclusion Goppert unites his own observation on the revival of vegetation that had been buried for many years under glaciers. He gives an extensive list of plants, and low temperatures which they are able to endure with impunity.

Dr. Sorauer communicates to the *Botanische Zeitung* for January some observations on the Influence of Moisture on Vegetation. He finds that in dry air branching is greater than in moist air, the length of the leaves is less and the breadth greater, and a moist atmosphere is more favorable to the length of leaf-sheaf, to the growth of the principal stem, and also to the development of the root. In dry air the epidermal cells of the leaves were more numerous and broader, the cells between the stomata shorter, and the stomata themselves shorter and more numerous than in moist air.

Among other papers bearing on the relation between meteorology and botany, we note a paper by Professor Rein on Mountain and Valley Winds, and their Effect upon the Vegetation of Volcanic Mountains, read at Cassel.

C. Eder, in an inaugural dissertation at the Leipsic University, republished by the Vienna Academy of Sciences, investigates the Quantity of Aqueous Vapor Expired by Plants, and concludes that the transpiration is a purely physical process, modified by numerous physical conditions, principally by the relative humidity and the quantity of water the air is able to contain, by the temperature, and by the wind. Light of itself has no influence. There is no periodicity except as determined by these exterior circumstances.

Lauterburg contributes to the Basle Association an excellent paper on the Influence of Forests upon the Springs and Rivers of Switzerland. Culmann, in some appreciative remarks, endorses the desire for a system of telegraphic predictions of approaching river floods, etc., in Switzerland.

The fluctuations in the level of the Great Salt Lake have been especially studied by Mr. G. K. Gilbert, of Powell's Survey, who finds that since 1869 there has been no great change in the water-level, which now averages 10 feet above its level

in 1847. The total area of the water-surface has increased by about 25 per cent., by which expansion the surface for evaporation was increased. This extension of the lake is shown to be clearly an anomaly in its history, and to explain it Mr. Gilbert states that he has reason to believe that the industries of the settlers have so modified the surface of the land that a larger share of the snow and rain finds its way into the watercourses and the lake. He believes that the tax imposed upon the streams by the work of irrigation is more than repaid by the effects of the draining of marshes and the destruction of herbage and timber.

The influence of wind and climate upon the migrations and spread of the grasshoppers has been very fully considered in the reports of Riley and Whitman, State entomologists for Missouri and Minnesota respectively (see also the report for 1876 of the Commissioner of Statistics for Minnesota). The report for 1877 of the United States Entomological Commission is remarkably full on this point.

Hellmann, in Petermann's *Mittheilungen*, calls attention to the possibility of predicting the invasions of grasshoppers or locusts, which, leaving the Sahara in the spring with southwest winds, are carried over Algeria and Egypt, and do more damage than the severest storms. A similar duty has been frequently urged by Dr. Packard and others upon our Signal Service; and in this connection it may be well to call attention to a theoretical explanation of the grasshopper migrations which has lately been proposed by Abbe, and which is said to account for most of the phenomena that have been observed. According to this explanation, the grasshopper is an insect at home and comfortable only in a rather dry atmosphere, and possibly a diminished atmospheric pressure; air that is either too dry or too moist is equally liable to make the insect uncomfortable, and in either case he seeks relief in flight, not knowing whither he shall go. Now the very dry winds are the westerly winds, that bear him rapidly eastward to the Missouri and Mississippi valleys. The very moist winds are the south and southeast winds of the Mississippi valley, that bear him or his progeny in the next year back to his original breeding-grounds. It will be curious to show whether this hypothesis holds good for the African as well as it does for the American insect.

The observations of such meteorological phenomena as affect the fisheries continue to be published by the German government, under the supervision of the Commission to Investigate the German seas. This prompt monthly publication must greatly facilitate and stimulate the study and utilization of these data, and naturally suggests the advantages that must result from a regular monthly publication of all meteorological data specially pertaining to the United States fisheries, forestry, injurious insects, etc., etc.

The United States Fish Commissioner has collected an immense amount of data relative to water-temperatures, winds, currents, etc., in the United States rivers, lakes, and seas, which will be properly collated.

In a memoir on Red Snow, in the "Memoirs of the Academy of Toulouse," vol. vii., Dr. Armieux advances the hypothesis that the *Uredo nivalis* of Bauer, or the *Protococcus nivalis* of Agardh, the *Protococcus pluvialis* of Cohn, and possibly the *Lepraria kermesina* of Wrangel are the same; and that to these spores, in different stages of development, are due the green, red, etc., snows—that, in fact, these cryptogams can also live on rocks, in peculiar circumstances, as at Rioulet.

Refraction of Light and Sound.

Dr. Fabitius, of Kief, shows that atmospheric refractions may be computed for great zenith distances on the assumption that the coefficient of refraction is constant quite as well as for small distances. To this end he simply adopts for distances greater than 75° a value of the reciprocal coefficient of refraction increasing in direct proportion with the zenith distance. He hence concludes that the constitution of the highest portion of the atmosphere has but little influence on the horizontal refraction, and that it is sufficient to assume for the upper portion the same law for the variation of temperature and density as obtains near the earth's surface. On this assumption he develops the formulæ for atmospheric refraction, which he is able to express in a series whose successive terms diminish very rapidly, and which are extremely convenient for the computation of special tables for any locality.

The atmospheric refraction has been studied by Professor Kowalski, of the University of Kazan, Russia. With most other investigators, he pays special attention to the law of

diminution of the temperature of the air. The law of this diminution is, according to him, fixed by the mechanical theory of heat, and Lubbock, in 1856, was the first to find the solution to this question by starting with the principles of this theory. The present essay dates from 1867, or earlier. By the aid of the mechanical theory of heat, as developed by Thomson and Mendelieff, but with still further generalizations as deduced by himself, Kowalski finds—first, during winter the diminution of temperature with altitude is, on the average, very small, and it augments in proportion as the temperature observed near the surface of the earth becomes higher; second, during the heat of summer the diminution of the density of the layers of air near the surface of the earth can become very feeble, so that the least force suffices to disturb the stability of the equilibrium of the layers, which case can rarely happen during winter; third, the variation of temperature in a higher stratum of atmosphere always manifests itself by the relatively greater variations taking place between the lower layers.

Kowalski's volume is, therefore, of interest to the meteorological observer principally because of its bearing on the question of the temperature of the air.

The important Experiments on Fog-signals, by Tyndall and others, under the auspices of the Elder Brethren of the Trinity House, have an important bearing upon meteorological matters, as they apparently give us a new method of exploring the atmosphere; in fact, as the spectroscope tells us of the total amount of moisture in a great length of the atmosphere, so do Tyndall's aerial echoes tell us of irregularities in density throughout a circle of many miles in diameter. Practically, however, the most important result of the Trinity House experiments has been to definitely establish the fact that two to four ounces of gun-cotton exploded 1000 feet above the sea by a rocket give forth such a volume of sound, and the sound-waves are so little affected by echoes or acoustic opacity, as to immensely surpass all other methods of fog-signaling hitherto tried. Such discharges were heard very loud at six miles, distinct, as distant thunder, at fifteen miles, and with a rumbling detonation at twenty-five miles. "A signal of great power, handiness, and economy is thus placed at the service of our mariners."

In the "Smithsonian Report" for 1877 is given a summary of the results of the investigations of Professor Henry in reference to fog-signals and the audibility of sound, and as this summary includes his very latest results, it will have permanent interest. He finds the most efficient cause of the loss of audibility is the direct effect produced by the wind. Sound is heard farther when moving with the wind than when moving against it. This is due to a change in its direction: it is refracted or thrown down towards the earth when moving with the wind, but passes over the head of the observer when moving against the wind. Sometimes a strong upper wind opposite to the surface wind produces an apparent reversal of the preceding law, as shown by his experiments in 1874. Although sound issuing from a trumpet or parabolic reflector is at first concentrated, yet it tends to spread so rapidly that at the distance of three or four miles it is heard nearly equally well on all sides. Neither fog, snow, hail, nor rain materially interferes with the transmission of sounds. Sound-shadows of great extent can be produced by buildings or other obstacles. The alternate audibility and inaudibility of a sound, as we approach to or recede from its origin, is attributed to the upward refraction of the sound-wave and its successive reflections at the upper and lower surfaces, or the right-hand and left-hand bounding surfaces of shallow or narrow currents of air. The phenomenon of an aerial echo which comes back to the observer from a portion of the horizon directly in front of the trumpet is attributed provisionally to the fact that in the natural spread of the waves of sound, some of the rays must take such a curved course as to strike the surface of the water in a perpendicular direction, and thus be reflected back towards the origin of the sound.

Pneumatics and Aeronautics.

The ventilation of buildings and railway tunnels, etc., and the driving of the carriages in pneumatic tubes, railways, etc., introduce the application of principles and data that also have an application in meteorological problems; while, on the other hand, meteorological data relating to wind, temperature, and pressure enter into the computations of the engineers. Among these problems whose discussion we have noted during the past few years, we mention, the Ventilation

and Working of Railway Tunnels, by Morrison and others, in *Proceedings* of the Institute of Civil Engineers, art. xliv.; also, in the same volume, the Pneumatic Transmission of Telegrams, art. xliii., by Culley, Sabine, etc.—a very thorough and important discussion.

The enthusiastic aeronaut De Fonvielle writes to Captain Howgate to say that the study of clouds and currents by means of small balloons will be now systematically pursued at the Paris Observatory. This is, he states, in consequence of the fact that Captain Howgate (at Mr. Abbe's suggestion) furnished the meteorologist of his preliminary expedition with a quantity of these balloons for use in the arctic regions. The resistance that the air experiences from friction and obstacles on the earth's surface is in many ways shown to be a very important factor in meteorology; and as it is very difficult to make even an approximate allowance for this friction, it will conduce greatly to the reconciliation of theory with observation if some of the national meteorological systems will introduce the daily use of these balloons to determine the direction and velocity of the air-currents within 1000 feet of the earth's surface.

Professor S. A. King, formerly of Boston, and now of Philadelphia, continues to make aeronautic ascensions as much as possible in the interest of the science of meteorology, although also strictly a business and professional matter. Could the results of his balloon voyages since 1851 be collected together, it would be seen that he ranks among the foremost aeronauts in his intelligent appreciation of the physical and meteorological problems that concern his profession. Such a work has, we understand, been in progress for some years, and doubtless now only awaits an enterprising publisher.

Professor Mendelieff is understood to be devoting his spare time to an extensive historical and scientific work on aeronautics.

An important volume on aeronautics has been published by Tissandier, entitled "Histoire de mes Ascensions," being a record of twenty-four aerial voyages. The work gives special attention to the scientific exploration and study of the atmosphere, and is, of course, particularly valuable as containing Tissandier's own experiences.

The great event of the year in the application of aeronautics to meteorology has been the success of Giffard's giant captive balloon. This balloon has proved, as far as is known, perfectly manageable, and has made from two to twenty ascensions on every pleasant day, carrying up each time about forty persons (among them always a meteorological observer). The revenue derived from it has more than paid the original cost of the apparatus. A complete description of the balloon has been published by Tissandier, extracts from which have been published in numerous periodicals. The diameter of the inflated gas-bag is 36 meters; it was inflated with pure hydrogen made by the action of sulphuric acid on iron. The balloon is confined by a cable 660 meters long. The material of which the gas-bag is made has shown itself capable of retaining the hydrogen with scarcely any loss during four months. So complete has been Giffard's success that the Abbé F. Moigno, editor of *Les Mondes*, asserts that, had he been properly encouraged ten years ago by the French government, the investment of Paris could never have been completed, and the payment of five milliards need never have been forced upon France.

The receipts during the first 60 days exceeded $100,000, which was about the original cost of the balloon. In the beautiful weather of the commencement of October, the balloon accomplished between 8 A.M. and 6 P.M. 24 consecutive ascensions, so that in a single day 900 persons ascended and descended. The captive balloon is a veritable aerial sounding-line, and continually reveals the existence of superimposed currents which escape the observer on the ground. One is frequently plunged, at an altitude of 100 or 200 meters, into rapid currents, while the air is calm below; sometimes, on the contrary, the balloon is becalmed while strong winds prevail at the earth.

The Giffard balloon has been lately sold to a London company, and will be removed thither; while a new and larger one will be built to replace it in Paris.

Aeronautic ascensions were made from Paris, June 30 and July 2, in small balloons of only 450 cubic meters, or less than 14,000 cubic feet, but filled with hydrogen gas. According to *Nature*, it was on these occasions noticed that cumuli have a height sometimes twice as great as their hori-

zontal dimensions. These clouds play the part of humid conductors, connecting inferior with superior strata; and their dissolution, in the form of rain, is connected with electric phenomena.

Meteors and Zodiacal Light.

Although meteors are to be considered as proper subjects of study for the astronomer, yet often, by their entry into the earth's atmosphere, they come to have a special interest for the meteorologist. The phenomena shown by their trains have not yet, that we are aware of, been subjected to any comprehensive study during the past few years; but the important question as to the amount of heat introduced into our atmosphere by the destruction of a part or all of the *vis viva* of all the meteors that enter therein has been taken up by Govi, who finds that modern discoveries serve to abundantly elucidate the subject. It is not, however, likely that the temperature of the lower layers of the air is sensibly affected by this source of heat.

Dr. G. von Niessl communicates to the *Astr. Nach.* the results of a preliminary investigation into the Daily Variation of the Shooting-stars, in which he shows that numerous conclusions deduced from a careful consideration of the theory of the nature and movements of these bodies do not agree sufficiently well with the observations of the past few years; and he suggests that the true explanation lies in the following assumptions: first, that the density of the perihelia of the meteoric orbits diminishes with increasing perihelion distance; second, that the orbits are much more frequently hyperbolic than parabolic.

Some instructions for the observation of Zodiacal Light are given by Serpieri, in the "Meteorologia Italiana" for 1878, in which he calls special attention to the points observed by the Rev. George Jones, and also by Heis and Schiaparelli. Some connection between the zodiacal light and the aurora seems also to be indicated by the observations of Bruno at Mondovi, February 4, 1872.

In Vol. XXV. of the "Memoires Couronnés" of the Royal Belgian Academy, Houzeau gives a Summary of Astronomical and Meteorological Observations made by him in the tropics and adjoining portions of the temperate zone. His observations included the zodiacal light, which was seen on

56 days out of 179. This series is of remarkable accuracy and import, and demonstrates that the zodiacal light is in the plane of the ecliptic without sensible deviation therefrom. The meteorological observations consist of five years of records at 6 A.M., noon, and 6 P.M., near Kingston, Jamaica, West Indies. Among the remarkable phenomena he notes rain from a cloudless sky for 13 consecutive hours.

Professor Everett publishes in the *Proceedings* of the Belfast Society a lecture delivered by him Jan. 22, 1878, on Atmospheric Electricity. He sums up our knowledge as follows: "There is no other meteorological element, except perhaps the wind, that can compare with electrical potential for the extent and suddenness of its variations. On some rare occasions, with no assignable external cause, and notwithstanding the mitigating action of the collector, which eases off all sudden changes, the needle of the electrometer swings from side to side with a violent trembling like that of a magnetic needle in a strong field. As regards the variation of potential according to the season of the year, all observations concur in showing that the average strength of potential is greater in winter than in summer, but the months of maximum and minimum appear to differ considerably at different places. The chief maximum occurs in some one of the winter months; the chief minimum occurs everywhere in May or June; the average potential in the strongest month is about double of that in the weakest. As regards the variation of potential with the hour of the day, the Kew observations show a double maximum in the twenty-four hours. The hours of maximum are, in July, 8 A.M. and 10 P.M.; in January, 10 A.M. and 7 P.M.; and in the spring and autumn, about 9 A.M. and 9 P.M. The few observations taken during the recent Arctic expedition show that the general features of atmospheric electricity were the same at the winter-quarters of the *Alert* as they are in these temperate regions." He adds that our great want at present is balloon observations, and suggests a method by which such can be made. With regard to the origin of atmospheric electricity, he says: "I feel convinced that friction either of the air itself or of the solid or liquid particles contained in it against the surface of the earth is one cause of the generation of electricity in the air."

PHYSICS.

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GENERAL.

The year 1878 has witnessed a considerable progress in the science of Physics. A noteworthy occurrence is the address delivered at Glasgow, by Dr. C. W. Siemens, "On the Utilization of Heat and other Natural Forces," because he discusses in it the available sources of power when the supply of coal shall fail. Using at some central station water- or wind-power to drive dynamo-electric machines, the current generated could easily be reconverted into power where it is wanted, either for mechanical or other purposes. For light, for example, from 100 horse-power 125,000 candle-lights would be obtained, equivalent to 6250 Argand burners of 20 candles each, consuming six feet per hour, or 37,500 cubic feet for all. To produce this amount of gas, $3\frac{3}{4}$ tons of coal are required, while to produce the 100 horse-power only as many hundred-weights are necessary. In the case of Niagara, he computes that 100,000,000 tons of water fall every hour through a vertical height of 150 feet, giving 16,800,000 horse-powers, the only result being an elevation of the temperature of the water by one fifth of a degree Centigrade. To pump back the water would require an annual expenditure of 266,000,000 tons of coal (at four pounds coal per horse-power per hour)—an amount equal to the total coal consumption of the world. Since by electric means one half the energy supplied at the central station may be recovered at the distant one, the economy is greater than in the steam-engine. Greater care in the use of water- and wind-power is now possible, and the intermittent character of wind-power may be made permanent by using it to raise water into a reservoir. Moreover, the force of falling water in its descent from reservoirs and lakes, to supply our large cities, might be utilized on the way by driving turbines,

thus supplying light and mechanical power as well as the water.

Wild has communicated to the St. Petersburg Academy of Sciences an important metrological paper, in which he describes his new linear comparator, and gives the results of his examination with it of a normal meter made by Hermann & Pfister, of Berne. The new comparator reads to 0.0001 millimeter and to 0.01 of a degree Centigrade. The true length of the normal meter was found to be 999.9838 millimeters, with a probable error of ±0.00026 millimeter. Wild also discusses the desirability of quartz in the form of rock-crystal as a material for standards, especially for linear units, and gives his opinion strongly in its favor. A spherical or cylindrical standard hectogram of this material, or a standard divided decimeter, can now be had of Stein, in Oberstein, for thirty thalers. A simple and excellent method of reading the deflection in balances of great precision, by means of a mirror with its telescope and scale, placed at a distance, is also given.

The mathematical treatment of the problems arising from the motions of bodies confined to the surface of the rotating earth has been treated of by Bertram in an inaugural dissertation at Marburg, on the motion of a material point upon surfaces of rotation; and by Suttor, of the Royal Institute at Luxembourg, on the movement of bodies on the surface of the earth, etc. The former author confines himself to the elaboration of very general mathematical formulæ for rotating cylinders, paraboloids, spheres, etc. The latter author gives more special formulæ, deduced from Corioli's propositions, and shows their adaptation especially to the vibration of pendulums, and the experiments of Foucault on the rolling of spheres down inclined planes, and the fall of bodies, as in Reich's experiments at Freyberg.

Jewell has described in *Nature* a new form of sinker for deep-sea sounding, in which certain objections to the sinker of Sir William Thomson are obviated. An iron casting five inches in diameter at the top and three at the bottom, and 26.5 inches long, is cast with a cylindrical cavity two inches in diameter, extending from the top to within an inch of the base. A glass tube forty-eight inches long is closed at one end and bent so as to produce a U tube twenty-four inches

long. This is placed in the cavity in the sinker with the bend upward, and of course the closed end downward. The whole is supported by a swivel-link at top. When immersed, the air in the tube will be compressed, and at a depth of five and a half fathoms the water will rise in the open leg to the bend; any further descent will cause it to flow over into the closed leg. By calibrating and graduating this leg, the amount of water which it contains when raised will, of course, indicate at once the depth to which it has descended. If desired for use in water shallower than five and a half fathoms, the open leg may be made shorter than the closed one.

MECHANICS.

1. Of Solids.

In Mechanics Abbot has repeated and extended his experiments to determine the velocity of transmission of earth waves caused by explosions, in order to settle certain questions raised by Mallet. He concludes: 1st. That a high magnifying power of telescope is essential in seismometric observations. 2d. The more violent the initial shock, the higher is the velocity of transmission. 3d. This velocity diminishes as the general wave advances. 4th. The movements of the earth's crust are complex, consisting of many short waves first increasing, and then decreasing in amplitude; and with a detonating explosive, the interval between the first wave and the maximum wave at any station is shorter than with a slow-burning explosive. The seismometer used was a dish of mercury, whose surface was watched through a telescope, by which the beginning and duration of the tremor could be determined. The velocity observed was for short distances 8500 feet, and for long 5300 feet per second.

Cornu and Baille have continued their experiments on the determination of the density of the earth by the method of Cavendish, and have considerably improved their apparatus. They have quadrupled the force to be measured by increasing the attracting spheres of mercury from two to four, and by diminishing the distance through which the attraction is exerted in the relation of $\sqrt{2}$ to 1. With these improvements, the results are completely uniform, so much so that

the time of oscillation of the lever remained fixed at 408 seconds, within a few tenths, during more than a year. The numerical result of the new and numerous determinations made with the improved apparatus agreed closely with those previously obtained by the authors, and gave 5.56 as the mean density of the earth. They also call attention to the errors in Baily's results caused by the resistance of the air; and, allowing for this, they compute the density from his data to be about 5.55.

Stanley has proposed the use of the pendulum for the purpose of registering cumulative temperatures, or pressures. The pendulum consists of a steel cylindrical tube 32 inches long and $1\frac{3}{4}$ internal diameter, closed at both ends, to the upper of which is attached a rod to connect the pendulum with the clock-work. An air-tight division is placed across the tube at five inches from the upper end, from which a small tube extends to the bottom. Through a screw-hole in the lower end mercury is poured into the small tube, filling both it and the upper chamber. It is then boiled and inverted, and thus constitutes a steel barometer. To convert it into a thermometer a small air-hole in the outer tube is closed air-tight. Since by increase either of pressure or temperature the mercury rises in the tube, the centre of oscillation of the pendulum changes, and its rate is accelerated. The clock is arranged to count beats in units up to ten millions, and the number of beats per day, week, month, or year becomes the unit of temperature or pressure for the period. The upper chamber contains a conical plug for the purpose of automatically effecting certain corrections, especially that due to the expansion of the case. For a pressure apparatus, which the author calls a chronobarometer, the external tube is dispensed with, except at top and bottom.

According to *Nature* extensive preparations were made at the Champ de Mars, in Paris, for producing Foucault's pendulum experiment on an extended scale. The weight of the pendulum was 300 kilograms, and the iron wire which supported it was sixty-five to seventy meters in length. It was supported above a grooved pipe moving freely on an axis in its centre. In oscillating, the pendulum displaced this pipe, which, like the pendulum itself, remained fixed in space. Beneath the pendulum a large terrestrial globe twenty-five or

thirty meters in diameter was placed, which, being fixed, of course followed the motion of the earth. The pipe, on the contrary, supported by a pivot at the extremity of the axis, carried large indexes, which appeared to be displaced with it.

Siemens, of Dresden, the inventor of the new compressed hard glass, has recently exhibited it before the Berlin Polytechnic Society. Owing to the perfection to which the process has now been brought, the new hardened glass is not only more easily, but more cheaply made than ordinary glass. The resisting power of this glass varies from eight to ten times that of ordinary glass. The serious objection made to hard glass at the time of its discovery, that it often fell to pieces when entirely unexposed to pressure, has been successfully avoided. This property was found to result from overhardening, and it is now possible to detect all articles which have acquired it, by the use of the polariscope, under which overhardened glass shows a prevalence of violet tints. This condition is also detected by exposure to water heated to a certain and definite temperature.

2. Of Liquids.

Muirhead has communicated to *Nature* the results of some experiments, undertaken at his request by Whitely, to afford additional data in answering the question whether matter in the solid state will float upon the same matter in the liquid condition, with reference to the solidification of the earth. In the first experiments metals were used, various copper and zinc alloys being employed in the earlier, and cast-iron in the later, experiments. When the solid fragment was placed on the liquid surface, a portion of the liquid metal was at first chilled by it, and coated the mass; but this soon re-fused, and the floating solid mass gradually melted, beginning at the lower surface. The result was more marked in the case of the iron than the brass: a small piece of cold, dry iron, when dropped endwise on the liquid metal, bounded back to the surface, and melted in that position. Subsequently, experiments were tried with melted rock, in the first case whin-stone being placed on melted furnace cinder, and then solid cinder being put into the furnace containing the liquid mass. Pieces of five or six pounds weight

were employed. They at first sank, but soon came to the surface, and floated about until they were melted.

Mallet has published a paper on the density of solid mercury, the experimental investigation having been conducted with great care. A cylindrical specific-gravity flask was prepared of glass, whose capacity at 4° C. was determined both by direct and indirect calibration to be 59.7311 grams. The freezing mixture used was snow and hydrochloric acid, the temperatures were determined by an alcohol thermometer verified by comparison, and the weighings were made on a Becker balance. In the experiment, 558.9353 grams pure mercury were placed in the flask, which was filled with alcohol whose coefficient of expansion was known, the whole placed in the freezing mixture, the mercury frozen, the alcohol brought exactly to the mark, the temperature noted, the flask set aside to acquire the temperature of the balance-case, cleaned, and weighed. As a final result, the number 14.1932 was obtained as representing the density of solid mercury at its fusing-point, —38.85° C., referred to water at its point of maximum density, 4° C. taken as unity.

Jevons has continued his researches on Pedesis, the name which he has given to the well-known Brownian movement of microscopic particles. To decide between the hypothesis that this movement is due to surface tension, as some hold, and the one which ascribes it to chemical or electromotive action, held by the author, Jevons made the experiment in a solution of soap. Since soap lessens the surface tension of water without affecting its conductive power, the pedesis, if due to surface tension, should be lessened by it. The reverse, however, proved to be the fact, the pedetic motion becoming considerably more marked on the addition of soap, even when not only china clay, but also ferric oxide, chalk, and barium carbonate were employed. The author believes from his experiments that the detergent action of soap is due to pedesis, by which minute particles are loosened and diffused through the water, so as to be readily carried off. The high cleansing power of rain or distilled water, in contrast with that of impure hard water, is due to the fact that the electric conductivity of the former is lower, and hence pedesis is higher. The addition of salts to water increases its conductivity, but diminishes its pedetic and detergent power. If the salts be

alkaline, the pedetic power is lessened, but the water acts on oleaginous matter. But if soap be also added, we have the advantage of both the alkali dissolving power and of the pedetic cleansing power.

A paper has been published by Van der Mensbrugghe on the cause of the apparently spontaneous movements of bubbles of air in levels, and of bubbles of vapor in the microscopic cavities of minerals. These motions are explained by changes of tension in the surface of the liquid produced by changes of temperature, this tension always decreasing at the warmer end, and the bubble consequently moving towards this end. But now, as a thin film of water remains on the glass at this point, the surface of the liquid is increased there, thus lowering the temperature and increasing the tension; so that, when the temperature ceases to rise, the bubble goes back again. In the case of microscopic cavities, where the bubble is formed of the vapor of the liquid, the movement is yet more rapid, changes of temperature producing evaporation or condensation, by which the dimensions, and hence the tension, of the surface are altered. The author thinks the well-known Brownian movements thus explicable.

Thompson has communicated a paper to the London Physical Society upon permanent Plateau films, an abstract of which is given in *Nature*. The best films are obtained by using a mixture of 46 per cent. of pure amber-colored resin and 54 of Canada balsam, which should be heated to from 93° to 95° C. The frames for forming the films are made of brass wire 0.3 mm. in diameter, and when thicker wire is employed they are found to be irregular, in consequence of the retention of heat by the metal. The films are obtained by simply introducing these frames into the heated mixture, and they harden almost immediately on exposure to the air. But better results are obtained by slow drying in an air-bath heated up to 80° C., and allowed to cool. In proof of the toughness of the films, it was mentioned that a flat circular film four centimeters in diameter had supported a 50-gram brass weight at its centre.

Duclaux has studied quite extensively the phenomena of surface tension exhibited by the alcohols and the acids of the fatty series. The alcohols employed were methyl, ethyl, isopropyl, isobutyl, amyl, and capryl alcohols; and the acids

were formic, acetic, and butyric. The author shows that if the measured surface tensions of these liquids be taken as ordinates, and the percentages by volume of the liquid as abscissas, the resulting curve resembles an elongated parabola, or, more exactly, an exponential curve, the equation of which he gives. Methyl and ethyl alcohols have a point of inflection in their curves. From his results he formulates the following important law: If with the different alcohols or the different fatty acids mixtures be made in various proportions, and if those mixtures are compared together which have the same surface tension, the percentage ratios of alcohol or of acid which they contain are constant, and independent of the actual value of this tension.

3. Of Gases.

Stearn & Swan have improved the Sprengel air-pump by closing the reservoirs at top and bottom, so that no pressure is exerted on the surface of the mercury by the external atmosphere. In consequence, the fall tube may be very much shortened without impairing the efficiency of the instrument. On beginning exhaustion, the mercury reservoir at top is filled, and closed by a stopper, and, by means of a small exhausting syringe attached to the lower reservoir, a considerable portion of the air is removed from the receiver to be exhausted, and the pressure on the mercury in the lower reservoir is materially reduced. The flow of the mercury in the pump completes the exhaustion rapidly. With a fall tube only nine or ten inches long, a small vacuum tube furnished with aluminum wires separated by a quarter inch was exhausted in twelve minutes so perfectly that an induction coil giving half-inch sparks in air failed to produce the slightest luminosity. The new form of pump is for sale by Mawson & Swan, of Newcastle-upon-Tyne, at the price of £7 10*s.* sterling. This firm also make a compound pump of this sort having three fall tubes, by which the exhaustion is very much accelerated, at the price of £9. The small vacuum tube, which was exhausted with the former instrument in twelve minutes so perfectly that an electric spark of half an inch in air would not pass through it, was exhausted with the compound pump in three minutes.

Puluj, of the University of Vienna, has published the sec-

ond and concluding portion of his paper on the diffusion of vapors through earthenware cells. His apparatus consisted of a graduated tube of glass, having a porous earthenware cell at top, the upper portion of the apparatus being placed within a bell-jar into which the vapor could be conducted. A soap film placed half-way in the tube indicated the direction of diffusion as well as its amount by the direction and extent of its motion. With this apparatus the vapors of water, chloroform, alcohol, and ether were experimented with. The author concludes from his results that vapors follow the same law of diffusion as that discovered by Graham for gases, *i. e.*, that the times of diffusion are directly and the velocities of diffusion are inversely proportional to the square root of the density of these vapors.

Daubrée has experimented upon the mechanical actions of incandescent gases. A plate of steel twenty-three square centimeters in area, and weighing 3.479 grams, was placed in a powder-chamber of forty-three cubic centimeters capacity, in which twelve grams of powder were exploded by an electric spark. The plate of steel was found completely fused into a strangely twisted and puffed-out mass. An impalpable powder of ferrous sulphide was found in the chamber, and the plate had lost 0.738 gram in weight. In other experiments in which a minute opening existed between the powder-chamber and the air, closed by a steel conical plug, he found that when the plug was not completely screwed up, gases escaped at the instant of explosion, which completely melted away the conical part of the plug, and excavated deep furrows in the cylindrical portion. The author applies these facts to the solution of some geological problems.

ACOUSTICS.

Lord Rayleigh, in a lecture delivered before the Royal Institution, has discussed the theory of maintained vibrations in Acoustics, confining himself to that class of such vibrations of which heat is the motive power, and particularly to the case where the vibrating body is a mass of air more or less completely confined. The most common form of the phenomenon is that often observed in blowing a bulb on a glass tube, first investigated by Sondhauss, though the more

familiar examples of the hydrogen singing flame and the tube of Rijke are also cases in point. The explanation seems to be that the heat is communicated periodically to the mass of air confined in the sounding-tube at a place where in the course of a vibration the pressure varies. The phenomena, however, are yet quite complex.

Kayser has redetermined the velocity of sound in air by a modification of the method of Kundt. The dust figures in the glass cylinder were formed by the transverse vibrations of steel rods excited by a violoncello bow. A small cork piston attached to one end of the rod played in the glass cylinder, while a style affixed to the other end of the rod drew its vibrations on a phonautograph cylinder. The vibrations were compared with those of a fork recorded simultaneously. He assigns 332.5 meters as the velocity of sound in free air. The same research enabled him to determine the ratio of the specific heat of air at constant volume to that at constant pressure. The true value Kayser finds to be 1.4106.

Szathmari has ingeniously applied the method of coincidences to determine the velocity of sound in free air. His apparatus consisted of a pendulum whose rate was accurately known, which was made to close an electric circuit at each oscillation, the line being 220 meters long, and having two bells in its course. When the observer is close to both of the bells, he hears the strokes of both simultaneously; but if one of the bells be removed to a distance, the stroke of this bell is heard after the other, until a point is reached at which the strokes occur again at the same instant. The distance between the bells is that over which the sound moves between two successive strokes of the bells. In the experiments of the author the pendulum had a period of 0.2961 second. The distance between the bells when the sounds were again simultaneous was 99.25 meters. From this the value 335.19 is easily obtained as the velocity of sound in free air in meters. Reduced to zero, the value becomes 331.57 meters—between Regnault's value and that of Moll and Van Beck.

M'Leod, according to *Nature*, has described some experiments made with his new apparatus upon the exact number of vibrations made by tuning-forks. He used two sets of forks belonging to the South Kensington Physical Laboratory, and a third set just received from König. The results

showed a remarkable concordance, the extreme measurements in the worst set of observations on a fork of 256 complete vibrations only differing by 0.005 per cent., while in the good set they agreed within 0.00078 per cent. The new series from 256 to 512 he found to give from 0.3 to 0.5 of a vibration more than was anticipated, but this he ascribes to difference of temperature.

Ellis, who some months ago questioned the accuracy of König's forks, has made more experiments with Appun's tonometer, upon the indications of which he based his statement, and finds (1) that the beats of the harmonium reeds in Appun's tonometer are affected by taking place in a confined space of air; (2) that they are accelerated; and (3) that the acceleration, being roughly about one per cent., will probably, when completely ascertained, account for the discrepancy observed. The acoustic fact thus ascertained has undoubtedly important bearing on other similar phenomena.

Dubois has studied the vibrations of tuning-forks by means of vermilion, which is mixed with water and placed on the branches of the fork. When these are vibrated, striæ are produced, and the vermilion gives a figure by settling in the grooves. In the case of open pipes, a band of paper charged with the vermilion was placed over the opening. He finds (1) that two sounds of the same pitch but of different instruments give the same striæ, and (2) two sounds of different pitch give striæ inversely proportional to the number of vibrations of the sounds. The same results were obtained with vibrating plates.

Ellis has communicated to *Nature* a correspondence he has had with Cavaillé-Coll, the celebrated organ-builder of Paris, on the general question of musical pitch. He has in his possession one of Scheibler's tonometers—a series of fifty-six forks, varying from A 220 to A 440 double vibrations, by four beats. Their extreme accuracy is shown by the fact that the 400-vibration fork was found to be in unison with Foucault's mirror, determined by him to rotate exactly 400 times a second. With reference to the Cagniard de Latour siren, the present usefulness of it depends upon two improvements of Cavaillé-Coll—first, the regulator by which the wind pressure is preserved constant, and, second, the automatic counter. On comparing the French normal diapa-

son with Scheibler's forks, it is found that the former gives 435.875 double vibrations per second, or nearly one vibration more than is assigned to it by the report of the commission. Lissajous determined this pitch by means of the improved Latour siren.

Terquem shows very elegantly the phases of a vibrating-plate by placing a wide-mouth bell-jar over the plate, connecting the jar with one of König's manometric flames. If the axis of the bell be exactly over the centre of the plate, the flame is entirely unaffected; so, also, if symmetrically placed over a nodal line. When the bell is displaced even slightly, the flame shows serrations, which reach a maximum when it comes over a ventral segment. The experiment may be modified by using two smaller bell-jars, connected to the same capsule by a Y tube, a sliding tube being placed on one of the branches for adjustment. In this way the serration of the flame may be made very strong, being the sum or difference of the separate segments according as the bells are placed over alternate or adjoining portions. The gas jet used is made more brilliant by carbonizing the gas before burning, and by enclosing it in a tube through which a current of oxygen is passed. A cylinder of mica, blackened except opposite to the flame, surrounds the outer tube.

Blaikley has contrived a simple method for experimentally determining the position of the nodal points in tubes of varying section—a matter of great importance in the theory of brass musical instruments. For example, given a conical tube open at both ends, whose pitch is C 512 vibrations. The node is nearer the small end, and by sinking one end in water and holding a fork of the pitch of the tube over the other, the exact position of the node is shown by the level of the water at maximum resonance.

Gordon has proposed an extremely simple form of phoneidoscope, free from the defects of the ordinary instrument. All the apparatus required is the hand and some soap-suds. The forefinger and thumb being bent so as to form a circle, a soap film is drawn across them with the other hand. By turning the wrist the angle made with the direction of the light may be readily adjusted, a motion of the elbow alters the distance from the mouth, and the tension of the film can be exactly regulated by moving the thumb and finger. On

singing or speaking to the film when in proper tension, beautiful figures appear, which may be reflected from the film directly on a screen.

Mann has described in *Nature* an improved method of projecting Lissajous curves upon the screen. On a base-board two reed boxes are placed, one horizontal, the other vertical, capable of slight adjustment, so arranged that the reeds face each other. These reeds are inserted in reed plates, clamped to the face of the boxes, the vertical one giving the fundamental note, the horizontal consisting of a series giving all the intervals up to the twelfth. The reeds themselves are similar to those used in harmoniums. To each, about an inch from its free end, a small mirror of silvered glass is attached. By means of an air current, controlled by two taps, the reeds may be thrown into vibration, the rate being controlled within certain limits by the air pressure. A beam of light being thrown on one mirror is reflected to the other, and thence to the screen. By admitting the air blast the reeds are thrown into vibration, and the figure characteristic of the ratio represented by the reeds is produced.

Terquem has proposed a new method of projecting the curves of two forks vibrating rectangularly, known as Lissajous figures, which he says renders it impossible to produce these figures even by means of the calcium light. Upon one of the forks, placed vertically, is fixed, at the end of one of the prongs, a small square plate of aluminum, in which a minute hole is pierced with a fine needle. Upon a prong of the other fork, which is supported horizontally, with its plane parallel to that of the first, is placed a small lens having a focal length of three or four centimeters. This lens is attached to a screen of aluminum, which is screwed to the one prong, a counterpoise being placed on the other. On strongly illuminating the minute opening, and placing the second fork so that its lens forms a sharp image of this opening on the screen, extremely sharp and well-defined curves are obtained, whose amplitude exceeds that given by mirrors.

Tisley has improved his compound pendulum apparatus for drawing curves, and now gives to it the name harmonograph. It is capable of giving a great variety of curves, since parallel and elliptic motions can be combined in it with rectangular vibrations. Each pendulum is independent, and one of

them carries at its upper end a table which can be caused to rotate by clock-work if required; the other carries a pencil which moves over the table. If two pens be used two and a half inches apart, two curves will be traced, not exactly similar, but which combine in the stereoscope to give a solid figure. By changing the relative motions of the pendulums, very curious forms of curves have been obtained, resembling those given by biaxial crystals under the polariscope.

Mayer has written an illustrated article in *Nature* on the phonograph of Edison, calling it, in Indian parlance, "the sound-writer who talks." After a detailed description of the instrument and the mode of operating it, he describes his method of getting the form of the indentation in the foil. A delicate lever has a point on the under side of the shorter arm, which, by turning the cylinder, is made to traverse the indented groove. At the same time a style of copper-foil, attached to the longer end of the lever, moves over the smoked surface of a piece of glass held vertical, and reproduces the curve magnified in the ratio of the arms. A cut is given of the indentations, of the tracing thus made from them, and of the corresponding manometric flame-curve of König, showing their identity. Impressions have been got by Edison on copper-foil and on Norway iron.

At the April session of the National Academy in Washington, Dr. Edison gave an exhibition of the phonograph, after which various speculations were indulged in as to the possible uses of the instrument in the future. There are two advantages which the anthropologists may gain from it. If a savage were to utter his thoughts in front of the phonograph in his vernacular, and the foil were carefully submitted to some learned society, the language could be exactly reproduced. The endless confusion which has arisen by the adoption of various alphabets in securing vocabularies would thus be avoided. Again, the most cultivated languages change their pronunciation, and all peoples in passing through various stages of culture change their methods of vocalization. Let a series of phonographic sheets be struck off, stereotyped, and preserved with a proper register, and centuries hence the philologist will have the material for a comparative study.

Ellis has described some results obtained by Jenkin with

an apparatus by which he obtains vertical sections of the impressions made on the tin-foil of the phonograph, magnified 400 diameters, and called "speech-curves." In the word *tah*, for example, intoned, there is first the "preparation," the curve gradually but irregularly rising; then the "attack"—a bold serrated precipice, with numerous rather sudden valleys; next the "glide"—a perfect tumult of curvatures, which gradually settle down into the "vowel" proper. This remains constant for a considerable number of periods, and vanishes away gradually to silence. This curve Jenkin has submitted to analysis, reducing it to its separate pendular curves, and has succeeded in tracing out as many as five partial tones. The results differ materially for different speakers, and Jenkin is endeavoring to classify these speech-curves into genera. Thompson proposes to improve the sibilants in the phonograph by placing a strip of card or watch-spring across the opening edgeways, so that the voice impinges on the edge of the strip. The aspirates are also well spoken by such an instrument.

Jenkin and Ewing have studied elaborately the form of the sound tracings produced by Edison's phonograph. With reference to the vowels, these observers note that if a set of vowel sounds be spoken to the phonograph, and then it be made to speak at several different velocities of rotation, no difference can be detected in the quality of the sounds. This they regard as contradictory of Helmholtz's statement that each vowel sound has a characteristic note of definite pitch. Moreover, they have observed that the wave form of the markings produced by any vowel sound does not remain unchanged at all pitches; but whether these changes are due to alterations in the amplitudes of the constituents or to variations of phase is not determined. Subsequently, in a paper before the Royal Society of Edinburgh, they announced the curious fact that both vowels and consonants are unaltered by being spoken backward. Words such as *ada*, *aba*, *aja*, *ete*, could be readily identified whichever way the cylinder was turned, even by persons ignorant of what had been said. Moreover, they find that *ab* said backward becomes *ba*, thus proving that a reversible part really constitutes an element of speech. Thus putting the word *noshäeesossa* on the cylinder, and turning it backward, it repeats *association*

beautifully. Preece has described two phonographs made in England from Edison's descriptions. In one of these the rotation was rendered uniform by means of clock-work, thus maintaining the identity of the sounds; in the other the receiving membrane was of paper, and seemed to be the loudest.

Blake has devised and practically applied a very ingenious method of recording articulate vibrations by means of photography, and has obtained some very interesting results. The apparatus consists of a mirror of steel capable of oscillating about a diametral axis, to the back of which is attached a lever, by which it is attached to the centre of a telephone disk, arranged with the usual mouth-piece contrived by Peirce. Whenever the disk is caused to vibrate, the mirror oscillates with it, and a beam of sunlight thrown on the mirror from a heliostat describes lines of light on a suitably placed screen. If this screen be movable at right angles to these lines of light, and carry a sensitive collodion film, the light oscillation is recorded upon the prepared surface as a more or less complex curve having the peculiarities of the sound-wave which caused it. Representations of the curves of various sounds accompany the paper.

Pfaundler has given, in a communication to the Vienna Academy, the results of some physiological experiments to determine the question whether two isolated sound-pulses can produce a sensation of tone, either alone or by repetition. His first experiments were undecisive, but upon repeating them with the aid of Baumgarten's reflection-tones, he was able to answer the above question in the affirmative. Subsequently, using a siren with two air openings, analogous to Baumgarten's method, he confirmed his results.

HEAT.

Victor Regnault, whose death took place on the 19th of January, 1878, was a man of the highest scientific eminence. Born at Aix-la-Chapelle in 1810, he entered the store of a draper in Paris, and at twenty the École Polytechnique, where he remained two years. He then went to Lyons, occupying the chair of chemistry, and worked at research so successfully that in 1840 he was elected to the French Acad-

emy, and appointed professor in the École Polytechnique. In 1841 he was made Professor of Physics in the Collége de France. His removal to Paris changed the character of his investigations. First he made his celebrated research on specific heat, in the course of which he invented the air-thermometer in its present form; then he studied the phenomena of expansion, vapor tension, and hygrometry. In 1854 he was made Director of the Sèvres Porcelain Manufactory, and improved considerably the ceramic art at that place. The death of his son Henri, an artist of promise, on the battlefield during the Prussian war, depressed him exceedingly; and on his return to Sèvres after peace had been declared, the discovery that the results of his last great research on the heat phenomena accompanying gaseous expansion, drawn from over 600 observations, had been destroyed, seemed to shatter still more his nearly exhausted frame. He never recovered from these shocks, but died on the day that the artists of Paris were laying their wreaths upon the grave of his son.

1. Thermometry and Change of State.

Negretta and Zambra have contrived a new deep-sea thermometer, described and figured in *Nature*. To a cylindrical bulb containing mercury a tube is fitted, which is contorted and constricted near the bulb, and is enlarged at the remote end, from which end it is graduated. When the bulb is held downward, the mercury expands as usual, but when it is reversed, the column breaks at the narrowed portion of the tube, flows to the other end of this, and is there read. Hence, if the thermometer be lowered with the bulb downward, and reversed on attaining the desired depth, the reading on coming to the surface will represent the temperature at the time of reversal. To prevent the errors caused by pressure, it is enclosed in a glass sheath.

Himly has proposed to observe melting-points electrically by coating the bulb of a thermometer with silver to make it a conductor, which is then thickened with copper deposited electrolytically. The bulb is coated with the substance whose fusing-point is to be determined, and, when cold, is placed in mercury, which is in the circuit of a battery and electric bell. When the mercury is heated to the temperature at which the substance melts, the metallic contact is

completed, and the bell rings. The temperature observed on the coated thermometer at this instant is the melting-point desired.

Pictet has sought to determine experimentally the cause of the difference between transparent and opaque ice, and finds that it is due to the temperature at which the ice is formed. When frozen at temperatures between 0° and −1.5° C. it is as clear as crystal, but when frozen below −3° it is whitish and of less density, its cohesion being also diminished. The causes of this whitish opacity are two in number—first, the presence of air bubbles in the ice, and, second, the irregularity of the ice crystals, which destroys its optical homogeneousness. If a current of air be passed through the water while freezing, the ice is clear and transparent, no matter how low the temperature at which it is frozen.

Gernez has studied the phenomenon of supersaturation in salt solutions, and finds that other liquids besides water—such as carbon disulphide, the hydrocarbons, phenols, and especially the alcohols—show this property. A salt which does not give supersaturated solutions with one solvent never yields them with another; nor is the result attained by adding a substance such as dextrin to increase the viscosity. Sodium carbonate, calcium nitrate, magnesium sulphate, lead acetate, and alum yield supersaturated solutions most easily. In the case of all five, however, crystallization ensues only on the introduction of crystals of an isomorphous substance, and the latter lose this property if heated above a certain temperature, 98°, for example, for alum. Gernez gives a list of 120 substances which possess the property of yielding supersaturated solutions.

Mallet has examined the liquid contained in a cavity in a specimen of green fluorite from Alston Moor, in Cumberland, Eng., the cavity being irregular, 6 mm. long, 2.5 wide, and 1 deep, and filled with liquid in which was a readily mobile bubble. From the experiments which he made upon this liquid at different temperatures he concludes that it is simply water.

Handl and Pribram have described, in the Proceedings of the Vienna Academy, a new method for determining boiling-points, depending on the well-known law that the temperature

at which a liquid boils is the temperature at which its tension equals the pressure of the atmosphere. The apparatus consists of a thin U tube of glass about a decimeter long and 1.2 centimeters diameter, one leg being closed and the other open, and both graduated into millimeters. Upon filling the closed end of the tube with mercury, introducing a drop of the liquid at that end, and placing the apparatus in a suitable bath, the temperature at which the level of the mercury is the same in both branches is the boiling-point of the liquid. An apparatus for introducing the liquid is also described. Essentially the same apparatus was described by Jones in a communication to the Chemical Society of London, and by Main in the *Chemical News.*

Carnelley, having determined by careful calorimetrical experiments the fusing-points of various salts, has, in conjunction with Williams, made use of the data thus obtained for the purpose of determining the boiling-points of substances which are beyond the range of ordinary thermometers. Fragments of two or three salts are placed in the vapor or liquid and examined to see if they melt. Thus, for example, while sodium chlorate melts in the vapor of mercuric chloride, sodium nitrate does not. Anthracene vapor melts potassium nitrate, but not the chlorate. Its boiling-point is between 339° and 359°. The authors hope to fix in this way the boiling-points of potassium, sodium, etc.

Vincent has made a careful study of the use of methyl chloride in the production of cold. At ordinary temperatures and pressures it is a colorless gas, having a sweet taste, and an odor recalling that of chloroform. At a tension of 3.13 meters of mercury at 15° it condenses to a colorless liquid, which boils at −20°. It is prepared commercially from vinasse, which is the residue after the fermentation and distillation of beet-root molasses, by calcination for the preparation of potash salts. During the process there is disengaged a considerable quantity of trimethylamine, the hydrochlorate of which decomposes, when heated to 295°, into free trimethylamine, monomethylamine, hydrochlorate, and methyl chloride. The gaseous mixture being passed through an acid, the alkaline bodies are removed, and the methyl chloride is left pure for condensation. On exposure of the liquid to the air, it at once boils for an instant, until the tem-

perature falls to $-23°$. If a current of air be passed through it, a temperature of $-55°$ is obtained, in which mercury freezes. Placed in a closed vessel and the air exhausted, a very low temperature is obtained, which may be utilized in the production of ice. Methyl chloride is sold in the liquid form in Paris at four francs the kilogram.

The close of the year 1877 was distinguished by a series of remarkable discoveries in the liquefaction of gases. In November, Cailletet announced to the French Academy the liquefaction of acetylene, ethyl hydride, marsh gas, and nitrogen dioxide, the last under a pressure of 104 atmospheres at $-11°$ C. On the 22d of December a despatch to the Academy announced the liquefaction of oxygen by Raoul Pictet, of Geneva, under a pressure of 320 atmospheres at $-140°$. At the meeting on the 24th a sealed communication from Cailletet, deposited with the Secretary on the 3d of December, was opened and found to contain a statement that upon the previous day he had compressed oxygen and carbonous oxide to 300 atmospheres at $-29°$, and had then allowed them to expand suddenly; a thick mist appeared, which was evidently a liquid in droplets. Hence both these physicists appear as original and independent discoverers, their methods being entirely different, though attaining the same result. Pictet, however, obtained an amount of liquid oxygen which occupied one third of the length of a glass tube one meter long and a centimeter in interior diameter. On the 31st of December, at the École Normale, in Paris, and in presence of Berthelot, Boussingault, H. Sainte-Claire Deville, Mascart, and others, Cailletet liquefied nitrogen, hydrogen, and then atmospheric air. The nitrogen was compressed to two hundred atmospheres at $+13°$, and, when the pressure was suddenly relieved, the gas condensed into distinct droplets. Hydrogen yielded a mist when expanded suddenly from 280 atmospheres. On trying the experiment with carefully purified air, a stream of liquid air issued from the jet, resembling the spray from an atomizer. Thus disappears the last of the permanent gases, and molecular cohesion assumes its sway over all the forms of matter.

Cailletet has given subsequently the details of his experiment of liquefying air. Enclosing in his glass tube air dry and free from carbon dioxide, he cooled this tube with liquid

nitrous oxide at its upper part. Upon increasing the pressure to 209 atmospheres, streams of liquid were seen flowing down the lower portions of the tube. When they met the mercury, they seemed to turn back. At 310 atmospheres, the mercury, being in contact with the cooled part of the tube, was frozen, and on quickly removing the refrigerating apparatus it was seen covered with *frozen air*.

Pictet has determined approximately the density of liquid oxygen, and finds it to be the same as that of water, thus confirming an *à priori* conclusion of Dumas. Knowing the volume of the generator, of the condensing-tube, and of the potassium chlorate used, the temperature of the generator when the decomposition was complete, the pressure before and after condensation, and the variations of the manometer after two or three consecutive jets, up to the point where the limit between the liquid and gaseous states is attained, and combining these data with the density of the gas, its pressure and temperature, Pictet finds that at $-146°$, the temperature of the carbon dioxide bath, the pressure required to liquefy the oxygen is 74.26 atmospheres. The weight of liquid oxygen contained in the tube was consequently 45.467 grams, and it occupied a volume of 46.25 cubic centimeters; hence the density is not far from unity.

Thorpe, in a note to *Nature*, calls attention to a long-neglected paper of Mr. Perkins, which was published in the *Philosophical Transactions* for 1826, having been read on June 15, in which Mr. Perkins announces that he had liquefied atmospheric air, having obtained pressures of upward of 1000 atmospheres in an apparatus quite similar to that of M. Cailletet. The paper describes the appearances as the pressures were gradually increased, and says: "At 1200 atmospheres the quicksilver remained three quarters up the tube, and a beautiful transparent liquid was seen on the surface of the quicksilver, in quantity about $\frac{1}{2000}$ part of the column of air." Subsequently carburetted hydrogen was liquefied in the same way. This was in the year 1822.

Garnett has called the attention of physicists, in an article in *Nature*, to the peculiar form of the rosettes obtained when a drop of water is placed on a red-hot surface, as in Leidenfrost's experiment. The outline of the drop did not form a continuous curve, but was beaded in character, while within

was a fluted figure. On closer inspection it appeared that the forms were produced by the superposition of two retinal images of the drop in two extreme phases of vibration. In other words, the drop was really vibrating like a bell sounding its first harmonic, and had therefore six ventral segments. To prove this, the vibrating drop was illuminated in a dark room, with sparks from a Holtz machine, and two curvilinear pentagons, alternate with each other, appeared. When the drop had somewhat decreased in size, four-sided curved figures, alternating with each other, were seen. On opening the shutter, there appeared in the capsule an almost perfectly steady beaded octagon, formed by the union of the two crosses.

2. Conductivity and Radiation.

Lodge has described a simple form of apparatus for determining the conductivity for heat of rare substances, such as crystals, which cannot be obtained in slabs or rods. It consists of two small tin cans, with a copper arm about eight inches long projecting horizontally from each, the external ends being clean and flat. These arms are placed in a straight line, with the crystal between them, and held together by a slight horizontal pressure. Holes are drilled in the copper rods for thermometers, and the curves of temperature being given by these, that for the crystal enclosed between the bars can be calculated very readily.

Less has measured the conductivity for heat of seventeen varieties of stone and several kinds of wood, the method employed being in general that of Hopkins, though with some modifications of his own. He finds that density and compactness favor conductivity, other things being equal. Crystalline rocks conduct better than sedimentary, and fine-grained better than coarse-grained stone. He tabulates his results by placing Pyrenees marble as 1000. Then Saxon granite follows as 804; Carrara marble 769, etc., to ordinary clay, 275. He corroborates Tyndall's statement that the conductivity in wood is different, parallel and perpendicular to the fibre, but finds the difference much less than Tyndall gives. Since the ratios of the galvanometer deflections are greater in the better than in the poorer conducting woods, it would appear that the deflections are proportional not to

the conductivities themselves, but to a somewhat higher power of them.

Buff has experimented to determine the thermal conductivity and diathermancy of air and hydrogen, using for this purpose an apparatus similar to that used for the same purpose by Magnus, but modified considerably in its details. From the results obtained he concludes that the thermal conductivity of hydrogen and of other gases is far too small to admit of its being proved by the method Magnus adopted, the assumption sometimes made that hydrogen conducts heat like a metal not being justified; that, on the other hand, hydrogen possesses a diathermancy closely approaching that of a vacuum; that dry air absorbs from fifty to sixty per cent. of the rays of heat which it receives from a source heated to the boiling-point of water; that the absorptive power of moist air surpasses that of dry air by a trifling percentage, but by no means to such a degree as hitherto had been assumed by several physicists; and that rock-salt is not absolutely diathermanous for the so-called dark rays of heat; its thermal color rather resembles that of dry air in this respect.

Stokes has described the results of some experiments made with a radiometer whose vanes were all metallic, one side of each being roughened by ruling it closely with a sharp knife. In every case it appeared that when the fly is hotter than the bulb, the rough surface is repelled, and, when cooler, attracted. Results nearly the same were obtained with another radiometer, one side of each vane of which was electro-coated with finely divided silver. Hence Professor Stokes concludes that there are three conditions under which motion may be obtained in a radiometer: 1st, difference of temperature on the two faces, as in a pith radiometer, coated on one face with lamp-black; 2d, more favorable presentation of one face than the other, as in a radiometer with curved disks; and, 3d, roughness of surface on one face—if this be really different from the last. These effects, it is obvious, may be variously combined so as to oppose or assist each other in producing motion.

3. Specific Heat and Thermodynamics.

Lecher has communicated to the Vienna Academy the im-

portant fact that the specific heat of water, hitherto supposed to be greater than that of any known substance except hydrogen, is really less than that of a mixture of water with methyl alcohol, in various proportions. This mixture, therefore, has a specific heat next to hydrogen.

Dahlander has communicated to the Swedish Academy of Sciences the results of his observations on the comparative rapidity with which heated solid bodies are cooled by immersion in various liquids. If the cooling power of water be taken as unity, that of alcohol is 0.58; of mercury, 2.07; of a concentrated solution of salt, 1.05; and of a concentrated solution of copper sulphate, 1.03. The rapidity of cooling increases with the increased temperature of the liquid.

Ditte has proposed to show the heat produced by chemical action, by adding 125 grams of water to 100 of boric acid. The heat produced is so great that an ingot of Darcet's fusible metal put into the mixture is completely fused in a few seconds.

Olivier has observed the curious phenomenon that if one end of a bar of steel fifteen millimeters square and seventy to eighty centimeters long be held against a revolving grindstone, one hand grasping the bar at its middle point, the other at the end, the middle portion remains quite cold, while the end farthest from the stone becomes too hot to touch. This appears to indicate the transference of energy along the bar in some other form than as heat.

Joule has made a new set of experiments with a view to increase the accuracy of his former determinations of the mechanical equivalent of heat. The result he has now arrived at, from the thermal effects of the friction of water, is, that taking the unit of heat as that which can raise a pound of water weighed in vacuo from 60° to 61° of the mercurial thermometer, its mechanical equivalent, reduced to the sea-level at the latitude of Greenwich, is 772.55 foot-pounds.

Aitken has described an apparatus for illustrating the conversion of the motion of heat possessed by matter at its normal temperature into work, in which he anticipated Preston's experiment. Two glass tubes entered a large bottle through its cork, one passing to the bottom, its upper end being drawn out to a fine jet. The other terminated just below the cork, where were attached some strips of blotting-paper.

Its upper end communicated with a closed vessel containing ether or some other volatile liquid. Some water being placed in the bottle, the ether was allowed to run on to the paper strips. Here evaporating, pressure was generated in the interior of the bottle, which threw a jet of the water to a considerable height, thus doing work without the addition of heat.

LIGHT.

1. Reflection and Refraction.

Masse has called attention to the explanation given many years ago by Arago and Babinet of the phenomena exhibited by the so-called Japanese magic mirrors. These mirrors are made of an alloy of copper and tin, are circular in form, are from one eighth to one tenth inch in thickness, and have Chinese or Japanese characters in strong relief on the back. When sunlight is reflected from them on a wall, the characters appear. Since these mirrors are cast, they are not equally dense in all parts; and hence in the operation of polishing they become concave or convex over the characters in relief, and these characters are therefore shown in the reflection. Notwithstanding this entirely sufficient explanation—proved a year or more ago by President Morton, of the Stevens Institute of Technology, by polishing the letters S. I. T. with a little rouge on his finger on an ordinary Japanese mirror showing no characters on reflection, and obtaining these letters in the reflected image—the magic mirror is brought forward every few years as a phenomenon entirely inexplicable by science.

Hoffmann has devised a new form of camera lucida, which seems to be an improvement upon the ordinary instrument. In place of a total reflection prism he uses two mirrors, one metallized, the other plain, placed at a fixed angle. The latter mirror transmits the rays coming from the pencil, and at the same time reflects a part of the rays coming from the object to be drawn, and which have already been reflected from the metallized mirror. A neutral tint glass or a set of lenses may be attached to the apparatus for special kinds of work.

Gariel has devised an ingenious abacus or chart by which the relations of the conjugate foci and the principal focus of

lenses represented by the usual formulas may be given graphically, thus facilitating materially the calculation of these values. Upon two perpendiculars erected at the extremities of a base-line are laid off equal spaces from this line, representing the principal focus. Diagonal lines drawn from the corners to each of these divisions represent the conjugate foci. It may be easily shown geometrically that these are in the ratio required. Direct measurement gives the value of any one of these quantities when the other two are previously known.

The same physicist has proposed a change in the manner of numbering glasses for spectacles. They are now numbered in terms of the radius of curvature, expressed in inches, the sign being plus or minus, according as the glass is convex or concave. The new method proposes to number them in terms of a new unit called a dioptric, which is the power of a convergent lens of one meter in focus. Since the power of a lens varies in the inverse ratio of the focal distance, the number of any lens in the new system is easily obtained by dividing one meter by the focal length of the lens expressed in meters and fractions of the meter. These two systems have a simple relation to each other.

Javal has described an apparatus for determining astigmatism, and at the same time the number and position of the axis of the correcting glass regarded as a cylindrical lens. Two vertical disks, movable around the same horizontal axis, carry each a system of lenses, those of the first disk being cylindrical, inserted in mountings toothed upon their borders and gearing with a toothed wheel so that they can be simultaneously revolved; those of the second disk are spherical. The first disk is used to determine astigmatism by viewing through its lenses a circle divided into sectors of 15° by radii; and having determined its direction and adjusted the axes of the lenses to it, rotation of the disk gives the focal adjustment sought. The second disk permits the myopia and hypermetropia to be corrected. The instrument is called an optometer.

2. Dispersion.

Glan has contrived a new photometer for comparing the intensities of lights which differ in color. It is composed of a collimator carrying two slits, placed the one above the oth-

er. Behind the collimating lens is a Wollaston prism with its refracting edge perpendicular to the slits. By this means the two beams emanating from the same slit are deviated in contrary directions with reference to the length of this slit; and, for any convenient distance of the collimator from the prism, the two mean rays, each proceeding from one of the slits, and polarized in rectangular azimuths, are exactly juxtaposed throughout their length. Traversing the spectrum apparatus, they give two spectra, in which the lines of the one will be the prolongation of those in the other. A Nicol prism is used in order to equalize the intensities to be compared, placed between the Wollaston prism and the spectrum apparatus. By a previous calibration with the solar spectrum, using the same light for both slits, when the extinction coefficients are of course equal, the unit of intensity is determined. The substance to be examined is placed between the Wollaston and the spectrum prism, and the equality azimuth for each color measured; the ratio of the extinction coefficients is then easily calculated.

Herschel has proposed a simple form of scale for pocket spectroscopes. The slit plate is removed, and in its place is placed a disk of copper-foil having a fine slit cut through it on one side of the centre, crossing which obliquely is a row of twenty holes, one eightieth of an inch apart, five being on one side of the slit and fifteen on the other, perforated in the copper, the upper and lower holes being level with the top and bottom of the slit. Viewed by sodium light the slit appears bright, and the punctures appear as a series of yellow dots. They are placed obliquely, so that their spectra in white light may not overlap and confuse their images. The curve corresponding to the spectroscope is then obtained in the usual way, and the value of the points obtained in wave-lengths.

Günther has described a simple method of reversing the metallic lines by means of an ordinary gas flame. Into the flame of a Bunsen burner, on the opposite side from the slit, a fine platinum wire is placed, bent at a right angle, the end being directed vertically upward. On the other side of the flame a second wire is placed, carrying a sodium salt, for example. Looking at the flame through a prism of low dispersive power, the eye sees first the sodium line as a bright yel-

low band; and, second, the spectrum of the glowing wire, which is continuous except where crossed by the dark D line. Other metallic lines may be shown dark in the same way.

Duboscq has called attention to the appearance of relief obtained by projecting a spectrum with a direct-vision prism, using a cross, a V, a ring, or a spiral as the opening for the light. The illusion of relief is very strong in two rectangular planes, a cylindrical surface, etc. The effect is due to the great difference in intensity between the red rays forming the prominent parts of the image and the violet rays which form the more shaded portions of the figure.

Moser has examined the question whether each chemical compound has a spectrum of its own, as characteristic and definite for it as are those of the elements for them. After giving a *résumé* of what had already been done, mainly with emission spectra, he goes on to describe his own experiments made with the absorption spectra of iodine and bromine as elements, and of nitrogen tetroxide as a compound. From the results obtained he justifies the conclusion that compounds have definite spectra, which are measurably independent of mass and temperature.

Stoney and Reynolds have studied the peculiar absorption spectrum of the vapor of chlorochromic oxide, which is of special interest because it supplies information as to the duration and character of the motion of the molecules of the vapor which produces it. The spectrum consists of lines of various intensities, but uniformly distributed. Of these 105 have been examined, and from their position it has been ascertained that they are all to be referred to one motion in the molecules of the gas, of which motion they are all harmonics or quasi-harmonics. On the first supposition this motion is repeated 810,000,000,000 times every second in each molecule. From the succession of intensities it is surmised that this motion is in some way related to that of a particular point in a violin string vibrating under the influence of the bow, *i. e.*, a point nearly but not quite two fifths of the string from one of the ends.

Hurion has examined in the laboratory of Mascart the spectrum of iodine vapor, and shows that, as Le Roux had observed, this spectrum is produced by anomalous dispersion, the blue, contrary to the usual order, being less devi-

ated than the red. Using a hollow prism of glass, placed inside a hot-air bath, the author has successfully measured the refractive indices for the blue and red rays, and finds them as follows: for the blue 1.019, and for the red 1.0205. This gives 0.06 for the negative dispersion of iodine vapor, which is very near the positive dispersion of flint-glass. Assuming that the refractive power of a substance is independent of its physical state, the calculated indices for solid iodine would be for the red 1.89, and for the blue 1.83, the values obtained from measurements of the refractive power of a solution of iodine in carbon disulphide being 2.07 and 1.98 respectively.

Thompson has described a rainbow phenomenon, seen chiefly in Switzerland, in which radial streaks of light devoid of color are observed within the primary and without the secondary bow. He explains it by supposing that the wedge-shaped radial streaks are beams of sunlight, which become visible by diffuse reflection from particles of matter in their path, just as the apparently divergent beams of sunrise or sunset become visible. Being practically parallel, they appear to converge in the point exactly opposite to the sun by perspective, just as the parallel beams of the sun appear divergent. Since the rainbow has for its centre the point opposite to the sun, such beams must have positions radial with respect to the bow. They have never been observed crossing the dark span between the primary and secondary bows. The phenomenon is a frequent one in the Rocky Mountains.

Rosenstiehl has made use of rotating disks for the purpose of studying the phenomena of the sensations produced by colored light, using a method employed so successfully already by Rood. With regard to the chromatic circles of Chevreul, he has proved that what Chevreul calls equidistance between colors is really the result of a mixture of color sensations according to an arithmetical progression. It has not been possible to recognize the relation between the tones of a scale when the color is modified by white, in Chevreul's circles. For most of the scales each tone has another complementary to it, and there is no common measure between them.

Lommel has communicated to the Physical Society of Er-

langen a memoir on fluorescence, in which he divides all fluorescent bodies into three classes, the first comprising those substances upon which each homogeneous ray of light capable of producing fluorescence produces the whole fluorescent spectrum; the second including those bodies upon which the same ray of light produces only those rays of the fluorescent spectrum which are of a less refrangibility than the ray itself; and the third embracing those substances whose fluorescent spectrum consists of two parts, one of which corresponds to fluorescence of the first, and the other to fluorescence of the second order. He enumerates nine bodies belonging to the first class, twenty-five of class second, and seven of class third. He has not been able to prove that class three is a mixture of classes one and two.

Von Bezold and Engelhardt have examined the retina of the living animal, and conclude that it also fluoresces under the influence of the same rays which Helmholtz has stated exercise a fluorescent action upon the retina of the dead animal.

Abney has described to the London Physical Society the method he had adopted for photographing the least refrangible end of the spectrum. He had succeeded in obtaining a compound which is sensitive at the same time to the red and blue rays, by weighting silver bromide with resin, subsequently, however, causing the silver bromide molecules to weight themselves. While an ordinary silver bromide plate was of a ruddy tint, showing absorption of the blue rays, a plate containing weighted bromide of silver transmitted blue light and absorbed red. The latter plates are sensitive to the red and ultra-red rays, and photographs of the spectrum were exhibited extending from the line C to a wave-length of 10,000, the ultra-red showing remarkable groupings of lines. He explained the reversing action obtained by Draper at the red end as an oxidizing action, and found it to be accelerated in solutions of permanganate, hydroxyl, etc.

Chastaing has published an extended memoir on the chemical action of light. He concludes (1) that on inorganic bodies the violet end of the spectrum as far as the green exerts a reducing, the red end an oxidizing action, the latter being less marked; whence the total action of white

light is reducing. Between D and E the photo-chemical action is zero. (2) That on organic substances the action is an oxidizing one, continually increasing from red to violet, being represented by 2 in the former and 3 in the latter, if that in darkness be taken as 1. (3) That fluorescent rays do chemical work within the substance, transforming quinine, for example, into quinicine. The heat accompanying the light does not affect the result.

Timiriazeff has studied with great experimental precision the question of the decomposition of carbon dioxide by light in the leaves of plants, with a view to establish the connection of the rays of the spectrum active in this decomposition with the results. Since to obtain reliable results a pure spectrum is necessary, and in that case the light is much enfeebled, and the amount of decomposition proportionately small, the author contrived an exceedingly convenient apparatus for working on and measuring small quantities of gas. The solar light was received by a lens from the heliostat, nearly at the focus of which was a slit one millimeter wide. Beyond this was a second lens and a carbon disulphide prism. The purity of the spectrum was such that when a solution of chlorophyll was interposed, all its absorption bands were sharply defined. The leaves used were bamboo, the surface of each piece being a square decimeter. These pieces were placed in test-tubes of ten to twelve millimeters diameter, which were then filled with mercury, inverted, and a mixture of air with five per cent. carbon dioxide allowed to enter from a gasometer, filling the tube to a mark on the glass. Six tubes were thus prepared, one being used as a check, containing no leaf, and the other five being placed in the spectrum, the first in the ultra red, the second in the red between B and C, the third in the orange, the fourth in the yellow, the fifth in the green. They were exposed to the light for six hours, and the gas was then analyzed. The results were uniformly the same, and showed a maximum of decomposition in the second tube corresponding to the space between B and C. But this is exactly the position of the principal absorption band of chlorophyll. Hence the author concludes that his experiments prove the position that the identical energy absorbed by chlorophyll is the energy active in decomposing carbon dioxide in leaves.

This conclusion essentially confirms that of J. W. Draper, published more than thirty years ago.

3. Interference and Polarization.

Lockyer has suggested the use in the solar eclipse of July 29 of a Rutherfurd reflection grating in place of prisms for the purpose of observing the corona, using the coronal atmosphere in place of a slit. To test the question, he constructed an artificial eclipse by means of a circular aperture two inches in diameter, cut in card-board and placed thirteen yards distant from a $3\frac{3}{4}$-inch telescope, the circular slit being illuminated by a parallel beam of electric light. Some distance short of the focus of the telescope the grating was so placed as to throw the spectra of the circular slit on the photographic plate, and then photographed for the first, second, and third orders on one side, the slit being illuminated with sodium and with carbon vapor. The third-order spectrum gave in forty-two seconds a photograph showing the rings due to the carbon vapor flutings. Hence he thinks the third-order spectrum of the eclipse may be photographed in at least four minutes, the second order in two, and the first in one minute. This suggestion was anticipated by Henry Draper, who had constructed his phototelespectroscope on the above plan some months before the paper of Mr. Lockyer was presented to the Royal Society.

H. Draper, in a note to *Nature*, states the results of some of his investigations relative to the position of the oxygen in the sun's surface. Using for the purpose one of Mr. Rutherfurd's exquisite silvered glass gratings of 17,296 lines to the inch, giving a dispersion equal to that of twenty heavy flint glass prisms, attached to his 12-inch Clark refractor, the full aperture being employed, and placing in front of the slit the terminals of an induction coil, by which a strong oxygen spectrum was obtained in the same field, he was entirely unable to perceive that the lines of oxygen visible in the spectrum of the solar disk projected beyond the visible limb of the sun. In other words, they could not be detected in the base of the chromospheric layer.

Adams has presented to the Physical Society of London a new form of polariscope suitable for projecting on a screen the figures formed by any crystal, and for measuring the

angle between the optic axes. Parallel light from the electric lamp, after traversing a Nicol of about 2 inches aperture, is rendered divergent by a set of lenses. The crystal under examination is placed in a recess formed by removing a slice from the middle of a spherical lens which is capable of motion in any direction about its centre, while any movement in the vertical plane passing through the axis of the instrument can be measured by a scale and vernier; and if, by such a motion, the point on the screen representing the position of one axis, when the two are in the vertical plane, be transferred to that indicating the position initially occupied by the other axis, we have at once a measure of the optic angle of the crystal, since the rotation of two plano-spherical lenses forming an exact sphere has no effect on the direction of the beam.

Arzruni, in studying the crystalline properties of various organic bodies, has discovered that triphenyl-benzene possesses the property of double refraction to a degree surpassing that of any other crystalline body yet known. In substituted compounds he shows also that the introduction of the nitro-group invariably causes a much slighter change in crystallographic properties than when hydrogen is substituted by bromine or by iodine.

Sarasin has determined with great care the indices of refraction of the ordinary and extraordinary rays in quartz in the ultra-violet region of the spectrum. He used a goniometer with a collimator and observing telescope, the latter furnished with a fluorescent eye-piece. He believes his results accurate to the fourth decimal place, the metals used being cadmium, sodium, zinc, and aluminum.

Mackenzie has made some experiments in Helmholtz's laboratory in Berlin on the relation between electricity and light discovered by Kerr. A glass plate 16.1 centimeters long and 1.2 thick was covered on its opposite sides with tin-foil, the two surfaces being in connection with the secondary wire of a Ruhmkorf coil, and placed between two Nicol prisms. No perceptible increase of brightness was observed on electrification, though the high sensibility of the polariscope was fully proved. The conclusion follows that the result observed by Kerr is not produced by the electric tension itself, but is possibly an effect of heat.

ELECTRICITY.

1. Magnetism.

Sir William Thomson has presented a paper to the Royal United Service Institution upon a new form of azimuth and steering compass, with adjuncts for the complete application of the principles of correction for iron ships suggested by the Astronomer Royal. Hitherto, owing to the large size of the needles in the marine compass, the method of correcting the quadrantal error by placing masses of soft iron on the two sides of the binnacle, suggested by Professor Airy, has been practically unattainable. The new compass proposed depends upon the principle discovered by the author, that steadiness can only be obtained by increasing the vibrational period. It consists of a thin strong paper card supported on a thin rim of aluminum, from which thirty-two silk threads or fine copper wires pass to a central boss of aluminum, which rests on the projecting lip of an inverted aluminum cup in which a sapphire cap is mounted, the whole resting on an iridium pivot. Eight small steel needles from $3\frac{1}{4}$ to 2 inches long, weighing 54 grains, are fixed, like the steps of a rope-ladder, on two parallel silk threads, and slung from the aluminum rim by four fine copper wires through eyes in the four ends of the outer pair of needles. The weight of the central boss, aluminum cup, and sapphire cap is only five grains. For the 10-inch compass the whole weight upon the iridium point is about 180 grains. The period of vibration of this card is about forty seconds. With this compass the application of the principles of correction is easy and sure. The paper also describes an adjustable deflector for completely determining the compass error when sights of the heavenly bodies or compass marks on shore are not available, a new form of marine dipping-needle for facilitating the correction of the heeling error, and the navigational sounding-machine for taking soundings of 100 to 150 fathoms from a ship under full headway.

Duter has presented to the French Physical Society magnets obtained by subjecting circular steel plates to the action of an electro-magnet terminated with a conical point applied to the centre of the disk. In these magnets the neutral line is

a concentric circle of the disk. To study the free magnetism distributed over them, he used a small soft iron cylinder of a few centigrams weight, fixed in the centre to the rod of an areometer floating in water. The force required to detach this was estimated by the weight of water which had to be let off from the cylindrical vessel containing the areometer before the contact was broken. The precise instant of contact and detachment was indicated by an electric signal. In this way it was proved that the quantities of free boreal and austral magnetism were equal in the two portions of contrary name in the same plate. For plates of different diameters the forces of detachment depend simply on one specific coefficient, variable with the nature of the steel and with the thickness.

Gaugain has recorded the curious fact that a bar of steel magnetized at 400° or 500° C. not only loses its magnetism gradually as it is cooled until it becomes zero, but that magnetism of contrary sign appears, and increases until the bar reaches the temperature of the air, never becoming, however, as intense as the original magnetism. On again heating it, the same effects are produced in the inverse order, and they may be reproduced many times without remagnetizing. To account for this result, the author proposed the hypothesis that the bars which presented the phenomena consisted of two layers of magnetism of contrary name, which were differently modified by the variations in the temperature of the bars. To test the question, experiments were made with a steel tube enclosing a steel rod, forming a magnetic system. If the tube be magnetized, the rod inserted, and then withdrawn, the latter is found magnetized like the tube. But if, before withdrawing the rod, the system be heated to 300° and allowed to cool, the tube has lost nearly the whole of its magnetism, and the rod has become oppositely magnetized. The same results are obtained if the rod be magnetized in place of the tube. Moreover, if both tube and rod be magnetized at the ordinary temperature, or at 300° to 400°, and be at once separated, they are magnetized alike. But if the system be cooled before withdrawing the rod, their magnetism is opposite. If the magnetization has been effected at 300° to 400°, reheating the system increases the direct magnetism of the nucleus, and at the same time diminishes the inverse magnetism of the tube.

Thompson has contrived a simple apparatus for showing the field of magnetic force produced by parallel currents. A plate of glass is perforated by two holes close together, which are traversed by one and the same wire, so arranged that the current traverses the parallel lengths in the same or in opposite directions. If, now, the plate be held horizontally while the current passes, and fine iron filings be sprinkled on the plate, they arrange themselves in the well-known forms of magnetic spectra. They may be readily fixed by gum or shellac, so as to be preserved for lantern projection.

Becquerel has published an extended memoir on magnetic rotatory polarization. The results which he has obtained tend to show that both the direct and reverse magnetic rotations of the plane of polarization of light, as is the case in the phenomena of magnetism and diamagnetism, have a common origin, and are the manifestation of a general property of bodies—that of becoming magnetic. This property is possessed to a more or less considerable degree by various substances, and the effects which have been observed may be regarded as due to a difference between the magnetic action of the molecules of the bodies and that of the medium which envelops them.

2. Electromotors.

Maxwell has sent to *Nature* a note which he has received from Pirani, of Melbourne, describing an experiment in which an electric current appears to be produced by the direct action of gravity. A glass tube eighteen inches long is filled with a saturated solution of cupric sulphate, its ends closed by copper caps to which wires are attached, and the whole is connected with a delicate Thomson galvanometer. When the tube was held vertically a deflection of 200 divisions was observed, which was reversed on reversing the tube.

Gaiffe has described a new and convenient form of voltaic cell, which appears to be an improvement on the Leclanché battery. It consists of a cylinder of pressed carbon containing holes parallel to the axis, which are filled with manganese peroxide in fragments, and of a rod of amalgamated zinc. These are placed in a glass vessel which is filled with a twenty-per-cent. solution of zinc chloride as neutral as possible. In action the battery forms zinc oxide, which falls in powder

to the bottom of the vessel. The electromotive force, the interior resistance, and the constancy of this couple are quite equal to the Leclanché, while there is no incrustation of zinc ammonium chloride and no loss by evaporation, the zinc chloride being deliquescent. Moreover, when spent, this battery is easily recharged.

Jablochkoff has constructed a pyro-battery in which carbon is the substance attacked. Two plates, one of coke, the other of platinum, are placed in fused potassium or sodium nitrate. The electromotive force varies between two and three units, exceeding, therefore, that of the Bunsen or Grove batteries. The coke may be ignited and put into the nitrate, which is finely powdered; or the coke in fragments may be enclosed in a basket of iron wire.

An excellent illustrated description of Planté's arrangements for experiments with his secondary battery is given in *Nature*. In his laboratory he has 400 of these batteries, divided into ten sections, in each of two rooms. These 800 cells are charged by two ordinary Bunsen cells, they being united for this purpose in simple circuit by means of a commutator. When charged—a process of several hours—they may be united in series by the commutator, and then discharged, producing in a few seconds the enormous power which they have accumulated. He has studied the effect of these discharges upon various liquids, and has applied the results to the explanation of meteorological phenomena connected with electricity, such as thunder-storms, hail, and the like. In his opinion even the ovoid or pyramidal form of hailstones is due to their electric origin.

Ruhmkorf, so well known for his remarkable improvements in the induction coil, died at Paris on the 20th of December, having been in poor health for several months previously. He was born in Hanover, Germany, in 1803, went to Paris in 1819, became porter in Chevalier's laboratory, began the construction of physical apparatus shortly afterwards, and brought out a convenient form of thermo-battery in 1844. In 1851, after long experimentation, he brought out his famous "Ruhmkorf coil," which gave sparks eighteen inches long, and pierced glass two inches thick. He was rewarded in 1858 by the government prize of 50,000 francs for his discovery. In appearance he was of medium stature,

rather thick-set, with a smoothly shaven face and long bushy white hair. He was quiet and unassuming in demeanor, and courteous and agreeable in personal intercourse. He enjoyed the friendship of the leading men of science not only of Paris, but of the world.

Mallet has made the interesting observation that a wire placed east and west and traversed by an electric current suffers an apparent alteration in weight, due to the effect of the earth's magnetism upon it. The experiment, which was unsuccessfully attempted by Faraday, was made by attaching to the arm of a delicate balance a series of ten horizontal wires fastened to a strip of dry poplar three meters long, twenty-five millimeters wide, and five millimeters thick, the ends of the wires being branched and bent downward so as to dip into the mercury cups at each end. When the current of ten Grove cells was passed from east to west through the wires placed east and west, the side of the balance to which they were attached sensibly preponderated; while, when the current passed from west to east, the other side went down. These results may be observed with a single wire only a meter long.

Planté has constructed what he calls a rheostatic machine by combining a number of condensers (made of mica and tinfoil) so as to be easily charged from a secondary battery in quantity, and discharged in tension. The commutator is a long cylinder of hardened caoutchouc, having longitudinal metallic bands, and traversed by bent copper wire (for the two objects named). Metallic springs are connected with the two armatures of each condenser, and fixed on an ebonite plate on each side of the cylinder, which is rotated. A series of sparks can be got between the branches of the exciter in this arrangement, quite like those from electric machines with condensers. The discharges are always in the same direction, and the loss of force is less than in induction apparatus. A great many discharges can be had without the secondary battery being perceptibly weakened, as each discharge removes only a small quantity of electricity.

In a subsequent paper Planté has given a description of some of the effects obtained with this new rheostatic machine, which, as above stated, consists simply of a series of condensers so arranged as to be charged from a secondary

battery in quantity and discharged in tension. Using ten of these condensers charged with a secondary battery of 800 cells, as many as 15 brilliant sparks from 13 to 14 millimeters long were obtained per second, giving the same noise, and otherwise resembling closely the condensed spark from an induction coil. The difference between the negative and the positive spark is more marked in this machine than in the ordinary ones. Its length appears to increase with the number of condenser plates, 40 condensers giving a spark 4 or 5 centimeters long, and 51 of 6 centimeters. In vacuo the light is brighter than that of the coil, though no stratification is observable with it in tubes in which the induction spark gives it distinctly. Nor is there any difference between the poles in these tubes, the purple glow at the negative pole being absent. In proof of the minute quantity of electricity in each spark, a secondary battery of 40 cells was charged by 15 seconds contact with two Bunsen cells, and was then connected to the machine. It illuminated a Geissler tube for more than 15 minutes. Contact for 10 minutes would therefore illuminate a tube for more than 10 hours.

Jablochkoff has discovered and utilized the fact that if one of the surfaces of a large condenser be connected with one electrode of a to-and-fro current machine, an alternating current is obtained between the second condenser surface and the other electrode, much more powerful than the current given directly by the magneto-machine itself.

Sabine has investigated the remarkable motions which are produced by placing a drop of very dilute acid upon the clean surface of a newly filtered and rather rich amalgam of some metal which is positive to mercury. The drop does not lie still, as it would do on pure mercury, but sets itself into an irregular jerky motion. This is true of copper, tin, antimony, zinc, and lead amalgams. If, however, amalgams of metals negative to mercury be used, such as gold, platinum, and silver, the drop lies quite still. Sulphuric, hydrochloric, oxalic, and acetic acids were used, and all produced the result, but in different degrees. In oxygen the movements are increased; in hydrogen they are arrested. The author hence infers that the motions result from alternate deoxidation of the mercury beneath the acid by electrolysis,

causing the drop to contract by an altered surface tension; and reoxidation outside of the drop, causing it to expand again over the surface.

Beetz, from his experiments on the comparative value of the thermopiles of Noë and of Clamond, as modified by Koch, concludes in favor of the latter. The objection that it requires a little time to be heated he regards of little importance, but once in action it continues remarkably constant, both as regards its electromotive force and its resistance. Since with the same number of pairs the Noë pile gives the greater electromotive force, the utility of the Clamond battery is quite equal, from the facility with which the number of pairs may be increased. He suggests that the burner of the latter should be improved.

Gore has communicated to the Royal Society a paper on the thermo-electric properties of liquids, in which he describes a new form of apparatus he has contrived for the investigation, and gives the results of his observations made with it. He shows that the electric currents obtained were produced neither by chemical action nor by a temporary dissociation of the liquid, nor by the action of gases occluded in the metals; but they owe their origin solely to the heat, which disappears in producing them, and are thus true thermo-electric currents of liquids. He concludes as probable that when a metal is immersed in a liquid, heat results. His experiments suggest the construction of a new thermo-electric motor.

3. Electrical Measurements.

Gaiffe has contrived two simple forms of galvanometer, one for measuring electromotive force directly, and the other for measuring current strength. In the former the coil has a high resistance (about 3000 units of the British Association committee), so that the resistance of the rheomotor may be neglected in comparison, and the deflections of the needle be sensibly proportional to the electromotive forces. By means of two additional resistance coils the resistance may be increased 10 and 50 times. The circle is graduated empirically into 60 divisions, each of which represents one tenth of a volt when the galvanometer resistance alone is used. Electromotive forces from 0.1 to 150 volts may thus

be measured. The latter galvanometer has a coil of low resistance, with shunts by which its delicacy may by still further reduced. Using the galvanometer alone, one division on the scale represents one ten-thousandth of a B. A. unit. With the first shunt the divisions represent hundredths, and with the second whole units. Current strengths from 0.0001 to 200 units may thus be measured. These instruments are accurate to one per cent., sufficient for testing currents used in medicine, for which they were devised.

Foster has exhibited to the London Physical Society a very simple form of the trap-door form of Thomson's absolute electrometer. According to *Nature*, one arm of a balance has suspended to it by silk fibres a zinc disk hanging horizontally in the plane of a sheet of the same metal, which acts as a guard plate. Below the disk about one inch is a second horizontal sheet of zinc. The guard plate and disk are electrically connected by a bridge of very fine wire. To use the apparatus it is first accurately counterpoised, an excess weight—say, of one grain—is added, the guard plate and the lower attracting plate are connected with the electrodes of the electromotor—a Holtz machine, for example—a spark-measurer being introduced into the same circuit. If the machine be put in action, and the knobs of the spark-measurer gradually separated, a point will be reached where the attraction of the suspended disk just balances the excess weight. Reading off the length of spark, the data are obtained for calculating the difference of potential required.

Edison described, at the St. Louis meeting of the American Association, a new form of voltameter. Into a suitable vessel of acidulated water two electrodes are placed, one of which consists of platinum wire covered with gutta-percha, and perforated with a fine needle near its lower extremity. This electrode is made negative. The evolved hydrogen escapes in bubbles from the minute opening with a sound like the ticking of a watch, audible at the distance of several feet. By placing a rheostat in circuit, and regulating the bubbles to one a second, a constant current is obtained; and by calibrating the instrument by this means, the strength of any given current flowing through the instrument is known in terms of the number of gas bubbles evolved per minute. Should this number rise above 16 per second, a musical note

is produced, by the pitch of which the current strength may be determined. To obtain accurate results with the apparatus, corrections for temperature and pressure must be applied.

Haga at Strasburg and Clark at Heidelberg have investigated the electromotive force produced by the flow of water through capillary tubes, using a quadrant electrometer to measure the difference of potential. Clark finds that the electromotive force is greater the narrower the tube; that in very narrow tubes it is independent of the length; that different electromotive forces appear if the interior of the tube be coated with different substances; that the electromotive force decreases with the time; and that the seat of the electromotive force is the limiting surface of the liquid and the solid tube wall. Haga finds that the electromotive force is proportional to the pressure, independent of the length of the tubes, dependent on the nature of the inner surface of the tube, increases with the resistance of the water, and probably also with the temperature. The two results agree closely.

Lippmann has contrived an ingenious method of detecting minute quantities of a metal in solution, founded on the principle that when an electrode made of a given metal is placed in a solution, it will be depolarized only if a salt of that metal exists in the solution. Hence, for example, if a copper wire conveying a weak current be made the negative electrode in any solution, it will be polarized if there is no copper dissolved in this solution, but it will not be polarized if the liquid contain one five-thousandth of copper sulphate. The polarization is easily detected by closing the circuit through a galvanometer, the battery being left out. A contrary deflection indicates polarization. For silver, the sensibility seems somewhat greater.

Börnstein has experimented to determine the influence of light upon the electric resistance of metals, and gives the following as his conclusions: 1st, the property of having the resistance to an electric current diminished by the action of light is not limited to the metalloids selenium and tellurium, but occurs also in platinum, gold, and silver, and hence most probably in all the metals; 2d, an electric current lessens the conducting power of a conductor as well as its sensibili-

ty to light; but in both cases the former value of these constants is gradually attained after the current ceases to pass through the substance.

Mills has given the name electrostriction to a curious electrical phenomenon, which may be produced as follows: The bulb of an ordinary thermometer is first coated with silver by a chemical method, and then with some other metal by electrolytic deposition. The mercury will traverse some portion of the scale, and finally take up a definite position independent of temperature. Of the metals thus far experimented with, copper, silver, iron, and nickel constrict the bulb, while zinc and cadmium distend it. The author has succeeded in determining the electrostrictive effect in atmospheres of pressure, and shows that, since the metal which has been deposited on the bulb may be removed by a chemical solvent, it is possible to measure chemical action in terms of atmospheres of pressure.

4. Electric Spark and Light.

Cazin has studied the spectrum of the electric spark taken in compressed gas, both directly and by photography; and he concludes that the spark under these circumstances is compound, containing incandescent gaseous particles producing a spectrum of lines, and solid or liquid particles producing a continuous spectrum. The first of these come from the gaseous medium and from the electrodes; the second are torn from the electrodes or from the adjacent walls of the tube. The solid or liquid particles are collected in the central portions, the spark proper, while the aureole is formed of gaseous particles. This aureole is to the total spark what the bluish base of a candle flame is to the entire flame. As the pressure increases, the solid or liquid particles become more abundant, and their continuous spectrum predominates, finally extinguishing by its superior brightness the linear spectrum of the gaseous portion. Hence he regards it as incorrect to say that the gaseous lines widen and unite to a continuous spectrum.

Ayrton and Perry, in a letter to *Nature*, show that the wire cage proposed by Maxwell as a protection against lightning is not satisfactory, by quoting a case of lightning in a coal-mine in India by which two miners were killed.

The mine is shallow, only twenty feet of rock being above it, the accident occurring 130 feet from the mouth. The man and woman who were killed were at the working face in adjoining galleries, separated by twelve feet of coal. These two people were practically entirely surrounded by a partial conductor in connection with the earth, affording certainly quite as good protection as the wires Maxwell proposes to place along the edges of a building.

Planté has applied electricity of high tension for the purpose of engraving upon glass. If the surface of a sheet of glass be covered with a thin layer of potassium nitrate in concentrated solution, and this layer be put in communication with one of the electrodes of a secondary battery of 50 or 60 cells by means of a wire of platinum round its edges, and the other electrode be a fine platinum wire enclosed in a glass tube, except at its extremity, and held in the hand, then wherever the glass is touched with the platinum point it is permanently engraved. However rapidly the hand is moved, the tracings are clearly engraved on the glass, while if the hand move more slowly, the tracings are more deeply engraved. Either electrode may be used for writing, but the negative requires less current to produce an equal effect. Of course currents from other sources will act in the same way.

According to *Nature*, electric lights have become quite numerous in Paris. Eight electric lamps have been placed in the Place de l'Opéra, twenty-four in the Opera Avenue, and eight more in the Place du Théâtre Français. Six lamps were lighted for the first time on June 1 on the part of the Palais Bourbon facing the Place de la Concorde. Besides this, there should be noticed the private illumination of the Grands Magasins du Louvre, about seventy lamps; Belle Jardinière, eight; Concert de l'Orangerie des Tuileries, twenty; and the Hippodrome, thirty-two. This last illumination, being in a closed building, cannot be viewed from the streets. All these illuminations are made by means of the Jablochkoff candle. An electric lamp has also been placed on the top of the Trocadéro Palace.

5. Telephone.

Garnier and Pollard have described to the French Acad-

emy a form of telephone, in which a plate of sheet-iron is arranged with the end of a black-lead pencil pressing lightly on the central part. The plate and pencil are made part of an ordinary telegraphic circuit, at the other end of which is an ordinary telephone with a soft iron bar in the coil instead of a magnet. A battery of two Leclanché cells only is necessary. The plate, vibrated by the voice, compresses the black-lead, and so causes variations in its resistance, transmitting in this way a variable current to line. Du Moncel said to the Academy that, if this was original with the authors, it was entirely anticipated by the precisely similar arrangement contrived by Edison more than two years ago, and now practically utilized in his carbon telephone. Only in this instrument a disk of carbon is used in place of the pencil lead.

Trouvé has proposed a modification of the speaking telephone by which he hopes to increase the loudness of the tones received. He simply places several diaphragms about a cavity, each diaphragm having its magnet and coil. When one talks into the cavity, each membrane is thrown into vibration, and each generates a separate current, which all unite into one on the line, thus intensifying the sound. Such telephones he proposes to utilize for repeating purposes, since if half of the wires go on and the other half go back, talking to the next station beyond a message just received must send back to the previous station the message which has just been received from it.

Breguet has invented an exceedingly ingenious and novel telephone based on an entirely new principle. This is the fact first observed by Draper, and thoroughly investigated by Lippmann, that a close connection exists between capillarity and electricity, and that electric tension will change the form of liquid meniscus, and changing by mechanical means the form of the meniscus will develop an electric current. In Breguet's apparatus the sender and receiver are exactly similar. Each consists of a vessel containing mercury with dilute acid above it, into which dips a tube containing mercury, the lower end of which is drawn out to a capillary point. On speaking into the top of one of these tubes the sound waves depress the mercury, increase the convexity of the meniscus, and generate an electric current,

which passes by a wire to the other tube, affecting its meniscus, and causing oscillations in the mercury which reproduce the sound. The return current is through earth.

Page has succeeded in demonstrating the currents produced in the telephone, using for the purpose a Lippmann's capillary electrometer. De la Rue has measured the strength of the telephone current, and concludes that it does not equal that which a Daniell's cell would give through a resistance of 100,000,000 ohms. Brough has estimated it, even at a maximum, as only the 1,000,000,000th of a centimeter-gram-second unit. Breguet has pointed out that the effect of the telephone is much improved by placing one or more vibrating plates (perforated at the centre) at about one millimeter in front of the ordinary plate of the telephone.

Hughes has presented a paper to the Royal Society on an instrument he has devised for magnifying weak sounds, and which he calls a microphone. In its best form it consists of a stick of gas carbon placed vertically, and supported loosely between two small blocks of carbon fastened to a piece of thin board. When an electric current passes through the carbon, an ordinary telephone being in circuit, the slightest jar, and even the vibrations of the voice, is sufficient to interrupt the contact at the surfaces. This varying the current strength causes a sound in the receiver. The sensitiveness of the instrument is surprising—the ticking of a watch, the brush of a camel's-hair pencil, the tread of a fly, all being readily audible at the distant telephone. The principle of varying the resistance of a circuit by varying the number of points of contact in it, upon which these phenomena depend, was first utilized by Edison in January, 1877, and has within a year been brought to great perfection in the construction of the carbon telephone transmitter. The disks of carbon, or of silk thoroughly impregnated with carbon, he has also used in his tasimeter, which in various forms serves as a thermometer, barometer, hygrometer, and anemometer in a new and simple rheostat, and in a new relay contrived expressly for the relaying of telephone currents. Other workers have also discovered this sensitiveness of contacts.

CHEMISTRY.

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GENERAL.

Among the valuable contributions made to chemistry during the year 1878, we note the address of Professor Kekulé, on entering upon the duties of rector of the University of Bonn, upon the scientific position of this science and its fundamental principles. He defined chemistry, and differentiated it from physics and mechanics, thus: "Chemistry is the science of the statics and dynamics of atoms; physics, that of the statics and dynamics of molecules; while mechanics considers the masses of matter consisting of a large number of molecules." In opposition to the opinion that theory should be banished from the exact sciences, he regarded it as an actual felt necessity of the human mind to classify the endless series of individual facts from general standpoints—at present of a hypothetical nature—and that it was precisely the discussion of these hypotheses which often led to the most valuable discoveries.

Sylvester has communicated to *Nature* a novel paper on an analogy which he has observed between the valence-conceptions of modern chemistry and the theory of modern algebraic forms, between atoms and binary quantics. The number of bonds of an atom is the analogue of the number of factors in a binary quantic, a linear form of the latter being regarded as corresponding to a monad atom, a quadratic form to a dyad, a cubic form to a triad, etc. An invariant of a system of binary quantics of various degrees is the analogue of a chemical substance composed of atoms of corresponding valences. A co-variant is the analogue of a compound radical. Every invariant and co-variant is expressible by a graph precisely identical with the Crum Brown diagram or chemicograph. The author believes that in this analogy a rational basis for chemical valence may be discovered.

Smith, observing that a solution of ammonium or of sodium oxalate became alkaline on treatment with calcium carbonate, has investigated the conditions of the reaction. He finds that calcium carbonate on sodium oxalate results in the production of 19.83 per cent. sodium carbonate, strontium carbonate 7.63 per cent., and barium carbonate 4.84 per cent. If sodium carbonate act on calcium oxalate, 16.07 per cent. sodium oxalate is formed; strontium oxalate gives 57.24 per cent., and barium oxalate 73.20 per cent., these latter results being increased materially by heating the solution.

NON-METALLIC.

Varenne and Hebré have proposed a new and simple method of preparing perfectly pure hydrogen gas, which is an improvement on Schobig's method with potassium permanganate. The gas is prepared, as usual, by the action of sulphuric acid on zinc, and is then passed through a solution made with 100 grams potassium dichromate, 1 liter of water, and 50 grams concentrated sulphuric acid. A mixture of hydrogen arsenide, sulphide, antimonide, carbide, and silicide with hydrogen was perfectly purified when passed through twenty centimeters of this mixture. Illuminating gas passed through this solution loses its carbon as perfectly as with permanganate. Subsequent washing with potash is necessary to remove the CO_2 formed.

Remsen has suggested a modification of the hydrogen soap-bubble experiment which makes the ignition more certain. A large glass funnel is supported five or six feet vertically above the lecture-table by means of wires from the ceiling, the mouth of the funnel being downward. A fish-tail gas-burner is fixed horizontally at the centre of the mouth of this funnel, so that when the gas is lighted the broad flame is spread out in a horizontal plane over as much of the space included in the mouth of the funnel as it will cover. The bubbles are set free from the pipe in about the same perpendicular line as that corresponding to the axis of the funnel; they will inevitably come in contact with the flame, and if filled with hydrogen the flame frequently fills the funnel for a moment.

Berthelot has recommended the employment of bromine in gas analysis for the absorption of the unsaturated hydrocar-

bons, and has contrived an ingenious method for conducting the manipulations under water, so that the operator is not annoyed by the fumes of the bromine. The results obtained are accurate.

Berthelot has discovered a new oxide and acid of sulphur, produced by the action of the silent electric discharge upon a mixture of sulphurous oxide and oxygen gases in his improved ozonizer. The oxide appears in long silky needles somewhat resembling sulphuric oxide. Its formula determined by various methods is S_2O_7, and hence the discoverer names it persulphuric oxide. It is soluble in concentrated sulphuric acid without decomposition, forming persulphuric acid. Its barium salt is soluble in water. The acid is also produced directly by the electrolysis of sulphuric acid, or by mixing oxygenated water with concentrated sulphuric acid. Indeed, the oxidizing substance produced in ordinary electrolysis, and hitherto supposed to be either hydrogen peroxide or ozone, is really persulphuric acid, proved both by its positive and its negative reactions.

Buchanan, chemist of the *Challenger* expedition, in his analyses of sea-water, observed the curious fact that from the surface down to 300 fathoms the oxygen continuously decreases in amount, while below 300 fathoms it continuously increases. This is due to the scarcity of animal life at the greater depths.

Pasteur has recently stated that water containing bacteria —and all water, even distilled water, contains them, and can contaminate any cultivation liquid with a growth of them— if allowed to stand for several weeks at a constant temperature, becomes purer in its upper portions, the bacteria settling to the bottom. Dowdeswell has repeated the experiment, and though the water was perfectly clear and bright in appearance, the sediment showed under the microscope amorphous particles, spores of filamentous fungi, micrococci in great numbers, bacteria of the common form, and bacilli in long slender filaments.

Gatehouse has proposed a new method for the preparation of nitrogen gas by the reaction of manganese peroxide upon ammonium nitrate. In one experiment three grams of the nitrate, heated with an equal weight of manganese peroxide in a mercury bath kept at 205° C., yielded 630 cubic centimeters of gas, which was pure nitrogen. If the temperature

rises too high—say above 216°—the manganous nitrate decomposes, giving nitrous vapors.

Kämmerer has proposed a very simple and efficient way of showing the direct combustion of nitrogen as a lecture experiment. A jar of about half a gallon capacity, filled with air, has thrust into it a piece of burning magnesium ribbon from twelve to fifteen inches long. After the combustion of the magnesium is completed, the odor of nitrogen tetroxide is observable, and after the magnesia has subsided its color may even be discerned. Shaken with potassium iodide solution containing a little acetic acid, the liquid becomes brown from free iodine, and strikes the characteristic deep-blue color when a little solution of starch is added.

Warington has given in *Nature* a statement of the results obtained at Rothamsted in testing the new theory of nitrification proposed by Schloesing and Müntz, which completely confirm those of the French chemists. According to their view, nitrification, instead of being brought about by purely chemical forces, is, in fact, the work of a living organism. In proof of this they show that the process, however active, is stopped at once by the vapor of chloroform, and also by a temperature of boiling water. It must therefore be that the production of nitre in the soil is due to oxidation brought about by these living mycoderms.

Gilm has shown that a regularly tinted and beautiful green boric-acid flame is best obtained by passing the vapor of boric ether through a kind of Bunsen burner, made by enclosing a small narrow glass tube in a vertical one, so that the gas may mix with air previous to ignition at the upper end of the tube. An ordinary Bunsen burner may be used for the experiment, if only care be taken to heat the tube previously to prevent condensation. In qualitative testing it is most convenient to use a small flask provided with a cork, through which passes a short glass jet drawn out to a point, a wider tube being placed over the latter, and the gas ignited at the top. After the addition of hydrochloric acid, very small quantities of boric acid may be detected by this means.

Laufer has suggested an improved method of determining the silica which exists as quartz in rocks, and of separating it from the silica contained therein in combination as silicates,

founded on the well-known fact that phosphorus-salt will decompose silicates and dissolve their metallic oxides, but will neither dissolve the silica nor attack the quartz. The finely pulverized mineral or rock is weighed, placed in a platinum crucible, sufficient phosphorus-salt to decompose the silicates is added, and the whole is carefully heated, first in an air-bath and then in the blast, till the whole is in quiet fusion. On detaching the fused mass and boiling it in hydrochloric acid, the silica and quartz are left undissolved; and on boiling the residue with soda solution, the silica from the silicates is taken up and the quartz is left. The results are said to be accurate.

METALLIC.

Brugelmann, of Düsseldorf, has succeeded in obtaining baryta, strontia, and lime in crystals, by heating their nitrates to complete decomposition. The three oxides were obtained in microscopic crystals which were cubes. In the case of baryta and strontia the crystals were exceedingly minute, while in the case of lime their form could be seen by the eye.

Frémy and Feil have communicated to the French Academy a paper on the artificial production of corundum, ruby, and different crystallized silicates. In a crucible of refractory clay a mixture of equal weights of alumina and minium is placed and calcined for some hours at a bright-red heat. After cooling, two layers are found; the one vitreous, formed chiefly of lead silicate, the other crystalline, often presenting geodes full of beautiful crystals of alumina. To obtain the red color of ruby, about two or three per cent. of potassium dichromate is added to the mixture. The lead silicate on the ruby crystals is removed by fused lead oxide or hydrogen fluoride. An aluminum silicate, apparently dysthene, was produced by heating for some time a mixture of equal weights silica and aluminum fluoride, silicon fluoride being evolved.

Nilson and Petersson have prepared beryllium with great care, and have studied its properties, especially its specific heat, in order to fix definitely its atomic weight. The metal was obtained by heating the chloride with sodium to bright redness in an iron cylinder, as a net-work of brilliant microscopic crystals of the color and lustre of steel. It is permanent in the air, does not decompose water when boiled with

it, is easily soluble in acids and alkalies, does not burn at a red heat even in oxygen. Allowing for impurities, its specific gravity is 1.64. The specific heat was found to be 0.4079. To give a normal atomic heat this value must be multiplied by 13.8, which must be, therefore, its atomic weight.

Lecoq de Boisbaudran and Jungfleisch have treated 4300 kilograms of the zinc-blende of Bensberg, and have obtained from it 62 grams of the new metal gallium, with which they will study its properties.

Friswell and Greenaway have reinvestigated the compound obtained by the former in 1871, and called thallous platinocyanate. It was a colorless body, while the body previously obtained by Carstanjen was blood-red in color. For this purpose platinocyanic acid was produced by the action of sulphuric acid on barium platinocyanate. To one portion an equivalent quantity of thallous carbonate was added, and the solution crystallized; the result was a colorless salt. To the other portion double this quantity of the carbonate was added; the result was the dark-red salt referred to, which was a double carbonate and platinocyanate. To confirm this result, barium platinocyanate and thallous sulphate were mixed in solution; the resulting crystals were perfectly colorless.

Kern has described more fully some of the chemical reactions of his new metal, davyum. The metal itself belongs to the platinum group, is silver-white in color, hard, malleable at a red heat, and has a density of 9.385 at 25° C. It is easily soluble in aqua regia, difficultly so in boiling sulphuric acid. Potassium hydrate precipitates its hydrate yellow, the precipitate being readily soluble in acids, even in acetic. Hydrogen sulphide gives a brown precipitate, soluble in alkali sulphides, yielding sulpho-salts. The sulphocyanate is in dark-red crystals, becoming black on heating. The nitrate is a brown mass, and yields a black monoxide on calcination. With potassium cyanide, davyum chloride gives double salts beautifully crystallized. The chloride is soluble in water, in alcohol and ether, and is not deliquescent. It forms double chlorides, that with sodium chloride being almost insoluble in water. Its atomic weight has not been accurately determined, but is believed to be not far from 150.

Moissan has made experiments which lead him to conclude that magnetic oxide of iron prepared (1) by heating ferric oxide in an atmosphere of hydrogen or carbonous oxide to 350° or 400°, or (2) by calcining the carbonate, and magnetic oxide of iron obtained by decomposing water by red-hot iron, or by burning iron in oxygen, are not identical, but are allotropic forms of the same substance. The former has a density of 4.86, the latter of 5 to 5.09; the former is acted on by nitric acid, and becomes ferric oxide on roasting. The latter is not acted on, and is unchanged by heat.

Regnard has recorded the fact that steel ingots when broken exhale a decided odor of ammonia, accompanied by a slight hissing, noticeable when the ear was placed against the ingot. On wetting the fractured surface with soap and water, a frothing resulted, the volume of gas evolved being about one cubic centimeter. The gas from one hundred ingots on analysis proved to be nearly pure hydrogen.

Smith has proposed a new and apparently very satisfactory method of decomposing chromic iron for analytical purposes by means of bromine. Fifteen centigrams of the very finely pulverized and elutriated chromite was placed in a tube of hard glass; a rather large quantity of bromine water was added, and ten or twelve drops of bromine, the tube sealed and heated to 130° for one day, and then to 170° for two days. Upon opening the tube, the residue, after washing, drying, and igniting, was found to be wholly soluble in hydrochloric acid. The decomposition was therefore complete.

Riche has published a memoir upon the electrolytic determination of manganese, lead, copper, zinc, and nickel, and on the analysis of alloys of these metals. The decomposition requires the use of two or three Bunsen cells. The decomposing cell is a platinum crucible connected with the carbon pole. Within this is suspended, without contact, either an open cone of platinum foil or a spiral of platinum wire connected with the zinc pole. The manganese is separated at the positive electrode as dioxide, which becomes saline oxide on calcination, and is weighed as such. Lead in an acid solution, kept at 60° to 90°, is all precipitated on the positive electrode as dioxide, which is dried at 105° to 120° and weighed. Zinc is precipitated from the ammonio-sulphate

slightly acid. The results are accurate. The author has ingeniously applied these methods to the rapid analysis of alloys.

Schützenberger has announced the discovery of an allotropic condition of metallic copper, obtained by electrolysis of a solution of about ten per cent. of copper acetate, previously boiled, with two Bunsen or three Daniell cells, the negative platinum plate being placed parallel to the larger positive copper electrode, and three or four centimeters from it. The allotropic copper is then deposited on the platinum as a brittle metal in rugose plates of an aspect resembling bronze. Its specific gravity is from 8 to 8.2, that of ordinary copper being 6.9. The moist plates quickly oxidize on the surface in ordinary air. Allotropic copper is changed to ordinary copper by heat or by prolonged contact with dilute sulphuric acid.

Dumas has called the attention of the French Academy to the presence of oxygen in metallic silver, and has shown that where silver has been used in the determination of atomic weights, and, after careful purification, has been converted into minute grains after fusion in presence of borax, nitre, and air, it is liable to absorb oxygen in amounts varying from 50 to 200 cubic centimeters per kilogram. This may cause a notable error.

Von Meyer has put to the test the theory of De la Rive, that the so-called catalytic action of platinum is due to the formation of a superficial layer of oxide, which is subsequently reduced, and so on alternately, by examining the action of platinous oxide, platinic oxide, and platinic hydrate upon mixtures of hydrogen and carbonous oxide. He finds that these gases are both oxidized at the expense of the oxygen in the oxide of platinum, the proportion of hydrogen being much the larger. Upon a mixture of hydrogen, oxygen, and carbonous oxide the action of the platinum is directly the reverse, the carbonous oxide being burned in largest proportion. The author concludes from these experiments that the theory of De la Rive cannot be admitted.

ORGANIC.

Cloez has studied the hydrocarbons which are formed during the action of acids upon spiegeleisen, and has found that

several of these bodies are identical with those which exist in the ground, and are extracted on a large scale under the name of petroleum. This production of complex carbonized compounds, without any intervention of life, supports the views of certain geologists on the origin of petroleum. The reproduction of a large number of organic species might be realized by commencing with ethylene or methane, hydrocarbons furnished in this way by the action of mineral acids on cast iron.

Merz and Tibirca have published a simple and easy method of producing formic acid synthetically, which consists simply in passing carbonous oxide gas over alkali heated in a tube. They find ordinary soda-lime to be the best, and state that when a rapid current of carbonous oxide is passed over soda-lime heated in a tube to 200° or 250°, it is entirely absorbed, producing sodium formate. As an example of direct synthesis it forms an exceedingly instructive lecture experiment.

Bougarel claims to have isolated from the leaves of the cherry laurel a new organic acid, to which he gives the name phyllic acid. The leaves are steeped in boiling alcohol, the alcoholic extract treated with ether, the ether distilled off, the amorphous grains dissolved in dilute potash, and crystallized. On redissolving and adding an acid, phyllic acid is precipitated as a resinous mass, soluble in alcohol, but insoluble in water. It is without taste, has a density of 1.014, rotates the yellow ray 28° to the right, and fuses at 170°. Analysis gave it the formula $C_{72} H_{64} O_{16}$. Further experiment showed that this acid was contained in the leaves of the quince, apple, peach, almond, lilac, and sycamore.

Atterberg has subjected to fractional distillation the so-called "wood oil," which is obtained as a first product in distilling the wood-tar made in Sweden from resinous woods, principally that of *Pinus sylvestris*. In this way he succeeded in isolating a terpene having the properties of australene, and another having the odor of fresh pine wood, and not identifiable with any other similar body. To this, therefore, the author gives the name sylvestrene. The two terpenes together constitute eighty per cent. of the oil. Sylvestrene has a density of 0.8612 at 16°, rotates the polarized ray 19.5° to the right in sodium light, and forms two

compounds with hydrogen chloride. Heated with potassium hydrate, sylvestrene yields an oil having a strong pelargonium odor.

Remsen and Morse, of the Johns-Hopkins University, Baltimore, have studied the products of oxidation of bromethyltoluene and its analogues, with a view to determine the influence which one substituting group exerts upon a second or a third entering the same benzene nucleus, with particular reference to any differences in result due to the use of homologous radicals of the marsh-gas series. Since bromethyltoluene yields bromparatoluic acid on oxidation, the effect of the ethyl group is quite distinct from that of the methyl group in the molecule, opening up a new field for investigation.

Zulkowsky has sought to produce rosolic acid from a mixture of cresol and phenol precisely as rosaniline is produced from toluidine and aniline, the corresponding amines. For this purpose two molecules of cresol, one of phenol, and three of sulphuric acid were heated with arsenic acid to 120°. The mixture became dark brown and thick, and yielded to water a gummy substance with a metallic lustre, having all the properties of rosolic acid. The relation of this coloring matter to rosaniline is thus rendered quite apparent.

PHYSIOLOGICAL.

Livache has examined in the laboratory of the Conservatoire des Arts et Métiers, in Paris, the gaseous products which are contained in the tissue of fruits. He finds that in perfectly healthy fruit the gases contained in its pulp consist entirely of oxygen and nitrogen in the proportion in which they exist in the air. In case this pulp is broken or torn, an oxidation results, and the oxygen is rapidly transformed into carbon dioxide. If the pulp thus mangled be left to itself, a true fermentation sets in, abundance of carbon dioxide is produced and disengaged, the oxygen disappears entirely, leaving the nitrogen unaltered.

Muntz has made a research upon the formation of alcohol in the cells of growing plants, and finds that when confined in an atmosphere of nitrogen or any gas not containing oxygen, the presence of alcohol can be invariably detected, even after only a few hours' exposure, while none appeared in

other similar plants not thus treated. The experiments were made with beets, maize, geranium, cabbage, etc., and the results are regarded as confirming the views of Pasteur, that the alcoholic fermentation produced by ordinary yeast is simply an exaggeration of the normal action of all organic cells in the absence of oxygen.

Wilson has presented to the British Association a paper on the amount of sugar contained in the nectar of various flowers. A single flower of fuchsia contains 7.59 milligrams, of which 1.69 is fruit-sugar and 5.9 cane-sugar. A flower of everlasting pea has 9.93 milligrams, 8.33 being fruit and 1.60 cane; a raceme of vetch 3.16 milligrams, 3.15 being fruit-sugar, a single flower giving 0.158 milligram of fruit-sugar. A head of red clover gave 7.93 milligrams, 5.95 being fruit and 1.98 cane, each floret giving 0.132 milligram, 0.099 being fruit-sugar; a flower of monk's-hood 6.41 milligrams, 4.63 being fruit-sugar. Approximately, then, 100 heads of clover give 0.8 gram of sugar, or 125 give a gram, and 125,000 a kilogram. As each head contains about 60 florets, it is evident that to obtain a kilogram of sugar 7,500,000 florets are required. Now as honey contains about 75 per cent. of sugar, 5,600,000 flowers would yield a kilogram of honey, or say two and a half millions a pound. Since this nectar is only of use to the flower by attracting insects to it, and in this way fertilizing the plant, as is evident from the fact that it is secreted at the time only when the visits of insects would be beneficial—*i. e.*, when the anthers are shedding their pollen—it is interesting to notice the connection now pointed out between the amount of nectar a flower secretes and the results of insect visits in changing the size, shape, color, etc., of the flower.

Böhm has shown by experiment that the common opinion that the starch in chlorophyll grains is in all cases the product of an intrinsic synthesis from carbon dioxide and water is entirely erroneous. Two positive and important conclusions follow from his researches: 1st, that the formation of starch in chlorophyll grains is in many cases the result of a metamorphosis of bodies not intrinsic to the cells in which this conversion takes place, but elaborated elsewhere by the plant; and, 2d, that this process of conversion is entirely independent of the action of light, white or colored.

Schmidt has discovered that by the action of aqueous ammonia upon carbonyl sulphide, urea is produced. For this reaction it is only necessary to pass the carbonyl sulphide gas through a concentrated aqueous solution of ammonia. The solution becomes yellow, and on spontaneous evaporation evolves ammonium sulphide and carbonate, and leaves a residue of urea. Pushing the saturation further, there is formed a compound by direct union.

North has made an elaborate research on the effect of starvation, with and without severe labor, on the excretion of nitrogen by the human body, and finds that the increase of nitrogen excreted is very small, and comes solely from reserve nitrogenous material. The results of Flint, obtained in experiments upon Weston, he thinks are due to the fact that before his walk Weston had accumulated a large nitrogenous reserve, from which, and not from his muscles, came the nitrogen excreted.

Jaffe has examined the results of the ingestion of benzoic acid in birds, with a view to determine the form in which it is excreted. In the mammalia, benzoic acid when taken into the organism, as is well known, is excreted as hippuric acid. But Jaffe finds that no hippuric acid is formed by birds, the benzoic acid forming a new conjugated acid which he calls ornithuric acid.

TECHNICAL.

Frankland and Thorne have studied the luminosity of benzene when burned with non-luminous combustible gases. After many unsuccessful attempts to burn benzene with a smokeless flame, the authors determined the luminosity of benzene vapor after dilution with hydrogen, carbonous oxide, and marsh gas. These gases were passed through a carburetter containing benzene, kept at a constant temperature, and were burned from a fish-tail burner. The results were as follows: One pound avoirdupois of benzene gives, when burned with hydrogen, the light yielded by 5.792 pounds of spermaceti; with carbonous oxide, that of 6.1 pounds of spermaceti; and with marsh gas, that of 7.7 pounds of spermaceti. The authors point out that this difference is probably due in part to the different pyrometrical effects of the gaseous mixtures.

Muir has discussed at considerable length the use of gas

as fuel, the advantages of which are the ease with which it can be regulated, the completeness of its combustion, the readiness with which cleanliness can be maintained, the high heating power of such material, etc. The requirements of such a gas are, 1st, it should consist of combustible constituents only; 2d, it should be possessed of high heating power; and, 3d, it should produce on burning compounds of low specific heat. Hitherto coal-gas has been the only gas available for heating, and, notwithstanding the disadvantages attending its use, has proved itself a cheaper, more effective, and more easily managed fuel than coal, wood, or other forms of solid heat-giving material. Latterly, however, the so-called water-gas, produced by passing superheated steam over anthracite coal at full redness, has come forward with much promise, improved machinery of preparation allowing it to be easily and cheaply produced on the large scale. Though the heating power of water-gas is only about one fifth of that of ordinary coal-gas, yet the cost of the gas is so much less that an actual saving of from one third to two thirds is effected by its use. By the use of oxygen in the blast a gas of very high heating power might be produced.

Long has made a series of experiments on the decomposition of steam by ignited charcoal for the production of water-gas. In his earlier experiments the results were complicated by the evolution of absorbed gases from the charcoal. When this source of error was allowed for, it was observed that no fixed relation existed between the carbonous oxide and the carbon dioxide present. But the author noticed that the carbonous oxide was directly as the amount of charcoal present in the tube. Hence it is evident that hydrogen and carbon dioxide are at first formed, and then that the latter gas is reduced by the excess of ignited carbon. If, however, there be an excess of steam present, this is reduced, and carbon dioxide again formed.

Professor Church makes the curious observation that the deterioration of the leather binding of library books, which is often rendered quite friable in time, is brought about by the action of the sulphurous gases given off in the burning of common coal-gas. He has noticed that it is the books on the uppermost shelves of the libraries that are the most affected—a fact which, as the combustion products in gradu-

ally cooling and descending would reach the uppermost ranges of shelves first in their descent, is made quite understandable. He asserts that he has found in the leather bindings of certain old library books that had become quite brittle as much as eight per cent. of sulphuric acid. Late researches on the permeability to gases and vapors of various materials used for building purposes have demonstrated that when not saturated with moisture, bricks, sandstone, tufa, mortar, and cements are permeable; while granite, porphyry, slate, alabaster, and limestone are practically impermeable. The sanitary bearing of these observations is obvious.

Muter has proposed a method of detecting the addition of glycerin to milk for the purpose of maintaining its normal specific gravity when it is watered. The residue after evaporation is treated with a mixture of alcohol and ether, and the residue of the evaporation of these solvents is examined for glycerin. If found, its amount must be determined by making a complete analysis of the milk.

Peckham has investigated the cause of the explosion of the flour-mills in Minneapolis in May last, and gives it as his opinion that the explosion was due to the ignition of the fine dust of flour, with which the mill was filled, by sparks coming from millstones which had been allowed to run dry. In the dust-house connected with these stones several hundred pounds of dust a day settled under ordinary circumstances.

A correspondent of *Nature* writes from Burton-on-Trent that explosions during the grinding of malt, due to the ignition of the fine dust in the air, are not uncommon. Any fine impalpable powder, such as flour, sugar, coal-dust, wood-dust, may be thus the cause of serious explosions.

Clémandot has patented in England a process for producing the beautiful iridescence on glass which has lately attracted attention. The glass is simply treated, under pressure and at a temperature of 120° to 150°, with a ten to twenty per cent. solution of hydrochloric acid. The colors are produced by interference.

Silliman has invented a process for making Britannia metal articles sonorous by heating them for fifteen or twenty seconds to 5° below the melting-point in a paraffin bath.

MINERALOGY.

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GENERAL MINERALOGICAL PROGRESS.

The past year and those which have immediately preceded it have been years of very important advance in mineralogy, marked by a decided increase in the number of those interested in the science, and a corresponding increase in mineralogical investigations. Until very recently there has been but one mineralogical journal, and even in this — the long-known *Jahrbuch für Mineralogie* — the space was shared with geology and palæontology. In consequence of this fact, the memoirs of the few active workers in this branch of science were scattered through a large number of chemical and physical journals and of society transactions.

Now, however, there is the *Zeitschrift für Krystallographie und Mineralogie*, published by Professor Groth at Strasburg, of which the second volume in nearly seven hundred pages is completed this year. There are also the *Mineralogische Mittheilungen*, of Professor Tschermak, a journal which, for several years, was published at Vienna in connection with the Yearbook of the Austrian Geological Survey, but which this year has commenced an independent existence in a new form with an increased range of topics. There is also the *Mineralogical Magazine of Great Britain and Ireland*, of which the second volume is now being published. It is the organ of the British Mineralogical Society. In addition to the above, the Crystallological Society of London, founded in 1877, also publish a series of *Proceedings*. Finally, there must be mentioned the "Société Minéralogique de France," which was organized in March, 1878, and which, with Professor Des Cloizeaux, of Paris, as the president, is showing a high degree of activity. The meetings of the society are held about once a month, and five of their *Bulletins* have already been issued.

Each one of the above-mentioned journals gives, in addi-

tion to the original articles, a more or less complete summary of mineralogical papers printed elsewhere. In consequence of this almost every paper bearing upon the science, wherever published, sooner or later finds mention in one of these half-dozen periodicals, and hence the range of mineralogical literature is narrowed down and brought within the reach of all those interested in what is being done.

RECENT PUBLICATIONS.

The number of independent works on mineralogy which have appeared within the past year is not large. Prominent among them stands the descriptive "Catalogue of the Mineralogical Collection of the Strasburg University." This is a quarto volume of nearly three hundred pages, prepared by Professor Groth. It is a work of more general importance than its name would indicate; for it contains not only a catalogue of the individual specimens in this exceptionally fine and complete collection, but also full crystallographic descriptions of the different species. In many cases these descriptions are in fact real monographs, and contain a large number of new facts.

The veteran mineralogist and poet of Munich, Von Kobell, has issued a fifth edition of his excellent little "Mineralogy."

The great work undertaken by Schrauf of Vienna—the "Atlas of Forms of Crystals"—has been advanced one stage farther towards completion by the publication of the fifth part. This work contains the figures of the various forms of the crystals of the different species. These species are arranged alphabetically; and as the author has not yet completed the third letter of the alphabet, it will be seen that the end is still far in the future. The first part was issued in 1865. A new book on "Mineralogy," of a somewhat practical and elementary character, has been published in England: the author is Mr. J. H. Collins, editor of the *Mineralogical Magazine.*

In this country there has recently appeared a new edition of Dana's "Manual of Mineralogy," an elementary work of about four hundred and fifty pages. The previous edition bears the date of 1857. A new edition of Brush's "Determinative Mineralogy" has been published, in which the mineral formulas have been altered so as to correspond to the

modern chemistry. An important addition to the literature of the science is Mr. G. W. Hawes's volume on the "Mineralogy and Lithology of New Hampshire," which forms a part of Professor Hitchcock's "Survey of the State."

RESEARCHES IN PHYSICAL MINERALOGY AND CRYSTALLOGRAPHY.

M. Dufet has made a series of experiments in regard to the indices of refraction in mixtures of isomorphous salts, and has arrived at the conclusion that the differences between the indices of a mixture of two isomorphous salts and those of the component salts themselves is in an inverse ratio to the number of equivalents of the two salts which enter into the mixture. Although obtained with artificial compounds, the results have an important bearing on the many series of isomorphous minerals.

The effect of increase of temperature on the indices of refraction of the natural sulphates of barium, strontium, and lead (barite, celestite and anglesite) has been investigated with great accuracy by Arzruni. He concludes that an increase of temperature diminishes the three indices in each of the species named, but to an unlike degree, though in an analogous manner. He finds also that the directions of greatest, mean, and least expansion bear no relation to the three axes of optical elasticity.

Sorby has published additional explanations of the method of determining the indices of refraction in thin sections, mentioned in the last volume of the *Annual Record.* The principle involved is indeed not original with him, but he has given it a new and more extended application. It promises to be of very considerable practical value. Another method of obtaining the indices of refraction has been redescribed and elaborated by Kohlrausch, which is of easy application and gives quite accurate results. It is based upon the determination of the angle of total reflection of the given substance when observed in a medium—as carbon disulphide—which has a higher index. Determinations made by him on a variety of substances, both isotrope and optically uniaxial and biaxial, gave most satisfactory results.

The papers of Professor J. P. Cooke upon the haloid salts of antimony contain some facts which have an important

bearing on the crystallographic relations of a large group of minerals. He describes the antimony iodide as obtained by him in three distinct modifications, belonging respectively to the hexagonal, orthorhombic, and monoclinic systems, and differing in color and melting-point. He found, moreover, that both the last two varieties, under proper conditions as to temperature, could be changed into the hexagonal variety, becoming red instead of yellow, and optically uniaxial instead of biaxial. Professor Cooke explains the change by a kind of molecular twinning or rearrangement of the molecules. The change is analogous to that which, as explained by the same author, and also independently by Reusch, is produced when thin plates of muscovite are combined in symmetrical positions, so as to produce uniaxial optical effects. The difference in the antimony compound is, however, truly molecular instead of laminar, and the author suggests that it may be a similar relation which determines the difference between calcite and aragonite. The number of minerals which, crystallizing in the orthorhombic (or monoclinic) system, and having a prismatic angle of nearly 120°, show in their twins a pseudo-hexagonal symmetry is quite large; to them the facts brought out by Professor Cooke have an immediate bearing.

The improved methods of research now employed, including the measuring of the angles of crystals with extreme accuracy, and, still more important, the careful examination of their optical properties, have led in many cases to a change in the system to which the crystals of a species have been referred. The tendency is thus very strong to throw the crystals of the more simple systems into those which are more complex and have a lower grade of symmetry. This is illustrated by the change accepted some years since in the case of leucite, formerly regarded as a typical isometric species, now referred to the tetragonal system. An extended article upon the subject, in part based upon experiments and in part simply speculative, has been published by Mallard. He takes up in succession a large number of species which have been long known to present anomalous optical characters. He rejects the explanations offered by others, as, for instance, the theory of lamellar polarization advanced by Biot, and offers another of his own, which, howev-

er, would make it necessary to refer the species to different systems from those now accepted. For example, leucite, referred to above, he would make monoclinic; boracite is made orthorhombic; also garnet, fluorite, senarmontite, and analcite are considered only pseudo-isometric; and an analogous change is argued in the case of apophyllite, vesuvianite, rutile, zircon, apatite, beryl, tourmaline, topaz, and other well-known species.

Another writer, G. Grattarola, in Florence, supplements the list of Mallard with a number of species which, on grounds which seem by no means sufficient, he would refer to other systems lower in regard to symmetry of form; for example, calcite, barite, nephelite, and so on. He argues that in fact we can regard only one system as having a real existence; that is the most complex and least symmetrical system, the triclinic system. Moreover, as an author remarks in reviewing the subject, even this system he seems to think too regular to be thoroughly satisfactory.

Aside from these partially theoretical results reached by the writers referred to, which seem to threaten to overthrow the rigid dividing-lines between the different systems, and to reduce crystallography to a far less simple subject than it is at present, there are a number of cases in which the change of system cannot be questioned. Thus Tschermak has shown most conclusively that all the micas are monoclinic. Moreover, his observations have made it extremely probable that corundum is also monoclinic instead of rhombohedral. Again, the peculiar form of silica, described by Vom Rath as hexagonal, under the name of tridymite, is now shown to be in fact triclinic, the apparently hexagonal form being due only to twinning. The same conclusion must be accepted in regard to milerite, which is now made orthorhombic instead of hexagonal. Harmotome was transferred to the monoclinic system by Des Cloizeaux, and now Lasaulx argues that the same change must be made for stilbite. Perofskite, which was once made isometric, and whose system has long been in doubt, is now made orthorhombic by Kokscharof. The above list might be easily increased.

Of recent crystallographic memoirs remarkable for their complete and comprehensive character, several deserve especial mention. One of these is devoted to epidote by Buck-

ing, and contains an enumeration of a large number of new planes. Another is by Becke on Cassiterite. Still another by J. McD'Irby on the forms of calcite, in which the subject is most exhaustively treated. Schrauf has given a memoir on the crystallized tellurium minerals of Transylvania; and Vom Rath and Bauer have described independently some remarkably perfect crystals of cyanite, a species never before obtained in satisfactorily terminated crystals.

RESEARCHES IN CHEMICAL MINERALOGY.

The discovery of the rare species samarskite was announced in the *Annual Record* several years since. During the past year this mineral has had attention called to it anew. The presence in it of the rare metal erbium was first made certain by the analysis of Rammelsberg; later Delafosse showed that the metal terbium — an element of so doubtful a character that its existence has not generally been granted—was also present. Since then Dr. J. L. Smith, who had previously published an analysis of the mineral, has announced the existence in it of a new element, which he calls *mosandrum*. Delafosse has followed by claiming to have discovered two new elements, which he names *phillipium* and *decipium*, while he states that the mosandrum of Smith is not a new metal, but, in fact, a substance identical with terbium. Marignac, of Geneva, has published an article on the subject in which he also throws doubt upon the real existence of the mosandrum. He was not, however, at that time in possession of all the facts. At present it is impossible to decide how far these three new names will be accepted among chemists.

A discovery of a character similar to the above has been announced by Marignac; he claims to have found a new element in the gadolinite of Ytterby, to which the name of *Ytterbium* is given.

Among other important papers upon chemical mineralogy may be mentioned that of Tschermak upon the mica group; it is in fact the second part of the memoir referred to in the last volume of the *Record*. He gives new and very carefully made analyses of many of the species of the mica group, and bases upon them an ingenious but somewhat artificial explanation of their variations in composition. It is impossi-

ble to go into the subject here, but it may be mentioned as a point of some interest that the varying amounts of water obtained by analysis in the ordinary potash-mica are explained by the different degrees in which the potassium is replaced by basic hydrogen in the different cases. Streng has made an extended examination of *chabazite* from different localities both crystallographically and chemically, and in the latter respect has arrived at a somewhat different view of the composition from that previously held. He shows, however, that between certain limits the composition of different varieties varies considerably.

Rauff has investigated the mineral *zancrinite* by chemical analysis, supplemented by the microscope, and concludes that the carbonic acid present in it is really an original constituent, and not, as has sometimes been urged, a product of later decomposition. A series of extended memoirs upon the mineralogy of Scotland have been published by Heddle. They cover a large range of subjects, and contain the results of much original work, particularly in the way of chemical analyses. Mallet has added an analysis to the few already existing of the Mexican selenide of bismuth, *guanajuatite*, which serves to establish its true composition beyond doubt. The associated mineral *silaonite*, originally described as another selenide of bismuth, has been proved by Bruns to be only a mixture.

The behavior of the natural sulphides with iodine and other reagents is the subject of a memoir by Bolton. The reagents employed were iodine, potassium iodide and citric acid, and potassium bromide and citric acid. Ninety minerals were examined, and only nine resisted these methods of attack.

ARTIFICIAL FORMATION OF MINERALS.

The formation of mineral compounds by artificial means—a most important branch of the science—has been much extended by recent researches. Fremy and Feil have found it possible to form crystals of *corundum* of such a size as to be suitable for use in watch-making. They obtained the best results when a fusible aluminate was combined with a suitable silicate, and kept in crucibles at an extremely high temperature for twenty days. The alumina is set free gradually by this means, and forms crystals of true corundum. By the

employment of suitable coloring agents, it was found possible to give them the color both of the blue sapphire and the red ruby. In hardness, and indeed other physical characters, they are identical with the natural crystals. By the employment of fluorine compounds, several silicates were formed; thus aluminium fluoride and silica gave crystals of a substance very nearly identical with fibrolite.

Hautefeuille has succeeded in making artificial crystals of albite, orthoclase, tridymite, and quartz. The albite was obtained by keeping a mixture in proper proportions of silica, alumina, and sodium tungstate at a temperature of 900° to 1000° C. for a month. The crystals obtained had the same form and gave the same angles as the natural albite crystals, and like them commonly occur in twins.

Orthoclase was formed from a mixture of tungstic acid and a silicate of potassium and aluminium kept for a long time at a high temperature; distinct crystals were obtained, as in the case of the albite. If amorphous silica is kept in sodium tungstate at the temperature of the fusion of silver, silica crystallizes in minute crystals in the form of the species tridymite. With a temperature of 1000° C. the tridymite is obtained in thick hexagonal scales. If, however, this mixture is made to oscillate in temperature many times between 800° and 950°, with the increasing heat the silica combines with the soda, and with the decrease the silica is precipitated by the tungstic acid. At the commencement of each period of cooling the silica takes the form of tridymite, but as the temperature falls below 850° C. it takes that of quartz, double hexagonal pyramids being obtained.

Connected with the above experiments are the observations of Fouqué and Levy, that some of the feldspar species may be fused, kept in a state of fusion for some time, and finally recrystallized in their original condition.

DESCRIPTION OF NEW MINERAL LOCALITIES.

Domeyko, of Santiago, Chili, has given a description of a locality of bismuth minerals in Bolivia. He mentions a considerable number of known minerals found there, and also describes two new species, *bolivite* and *taznite*, which are mentioned in the list which follows.

The rare mineral *dioptase*, known previously with certainty

only from the Kirgheez Steppes, has been identified with other copper minerals from Peru. The few localities of *diaspore* have been increased by the addition of Jordansmühl, Silesia, where it is found in a rock consisting mostly of a massive garnet; it is said to resemble closely the American mineral. The zinc arsenate *adamite*, previously known only from Chanarcillo, Chili, has been found in considerable quantities and in beautiful crystals at the mines of Laurium, Greece. A very large number of new occurrences could be added to those here mentioned.

In this country the discovery of large corundum crystals by Mr. Joseph Willcox, at a new locality in South Carolina, deserves to be mentioned. A new locality of more than ordinary interest has been described by Brush and Dana at Branchville, Fairfield County, Conn. A vein of albitic granite at that place has afforded a large number of new minerals, seven in all, and also some rare known species. The new minerals are mentioned in the list below; they are all manganesian phosphates, but differ most widely in composition and crystalline form, not only among themselves, but also from other known species. They are, moreover, all original minerals of the vein, and none of them products of decomposition. They are found associated, in the most intimate manner, in nests imbedded in the albite. In addition to the seven new species, some of the other minerals identified are: first, those associated with the phosphates, rhodochrosite, amblygonite, apatite, vivianite; also uraninite or pitchblende, gummite, uranium mica, etc.; also independent in the vein are spodumene, cymatolite, killinite, microcline, and also microlite in octahedral crystals, columbite, tourmaline, staurolite, and others. The vein was worked formerly on a small scale, for the sake of the mica it contains, but the interest connected with the new minerals discovered has led to its being reopened.

NEW SPECIES.

The following list contains brief descriptions of the recently discovered new species. They are arranged, for convenience of reference, in alphabetical order:

Argyropyrite.—A sulphide of silver and iron, containing these metals in a slightly different proportion from that in which they exist in sternbergite. It is properly only a vari-

ety of this species. Found at the Himmelsfürst mine at Freiberg, Saxony; described by A. Weisbach.

Arrhenite.—A silico-tantalate of zirconium, iron, cerium, and erbium containing water. Its specific gravity is 3.68, and in color it resembles a reddish yttrotantalite. Found with gadolinite, yttrotantalite, and other related minerals at Ytterby; described by A. E. Nordenskiöld.

Atopite.—An antimonate of calcium chiefly, containing also iron, manganese, sodium, and potassium in small quantities. It occurs in hair-brown octahedral crystals, which are semi-transparent and have a greasy lustre. Found with mimetite and rhodonite at Långban, Sweden; described by A. E. Nordenskiöld.

Barcenite.—An antimonate of calcium, mercury, and triad antimony. It is an opaque, nearly black mineral, with a dull earthy lustre. It has a more or less perfect columnar structure, due to the livingstonite from which it was originally formed. It is so intimately mixed with cinnabar and antimonic acid that its true composition was obtained only by calculation from the results of an analysis of the mixture. From Huitzuco, State of Guerrero, Mexico; described by J. W. Mallet.

Barylite.—A silicate of aluminium and barium. It occurs in crystalline masses, showing two distinct directions of cleavage. Found at Långban, Sweden; described by C. W. Blomstrand.

Blomstrandite.—A hydrated columbo-titanate of uranium. It occurs in black opaque masses; but in extremely thin fragments the mineral is translucent, and has a brownish-red color. From Nohl, in Sweden; described by C. H. Lindström.

Bolivite.—A sulphide of bismuth essentially, with also the oxide of bismuth. From Tazna, Bolivia; described by Domeyko.

Bravaisite.—A hydrous silicate of aluminium, potassium, calcium, and magnesium. It has a gray, slightly greenish color; its appearance is argillaceous, and its structure thinly laminated, though under the microscope it is seen to be somewhat fibrous. Found in the coal-measures of Noyant, France; described by M. E. Mallard.

Cleveite.—A mineral containing the oxides of the following metals: uranium, yttrium, erbium, cerium, thorium, and

lead. It occurs in regular octahedrons; it resembles uraninite, having an iron-black color and being quite opaque. The hardness is 5.5, and the specific gravity as high as 7.49. It is infusible in the blowpipe flame, though giving a globule of lead with soda or charcoal. From the feldspar quarry at Garta, near Arendal, Norway; described by A. E. Nordenskiöld.

Cotterite.—A variety of quartz, having a peculiar metallic-pearly lustre. It occurs as a coating on ordinary quartz crystals at Rockforest, Ireland; described by Harkness.

Dickinsonite.—A hydrous phosphate of manganese, iron, calcium, and sodium. It is found in crystalline masses, having a foliated, micaceous structure. The color is grass-green, and the appearance of the mineral hence very like some varieties of chlorite, although it is unlike it in its very brittle character. The crystals have a rhombohedral habit, but in fact belong to the monoclinic system. Found at the locality referred to above, at Branchville, Conn., with eosphorite, triploidite, and other related species; described by G. J. Brush and E. S. Dana.

Dietrichite.—A hydrous sulphate of zinc and aluminium, referred to the alum group. It has a white to brownish-yellow color, and a silky lustre; it occurs in aggregated masses, having a fibrous structure. It is easily soluble in water, and has the taste of the alums. Found at Felsöbanya, Hungary; it is a recent formation of the last fourteen years; described by Von Schroeckinger.

Duporthite.—A hydrous silicate of aluminium, iron, and magnesium. The mineral is greenish to brownish gray, and has a silky lustre. It is found in fibrous masses occupying fissures in serpentine; it resembles the chrysotile, or fibrous serpentine. Locality, Duporth, near St. Austell, Cornwall; described by J. H. Collins.

Ekdemite.—A mineral containing lead-arsenate and lead-chloride. It has a bright yellow to green color, a vitreous to greasy lustre, and is translucent in thin splinters. It occurs generally in small coarsely foliated masses imbedded in calcite, and also as a crystalline coating. It is referred to the tetragonal system. Found at Långban, Sweden; described by A. E. Nordenskiöld.

Eosphorite.—A hydrous phosphate of aluminium and man-

ganese, with a small amount of iron. It occurs in prismatic crystals belonging to the orthorhombic system, and showing a perfect macrodiagonal cleavage; it is also more commonly massive, sometimes closely compact. The characteristic color is bright pink, but in the massive forms it is also grayish and yellowish white and white; the lustre is sub-resinous. It is closely related in crystalline form to childrenite, and has also a nearly analogous chemical composition. Found with other manganese phosphates at Branchville, Fairfield County, Conn.; described by G. J. Brush and E. S. Dana.

Eucrasite.—A hydrous silicate containing principally thorium; but also cerium, lanthanum (didymium), yttrium, erbium, besides small quantities of other less rare elements. The color of the mineral is black-brown; the lustre is greasy, and in splinters it is slightly translucent. From Barkevik, Norway; described by S. R. Paikull.

Fairfieldite.—A hydrous phosphate of manganese and calcium, containing also small quantities of iron and sodium. It is a yellowish-white to colorless transparent mineral, with an adamantine lustre on the surface of best cleavage; the hardness is 3.5, and the specific gravity is 3.15. From Branchville, Fairfield County, Conn.; described by G. J. Brush and E. S. Dana.

Freyalite.—A hydrous silicate containing principally cerium and thorium; also lanthanum (and didymium), aluminium (and zirconium). The color is brown, and the lustre resinous; it resembles some varieties of thorite. The specific gravity is 4.1. From the region of Brevig, Norway; discovered by Esmark, and described by Damour.

Friseite.—A sulphide of silver and iron, very closely similar to sternbergite in crystalline form and physical characters as well as composition. These two minerals, with argentopyrite and argyropyrite (described above), form a group of very nearly related minerals. From the Joachimsthal, in Bohemia; described by C. Vrba.

Galenobismutite.—A sulpho-bismutite of lead, related in composition to zinkenite. It occurs massive, with a black color and metallic lustre. From Nordmark, in Wermland; described by H. Sjögren.

Ganomalite.—A silicate of lead, manganese, calcium, and magnesium. It is colorless to whitish-gray; it has a greasy

lustre and is transparent. The hardness is 4, and the specific gravity 4.98. Found at Långban, Sweden, with tephroite, which it closely resembles, with jacobsite, and native lead; described by A. E. Nordenskiöld.

Hibbertite. — A hydrated carbonate of calcium and magnesium. It is found as a loose lemon-yellow powder imbedded in purple kammererite. Found at a chromite mine in the island of Unst; described by Heddle.

Hullite. — A hydrous silicate related to delessite. It is velvet-black, brittle, waxy to dull in lustre. It occurs filling cavities in the basalt of Carnmoney Hill, near Belfast, Ireland.

Hyalotekite. — A silicate of lead, barium, and calcium. It is found in coarsely crystalline masses, showing two cleavages at right angles, or nearly so, to each other. The color is white to pearl-gray, the lustre vitreous to greasy; it is semi-transparent and brittle. Before the blowpipe it melts to a clear glass, and to this it owes its name. Found with mimetite and schefferite at Långban, Sweden; described by A. E. Nordenskiöld.

Hydrocerussite.—A hydrated carbonate of lead. It appears as a crystalline coating on native lead. This coating consists of transparent quadrangular crystals showing a perfect cleavage. From Långban, Sweden; described by A. E. Nordenskiöld.

Iodbromite.—A mineral containing the bromide, iodide, and chloride of silver. It crystallizes in regular octahedrons, of a sulphur-yellow color; like the well-known cerargyrite, or horn silver (silver chloride), to which it is closely related, it is eminently sectile, so that it may be cut with the knife. Found in cavities in quartz at Dernbach, Nassau; described by A. von Lasaulx.

Ionite.—A hydrocarbon related to pyropissite. It has a brownish-yellow color and irregular fracture. It occurs in thin seams in the Pliocene argillaceous lignite of Ione Valley, Amador County, California; described by S. Purnell.

Leidyite.—A hydrous silicate of aluminium, iron, calcium, and magnesium, supposed to be related to the zeolites. The mineral occurs in wartlike incrustations on grossularite and zoisite; also occasionally on quartz, and sometimes as small stalactitic forms consisting of pearly scales. It has a grass-

green to olive-green color, a waxy lustre, and is quite soft. Found at Leiperville, Delaware County, Pa.; described by G. A. König.

Liskeardite.—A hydrous arsenate of aluminium and iron, related to evansite. It has a white color with a slight bluish tint, and is observed in thin fibrous layers lining hollows in quartz and other minerals. From Liskeard, Cornwall; described by N. S. Maskelyne.

Lithiophilite.—A phosphate of manganese and lithium, analogous in composition to triphylite, which is a phosphate of iron and lithium. It is found in large masses, commonly of a delicate salmon color and a sub-resinous lustre. It has three distinct cleavages, two at right angles to each other, and a third prismatic. Found at Branchville, Fairfield County, Conn., where it is immediately associated with a large amount of a jet-black manganesian phosphate formed from its alteration; described by G. J. Brush and E. S. Dana.

Mangantantalite.—A manganesian variety of tantalite (9.5 per cent. MnO) from Utö, Sweden; described by A. E. Nordenskiöld.

Pandermite.—A hydrous borate of calcium. It has a snow-white color, and in appearance resembles a fine crystalline marble. Found in rounded masses imbedded in gypsum at Panderma on the Black Sea; described by G. vom Rath.

Penwithite.—A hydrous silicate of manganese. It is a highly vitreous, transparent, reddish-brown mineral, occurring with quartz and rhodochrosite. From the district of Penwith, Cornwall; described by J. H. Collins.

Picroalumogene.—A hydrous sulphate of magnesium and aluminium, differing from pickeringite in its larger percentage of water. It is a white or slightly reddish mineral, forming stalactitic fibrous masses in the iron-mine of Vigneria, Elba; described by G. Roster.

Pseudobrookite.—A mineral similar in composition to menaccanite (titanic iron), but unlike in crystalline form. It is found sparingly in minute thin tabular crystals belonging to the orthorhombic system, and closely resembling brookite in general appearance and habit. The color is dark brown to black, and the lustre metallic adamantine; opaque. From the Aranyer Mountain, Transylvania; described by A. Koch.

Pyrophosphorite.—An anhydrous pyrophosphate of cal-

cium and magnesium. An opaque, earthy, snow-white mineral, having a hardness equal to 3 and a specific gravity of 2.5. From the West Indies.

Reddingite.—A hydrous phosphate of manganese, related to scorodite in composition, and closely similar in form. It appears in minute orthorhombic octahedrons, of a rose-pink color and a vitreous to sub-resinous lustre. Found rarely with other manganesian phosphates at Branchville, Fairfield County, Conn.; described by G. J. Brush and E. S. Dana.

Rhabdophane.—A phosphate of didymium, erbium, and other metals. It resembles sphalerite, and has formerly passed for that species, but was recognized by the absorption-bands which it gave in the spectrum. From Cornwall, England; described by W. G. Lettsom.

Steelite.—A variety of mordenite, described by How as occurring in the trap at Cape Split, thirteen miles from Cape Blomidon, Nova Scotia.

Stibianite.—Supposed to be a hydrated oxide of antimony formed from the decomposition of stibnite. It is a massive, somewhat porous mineral, of a reddish-yellow color. From Victoria, Australia; described by E. Goldsmith.

Stützite.—A telluride of silver, isomorphous with dyscrasite and chalcocite. Found in minute, highly modified crystals upon a specimen of gold from Transylvania; described by Schrauf.

Szaboite.—A silicate of iron and calcium, related to babingtonite. It occurs in small thin crystals belonging to the triclinic system. The color is hair-brown to hyacinth-red, and it is almost opaque. Found in the Aranyer Mountain, Transylvania; described by A. Koch.

Tazniite.—A chloroarsenate and chloroantimonate of bismuth found at Tazna, Bolivia; described by J. Domeyko.

Totaigite.—A mineral of uncertain character, related to serpentine, and probably produced by the alteration of pyroxene. From Totaig, Ross-shire, Scotland; described M. F. Heddle.

Triploidite.—A hydrous phosphate of manganese and iron, related to triplite. It is found occasionally in distinct crystals belonging to the monoclinic system, and similar in form to those of wagnerite; more generally it has a fibrous to columnar structure. The color is yellowish to reddish brown, occasionally hyacinth-red; it is transparent, and has a vitre-

ous to greasy lustre. Found at Branchville, Fairfield County, Conn.; described by G. J. Brush and E. S. Dana.

Vietinghofite.—A highly ferriferous variety of samarskite, from the neighborhood of Lake Baikal, in the Ural; described by Von Kokscharof.

METEORITES.

In the last volume of the *Record*, allusion was made to the native iron of Ovifak, Greenland, which was first described by its discoverer, Professor Nordenskiöld, as of meteoric origin. A recent memoir, by Dr. J. Lawrence Smith, published in the *Comptes Rendus* of the French Academy, is an important contribution to our knowledge of the subject. Dr. Smith expresses himself strongly in favor of the theory of the terrestrial origin of the iron, and mentions a number of arguments which seem to prove this conclusively. One of the most important of these is derived from the microscopic study of the rock in which the masses of iron occur; by which means the iron is discovered to be scattered in minute grains through its mass, and so intimately mixed with the feldspar as to imply a contemporaneous origin.

Dr. Smith also shows that certain other masses of native iron, discovered during the past sixty years at different points on the Greenland coast, and which have been called meteorites, are remarkably similar to the Ovifak iron, and, with that, are probably in fact terrestrial. The occurrence of this native iron may be explained either—as argued by Steenstrup—as due to the reduction of the oxide by the carbonaceous material through which the basalt has been ejected, or else by assuming that the iron itself was thrown up with the basalt from some profound depth.

The locality of the iron described, at Ovifak, near Disco, was visited during the past summer by Captain Tyson and his party, on board the schooner *Florence*. Both he and Mr. O. T. Sherman, the meteorologist of the Howgate expedition, brought away a number of interesting specimens of the iron, and of the basalt which contains it.

Of true meteorites, several have been described during the past year—as those of Grosnaja, of Ställdalen, of Tieschitz, and of Vavilovka. None of them, however, offer any points of peculiar interest.

GEOLOGY.

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PRE-CAMBRIAN ROCKS.

The attention of geologists is more and more drawn to the study of the stratified crystalline rocks. So long as these were supposed to be due to the alteration, over certain regions, of sediments of Paleozoic or more recent times, they possessed but a secondary interest; but since we have learned to recognize in them portions of great series of higher antiquity, they assume a new importance to the student, alike from the geognostic and the geogenic side. As regards the former, much progress has been made in their lithology, paleontology, and stratigraphy; while the question of their origin brings up in new forms the old questions of plutonism and neptunism. The microscope is now applied with great success to the study of crystalline rocks, but the opinions of microscopists on many points of lithology are as yet unsettled, and the criteria upon which some have relied to distinguish between eruptive and indigenous rocks are found to be fallacious; while the tendency of the latest results, in the judgment of many, is towards a limitation of plutonism and a wider extension of neptunism.

WALES.

The crystalline rocks of Wales, noticed in the *Record* of last year as pre-Cambrian, have been further examined with important results. The groups to which Hicks gave the names of Dimetian and Pebidian were first found in a ridge protruding from the Cambrian strata at St. David's, in Pembrokeshire, South Wales, but have since been found in a second parallel ridge about ten miles to the east, on which is situated Castle Roche, and also in North Wales, both in Caernarvonshire and Anglesea; in each one of the four districts presenting the same geognostical and lithological re-

lations. The lithological characters of the oldest series, which received the name of Dimetian, were at first somewhat vaguely given. It may be described as consisting essentially of a somewhat granitoid gneiss, generally without mica. What were called quartzites are really very quartzose feldspathic rocks. Interstratified with this series at St. David's are several thin bands of a coarsely crystalline limestone, mixed with quartz and a serpentinic mineral. The exposures of these rocks are comparatively small. Hicks at first included in the Dimetian great masses of what had been by the geological survey of Great Britain described as an intrusive feldspar-porphyry, which, associated with granite (Dimetian), had been injected among the Cambrian strata, locally changing them into the crystalline Pebidian schists. These porphyries, which are found in each one of the four districts, consist of a great series of highly inclined beds of a compact petrosilex or orthofelsite, at times laminated, sometimes concretionary or spherulitic, often including crystals of feldspar and of bipyramidal quartz (as described by Tawney), and undistinguishable from the hälleflinta of Sweden and the feldspar-porphyries so widely displayed in North America (*Record* for 1876, p. xcvi). These latter were originally regarded, like those in Wales, as eruptive, but were by Hunt declared to belong to a stratified series included by him in the base of the Huronian, and subsequently distinguished by Hitchcock under the name of Lower Huronian. They are absent in many localities in North America, between the Laurentian and the Huronian, with which latter the Pebidian of Wales is apparently identical; and near St. David's, in Pembrokeshire, a conglomerate at the base of the Pebidian includes, in a paste of greenstone or diorite, fragments and pebbles of the banded orthofelsite-porphyries of the vicinity. Elsewhere in that region these rocks are wanting, and the Dimetian granitoid rocks are directly followed by the Pebidian. Hicks, therefore, now refers the feldspar-porphyries to an intermediate series, distinguished by the name of Arvonian, from Arvonia, the ancient Roman name for Caernarvon. The Pebidian rocks of the various areas named are undistinguishable in lithological characters from the Huronian of North America, as seen alike in the Atlantic belt, near the great lakes, and in the region of

the Sierra Nevada. They include, in Wales, great quantities of massive and slaty greenstones, serpentines, chloritic, epidotic, and quartzose schists, with argillites and so-called talcose slates. The thickness of the portion of Pebidian rocks exposed at St. David's, between the Arvonian and the unconformably overlying Cambrian, is, according to Hicks, not less than 8000 feet.

These pre-Cambrian rocks enter into certain conglomerates at the base of the Cambrian in Wales, this being especially the case with the Arvonian orthofelsites. Ramsay, from his former studies about Llyn Padarn, near Snowdon, where the Llanberris slates rest upon these older rocks, with such a conglomerate at the base, in which the matrix is very like the pebbles in composition, was led to regard the underlying porphyry as but the result of an alteration of a portion of the stratified Cambrian series. It is shown, however, by Hicks and by Hughes, that this view is untenable, and that we have nothing more than a conglomerate, of which both pebbles and matrix are derived from an adjacent pre-Cambrian rock. Hunt has verified these observations, and points out the fact that they derive an additional interest from the existence of similar conglomerates, derived from Arvonian orthofelsites, along the coasts of Massachusetts and New Brunswick, which have been in like manner regarded by some as half-developed or inchoate porphyries. These conglomerates in different parts of North America are of Lower Carboniferous, Silurian, and Lower Cambrian ages; and it is probable, from some recent observations, that there exist near Boston, Mass., still older conglomerates and breccias of this kind, which are, perhaps, of Huronian age, and may correspond to those already noticed in the base of the Pebidian or Huronian in South Wales.

The pre-Cambrian age of the crystalline rocks of Wales, maintained in a general way by John Phillips and by Sedgwick, is now placed beyond a doubt, and the existence therein of strata belonging to three distinct series or eras seems established. Hunt has recently examined them in each one of the four districts studied by Hicks, and compares the Dimetian to portions of the Laurentian gneisses, while showing the apparent identity of the Arvonian with the North American hälleflintas or orthofelsite-porphyries, and of the suc-

ceeding Pebidian with the Huronian. These Huronian rocks are well displayed in Anglesea, both near the Menai Bridge and at Holyhead; while between these, near Ty Croes, the ancient gneissic series and the Arvonian orthofelsites may be studied to advantage.

SCOTLAND.

Hunt has also pointed out the existence of Huronian rocks near Lough Foyle, in the north of Ireland; and in Scotland in various parts of Argyleshire and Perthshire, as along the Crinan canal and in the vicinity of Loch Etive and Loch Awe. They are, moreover, met with, together with the Laurentian gneisses, in the island of Islay.

The crystalline schists of the Scottish Highlands, like the similar ones in the Atlantic belt of North America, had been described as altered Paleozoic rocks, a view maintained by most British geologists, though opposed by Nicol. Hicks has lately examined a section near Loch Maree, in Ross-shire, where gneisses were said to overlie, to the eastward, the fossiliferous Cambrian strata. He has found that these supposed gneisses are uncrystalline sediments, very distinct from the truly crystalline gneisses and schists which appear farther to the eastward in the section. The various sedimentary strata, including the fossiliferous Cambrian limestones of the region, here occupy a trough in the pre-Cambrian rocks. The massive basal Cambrian conglomerates along the western border of the trough rest upon the fundamental Lewisian (Laurentian) gneiss, the ruins of which predominate in the conglomerate, accompanied, however, by fragments of Pebidian (Huronian) rocks.

IRELAND.

Hunt has examined the granitic and mica-schist series which forms the Dublin and Wicklow, or southeastern, mountain-belt of Ireland. These rocks, which include in the mica-schists alike indigenous granitoid gneisses, erupted granites, and endogenous granitoid veins, have been described, like the crystalline schists of Wales and Scotland, as altered Lower Silurian (Cambrian, Sedgw.), but apparently with no better reason. The adjacent Lower Cambrian sandstones and shales of Bray and Howth are wholly uncrystalline, and the mica-schist series is by Hunt regarded as pre-

Cambrian, like the Montalban series of North America, which it closely resembles. Areas of similar rocks are found near Loch Maree, in Scotland.

LEICESTERSHIRE.

The crystalline rocks of Charnwood Forest, in Leicestershire, which rise like islands through the Triassic strata, have been examined by Hill and Bonney. They consist in part of ancient eruptive rocks, including probably the reddish hornblendic granitoid masses of Mount Sorrel, and in part of crystalline schists which, like those of the Welsh areas, to which they are compared by Hicks, will probably be found to contain representatives of two or more pre-Cambrian series. Portions of them, according to Hunt, closely resemble the Huronian of North America.

SHROPSHIRE.

Another area of crystalline rocks appears in Shropshire, forming several hills, among which are the Wrekin and Caer-Caradoc. The former of these was described by Murchison as an igneous outburst which had altered to a quartzite the adjacent sandstones, then believed by him to be of Caradoc age (Upper Cambrian, Sedgw.). Callaway has, however, shown that the crystalline rocks are unconformably overlaid by the fossiliferous strata, which are in part of Tremadoc age, and in part identical with the Hollybush sandstones of the similar Malvern area, which are probably Menevian. The quartzites in question are still older, and, in the opinion of Callaway, are perhaps pre-Cambrian. They contain worm-burrows, but no other evidence of organic life, and rest unconformably upon the still older, or so-called, volcanic series. The greenstones, which form a part of the latter, are, according to Allport and Callaway, distinctly bedded. Another portion consists of rocks which, according to Hunt, are reddish banded petrosilex-porphyries, sometimes epidotic, and resemble closely the Arvonian series of Wales and the similar rocks in North America.

ARDENNES.

Portions of the ancient crystalline rocks of Charnwood have been by Hill and Bonney compared with those of the

Ardennes, which have lately been studied by Poussin and Renard (*Record* for 1877, p. 169). In the belt of the Ardennes in France and Belgium is found a series of argillites and crystalline schists, including more coarsely crystalline masses of rock, with well-developed feldspar, quartz, hornblende, epidote, etc. Some of these have been variously regarded as detrital and as intrusive rocks, but are by the writers just named shown to be indigenous masses. These rocks, the Ardennian series of Dumont, and by him divided into the subordinate Revinian, Devillian, and Salmian groups (called by him systems), have been described by different observers as altered Devonian or Silurian, and by the writers just named are conjectured to belong to the lower portion of the Cambrian. As shown by Gosselet, they formed islands in the Devonian sea, and in one part of the region, at Haybes, include schists with Oldhamia and undescribed graptolites, the relation of which to the crystalline schists is not apparent. In the opinion of Hunt, who has lately examined the region, the great mass of these rocks is probably pre-Cambrian, and has in part resemblances with the Huronian, and in part with the argillites of the Taconian (Lower Taconic, Emmons), which includes considerable developments of crystalline schists. The purple argillites of Viel Salm, in the Ardennes, are remarkable for containing thin interstratified layers of a peculiar cream-colored rock, long esteemed as a fine hone-stone, or coticulite. This has lately been examined by Renard, who finds these layers to be made up of microscopic grains and crystals of manganesian garnet, with occasional tourmalines, and a green crystallized mineral, which is believed to be either epidote or chrysoberyl; the whole imbedded in a hydrous micaceous mineral allied to damourite. These crystalline minerals are also found in smaller quantities diffused through the accompanying argillites.

BRITISH SERPENTINES.

Bonney has lately studied with much detail the serpentines of Cornwall, with their associated hornblendic and chloritic schists, and adheres to the old view that the serpentines themselves are eruptive masses. He has since carried his observations to the coast of Ayrshire, where similar serpentine rocks and crystalline schists are met with, and extends to

them the same view. James Gickie, from his previous studies of the latter region, had regarded the whole series as one of altered sediments. The serpentines of both of these regions resemble those of the American Huronian, and the similar ones of Anglesea which are included in the Huronian (Pebidian) series. When it is considered that there is abundant evidence that the North American serpentines are indigenous, though often, like deposits of gypsum and of iron ores, in lenticular masses; and, further, that the movements which the ancient strata have suffered have produced great crushings and displacements, it is not difficult to understand the deceptive appearance of intrusion which these rocks often exhibit, and which are scarcely more remarkable than the accidents presented by coal-seams in some disturbed and contorted areas.

WISCONSIN.

The pre-Cambrian rocks of Wisconsin (noticed in the *Record* for 1877) have been further examined by Irving, and chiefly as they occur to the south of the great Primary or pre-Cambrian area of the region, where they appear rising through the horizontal Cambrian (Potsdam) sandstone, "protruding, but not intruded." They are described as consisting in large part of quartzites, massive and vitreous, or slaty and interlaminated with soft so-called talcose schists. These rocks—the Lower Potsdam of Alex. Winchell and the altered Potsdam of Percival—were long since, by James Hall, regarded as Huronian, a view which is adopted by Irving. With them is found a great development of the hälleflinta or petrosilex-porphyry, which is found conformably succeeding the quartzites, in beds with a high northern dip, and in parts becomes schistose, or is interstratified with soft schists. In one section the petrosilex beds measure 3200 feet; while another section of 5000 feet, chiefly of quartzites and schists, shows 600 feet of the petrosilex. Irving, who has studied these petrosilexes both chemically and microscopically, follows Hunt in referring them to the Huronian series. They should probably be included in the newly proposed Arvonian series of Hicks.

THE BLUE RIDGE.

Bradley has further set forth his views as to the supposed Paleozoic age of the crystalline rocks of the Blue Ridge in

Northwestern Georgia, which, according to him, may be divided into four parts, referred respectively to the Lower Potsdam, 13,000 feet; Upper Potsdam, 2000; Quebec group, 12,000; and Cincinnati group, 15,000; the great mass of the Chazy and Trenton limestones being unrecognized. These figures, regarded by him as approximative, give a volume of 42,000 feet. The rocks are described as chiefly gneisses and hornblendic and micaceous schists, varying somewhat in mineralogical characters, but more or less auriferous throughout, with the exception of the lower division. According to Hunt, who has lately examined a section across the region, there is nothing resembling the so-called altered Quebec group of Logan (Huronian), nor yet the Laurentian; the whole series being apparently Montalban, with the exception of some portions of Lower Taconic (Taconian); and the section similar to that described in the *Record* for 1877 (p. 173) in the Blue Ridge in North Carolina, to the east of Roan Mountain. These rocks in Northern Georgia are, as elsewhere southward in the Atlantic belt, deeply decomposed, and the hornblendic gneisses, still retaining their cohesion, are reduced in specific gravity from about 3.1 to 1.2, and even to 1, by the process of decay. There seems no reason whatever for supposing this great series of crystalline rocks to have been generated by the alteration of the 8000 feet of sandstones, shales, and limestones which, at the western base of the Blue Ridge, represent the Cambrian series of Sedgwick, from the base of the Potsdam to the top of the Cincinnati group inclusive. The evidence of the pre-Cambrian age of these crystalline rocks is as undoubted as that of the similar strata in the northwest (*Record* for 1877, p. 173).

EASTERN CANADA.

Selwyn has recently announced that late investigations by the geological survey in Eastern Canada show that the crystalline rocks of the Green Mountain belt in that region, which were by Logan maintained to be derived by alteration from the fossiliferous Cambrian strata of the so-called Quebec group, are really pre-Cambrian, and unconformably overlaid by the latter, thus confirming the view of Hunt, who had long maintained these crystalline rocks to be of Huronian age.

PALEOZOIC ROCKS.

The thickness of the Lower Paleozoic rocks of Northwestern Georgia, supposed by Bradley to be the equivalents of the crystalline belt of the Blue Ridge, is, according to Little, as follows: Above the Ocoee slates and conglomerates, which are of great and uncertain volume, and perhaps correspond to the Taconian (Lower Taconic, Emmons), is the Chilhowee sandstone, considered the equivalent of the Potsdam, and 2000 feet in thickness, followed by the Knox group of limestones, sandstones, and shales, regarded as the representatives of the Calciferous sand-rock and the Quebec group, and measuring 4400 feet. To these succeed the Chazy limestone, 600 feet; the Trenton limestones and shales, 700 feet; and the Cincinnati group, consisting of silicious limestones and shales, including layers of red hematite, from 200 to 400—making in all about 8000 feet from the base of the Potsdam.

Linnarsson, in the Swedish Paleozoic series, follows Belt, Lyell, and Hicks in giving the name of Lower Cambrian to the Paradoxides schists and the fossiliferous sediments below them (the whole being equivalent to the Lower Cambrian of Sedgwick), and that of Upper Cambrian to the succeeding Dictyonema and Olenus schists, which together are the representatives of the Lingula flags, and perhaps of the lower division of the Tremadoc, its upper division being represented by the Ceratopyge limestone, which is immediately overlaid by the Lower Graptolitic schists, the equivalent of the English Arenig or Skiddaw group. This is, by the authors named, included, together with the succeeding Bala group (Llandeilo and Caradoc), in the Lower Silurian (the Upper Cambrian of Sedgwick), to which, according to Linnarsson, the fauna of the Upper Tremadoc is more nearly related than to the underlying divisions. The strata which by Hunt and others have been called Siluro-Cambrian, or Cambro-Silurian, in North America, include only the Bala group (Trenton and Cincinnati), for the reason that the Arenig (represented by the Phyllograptus shales of Levis) was not recognized in the New York Paleozoic series. Hence the Siluro-Cambrian is not the full equivalent of the Lower Silurian of Linnarsson *et al.*, and of the Upper Cambrian of Sedgwick, whose nomenclature for these rocks is still retained in its integrity by

Hughes and some others in Great Britain, an example which American geologists might follow with advantage.

Callaway has studied the Lower Helderberg limestones in New York for the purpose of comparing them with their supposed British equivalents, and also with reference to the view put forward by some, in opposition to Hall, that these limestones are but an eastern development of the Niagara formation. He confirms Hall's determination of the distinctness of the Lower Helderberg both stratigraphically and paleontologically, and maintains that the Niagara is really the equivalent of the Wenlock, and the Lower Helderberg of the Ludlow of the British Silurian series.

Claypole has recently discovered in a rock holding the organic remains of the Clinton group, in Preble County, Ohio, the stem of a tree allied to Lepidodendron. The various plant-remains found in the Lower Helderberg of Michigan, and in the Cincinnati group of Ohio, have been carefully studied by Lesquereux, who concludes that we have already in these pre-Devonian formations represented, on a small scale, the flora of the Carboniferous, including the lycopodiaceous genus *Psilophyton;* a fern related to *Paleopteris; Sphenophyllum* and *Annularia*, representing the Calamiteæ; and the sigillaroid genus *Protostigma*, the latter occurring in the Cincinnati group.

Saporta has lately described a fern from the slates of Angers, in France, believed to be of about the same horizon as the last.

The well-known fossiliferous strata of the Falls of the Ohio have lately been discussed by Hall, who concludes that they embrace beds of Niagara age, followed immediately by Upper Helderberg (Corniferous) limestone. To these succeed about 30 feet of impure limestones, which are the sole representatives of the 1200 feet of strata, chiefly sandy and argillaceous, that constitute the Hamilton formation in Eastern New York. Overlying these Hamilton limestones is the Ohio black slate, regarded as the equivalent of the Genesee slate of New York. We remark in this section the entire disappearance both of the Lower Helderberg and the Salina formation.

SALT DEPOSITS.

In the *Record* for 1877 was noticed the remarkable devel-

opment of the Salina formation, with great beds of rock-salt, in Ontario, and the intercalation of the overlying Water-lime beds with fossiliferous strata apparently of Upper Helderberg age. Since that time rock-salt has been discovered at the same horizon by a boring at Wyoming, thirty-seven miles south of Rochester, in New York. After traversing 660 feet of strata representing the Genesee, Hamilton, and Marcellus divisions, 570 feet of limestones and some shales, supposed to include the Corniferous, the Water-lime, and part of the Salina, were passed through. Below, at a depth of 1279 feet, in soft shales, was found a bed of rock-salt 70 feet in thickness, of which the larger part is said to be pure. The boring was carried downward through the red marls and sandstones of the Salina until the Niagara limestone was reached at a depth of 1562 feet. The whole thickness of the united Salina, Water-lime, and Corniferous formations in this region is thus only 900 feet.

Ashburner, of the Second Geological Survey of Pennsylvania, finds in the centre of that State, beneath the Lower Helderberg limestones of Lewiston, a series of 580 feet of thinly bedded, more or less argillaceous, limestones, followed in descending order by 375 feet of fossiliferous limestones and slates, which in their turn repose upon the Clinton formation, and in part, at least, represent the Niagara; while the overlying portions are supposed to be the equivalents of the Salina and Water-lime series. The salt and gypsum which were deposited at this horizon in New York and Ontario are thus absent in this part of Pennsylvania.

Dieulefait, in a late memoir on the deposition of salt, insists upon the fact that the salt deposits of Europe belong to two horizons—the one Mesozoic, of the age of the Lias, and the other in the Middle Tertiary. It is to be noted, however, that the strata of these periods are not saliferous in Eastern North America, where the deposition of salt took place in Lower Carboniferous and in Silurian times. It has for some time been known that certain salt deposits in Southern Asia were as old as, or older than, the Salina period; and we are now indebted to Wynne, of the Geological Survey of India, for the following details, contained in a recent account of the Upper Punjaub. According to him the salt formation to the west of the Indus is above the Cretaceous, and probably Eo-

cene or Nummulitic in age. The beds of salt, more or less mixed with clay, have an apparent thickness of 1000 feet, and are overlaid by gypsum. To the east of the Indus, south of the Tertiary plateau of the Punjaub, and separating it from the great alluvial plain lying to the southward, rise, for 150 miles, the hills of the Salt Range. These include Nummulitic and Carboniferous rocks of marine origin, below which is a horizon of dolomites and sandstones without fossils, resting conformably upon a layer of 200 feet of dark glauconitic shales, which have yielded two species of *Obolus*. Below this is a thick group of dull-purple sandstones and conglomeratic shales, becoming earthy in its lower part, and passing downward into the red marls of a salt-bearing group, which is found for a great distance along the southern foot of the range. It has an estimated thickness of 1000 feet, of which the upper half consists in large part of rock-salt, with layers of clay and thick beds of gypsum, the latter sometimes holding crystals of quartz and of pyrites. These beds are accompanied by small intercalated masses of what is described as a purple volcanic rock, with crystals of actinolite, the only evidence of eruptive action observed in the range. In one locality the marls contain a small lenticular deposit of sylvine (chloride of potassium), with kieserite, as in the Mesozoic salt formations of Central Europe. The precise age of this very ancient salt formation is uncertain, but it is called by Wynne Cambro-Silurian. It is to be noted that Hunt has pointed out that some of the conditions of a salt formation existed at an early period in the American Paleozoic series, as is shown in the strong brines or bitterns which, in several parts of the St. Lawrence valley, rise through the Trenton limestone, and in the presence of small masses of gypsum in the underlying dolomitic formation known as the Calciferous sand-rock. The presence of salt deposits, as he has explained, shows the existence, at the time and place of their formation, of geographical and climatic conditions favorable to the evaporation of sea-water.

It is to be remembered that the great salt and gypsum deposits of Eastern North America are Paleozoic, and occur in part at the base of the Carboniferous (in which they are found over various areas from Colorado to Nova Scotia and Newfoundland), and in part in the upper portion of the Silurian,

indicating the existence over the eastern half of the North American continent, during great intervals of Paleozoic time, of geographical and climatic conditions similar to those of Western Europe in later periods. These conditions imply a great mountain-elevation in the present North Atlantic, which would make a desert of the lands of Northeastern America, and which was the Palæ-Atlantis (*Record* for 1877, p. 179).

In this connection Dieulefait points out that the presence of borates in saliferous deposits is explained by the fact that the waters of the Mediterranean hold in a cubic meter not less than two decigrams of boracic acid, which accumulates in the bittern until after the deposition of the double potassium-salt, carnallite. To the action of subterranean heat on the borates of the Tertiary salt deposits of Tuscany he ascribes the boracic acid of the *suffioni* of that region, as long since taught by Hunt. The latter has called attention to the fact that the gypsum so abundant at the outcrop of the Salina formation was found, in the deep borings of 1170 feet and upwards, at Goderich, Ontario, to be replaced by anhydrite, which readily changes into gypsum when placed in contact with water. He has suggested that the great pressure at such depths may have dehydrated the sulphate of lime of the originally deposited gypsum, effecting its conversion into anhydrite, an hypothesis which it would be desirable to test by experiments.

GEOLOGY OF INDIA.

In addition to the facts already given as to the geology of the Salt Range in Northwestern India, it may be added that, while the rocks of the higher Himalayas are described as syenitic gneiss, they are succeeded by various crystalline schists and greenstones, including silky slates decaying to a white clay. In the conglomerates of the sandstone overlying the salt-beds, and also through nearly all the formations below the Himalayas, there occur boulders and pebbles of crystalline rocks, which are described as being unlike those of the northern mountains, and as pointing to the existence of an ancient land-area to the southward. This, according to Wynne, may have been a part of the old tropical continent to which the name of Lemuria has been given, and which, so late as the Tertiary, is supposed to have connected the present

Indian peninsula with Africa. (Compare with this the *Record* for 1877, p. 179).

The Carboniferous strata already noticed are followed by a great series of Triassic, Liassic, and Cretaceous strata, the whole succession down to the base of the Cambrian salt-group being here apparently conformable. In some regions farther northward the rocks are very much disturbed and even completely inverted, as in one case where, in the absence of the Cretaceous, Jurassic beds are found resting for a considerable distance at low angles on the Eocene Tertiary. In another locality the Trias itself appears overlaid by crystalline schists. Phenomena of inversion on a great scale are common in the Himalaya region. In Afghanistan, along numerous parallel ridges, the reversed anticlinals present examples of completely overturned strata, lying nearly horizontally over the same beds in their normal position for breadths of from a quarter to nearly half a mile. The salt deposits at the base of the Tertiary are very local; but the great mass of Tertiary strata, including the Siwalik sandstones and conglomerates, with their remarkable vertebrate fauna, are widely spread, and of immense volume, having, at a reduced estimate, a thickness of not less than four or five miles. Above all these are deposits of Post-tertiary gravels and silt, over and upon which are numbers of erratic blocks along the left bank of the Indus. These, unlike the rocks in the older conglomerates, appear to have a Himalayan origin, and their transportation is variously assigned to floods, to floating ice, and to terrestrial glaciers.

GEOLOGY OF THE ARCTIC REGIONS.

Among the geological results of the polar expedition under Sir George Nares, it may be noted that the ancient crystalline rocks (called, by Fielden and De Rance, Laurentian gneiss), outcrops of which are widely spread in the polar area, are directly overlaid by Cretaceous and Tertiary on Disco Island, by Jurassic on the east coast of Greenland, and by Paleozoic rocks in the Parry Archipelago; while on the coast-line between Scoresby Bay and Cape Creswell unfossiliferous shales and grits of unknown age rest at high angles upon the gneiss. The Paleozoic strata include a large development of Carboniferous limestone, well-characterized marine

strata of Devonian age, and large areas of Wenlock (Niagara) strata. In addition to these, the collections show, for the first time, the presence of strata of Llandeilo (Trenton) age, which had been supposed to be unrepresented in these northern regions. As regards climatic conditions, the flora of the Arctic Cretaceous is said to correspond to a climate like that of Egypt or the Canaries; while the Eocene flora is chiefly dicotyledonous, and wants the tropical character which belongs to that of Western North America. On Grinnell Land, lat. 81° 45′ N., Fielden found a bed of lignite 25 feet thick, with a Miocene flora, which Heer has compared with that of Spitzbergen, lat. 76°–79°, and that of Disco, in Greenland, lat. 70°–71°. That of the most northern station still presents coniferous forms, with elm, hazel, viburnum, and poplar; but a progressive diminution of genera and species is noticed in the Miocene flora as we approach the pole from Central Europe, showing that the temperature then, as now, decreased in going northward, though more slowly than at present. It would thus appear that it is not the geographical position of the pole, but the temperature of the polar region, which has changed since the Miocene period. (See in this connection the *Record* for 1876, p. cii, and for 1877, pp. 177, 178.)

MESOZOIC OF SCOTLAND.

It has long been known that small areas of various Mesozoic rocks exist in the Hebrides and the Western Highlands of Scotland, where they are often partially concealed by faults, which have let them down thousands of feet among older and harder rocks, or are overlaid by great masses of Tertiary lavas. Judd, after many years of study, has made known their history, and has shown that these patches of Mesozoic rocks in the Western Highlands extend over a large area, and were probably continuous with the same rocks of the northeast coast of Scotland, of Ireland, and of England. These rocks in the regions examined were generally deposited either upon the ancient gneiss or upon the Lower Cambrian (Torridon) sandstones; but in one place rest unconformably upon Carboniferous sandstones and shales, with coal-plants. Beneath the Jurassic series he has found 1000 feet or more of Pœcilitic (Permian and Triassic) strata, consisting of sandstones and marls, with some lime-

stones and gypsums. The infra-Lias holds intercalated in marine strata a series of estuarine beds with thin coal-seams, and the succeeding members of the Jurassic series show many evidences of having been deposited in shallow waters and near the shore. The whole Jurassic group has an aggregate thickness of over 3000 feet, and is succeeded unconformably by the Cretaceous, which, though not over 200 feet thick, is of great interest to American geologists. Above the Upper Greensand beds are sandstones with small coal-seams, succeeded by a thin layer of white chalk with flints and various silicified organisms. These are overlaid by argillaceous beds with coal-seams and plant-remains, which, according to Judd, are the remains of Cretaceous beds newer than anything hitherto found in Great Britain, or else are to be regarded as beds of passage between the Cretaceous and Tertiary. He points out the resemblances in the conditions of deposition between these and the Cretaceous of North America, and shows that the great estuarine deposits of the Hebrides demonstrate the former presence of land in the present North Atlantic area. He concludes that not only the Highlands, but the larger part of the remainder of the British Islands, were once overlaid by great deposits of secondary strata, which have been subjected at different times to enormous denudation, and that the principal surface-features of the Highlands were produced in Pliocene times.

TERTIARY STRATA.

We have noticed the great thickness of the Tertiary strata in India, amounting to four or five miles. It would appear that they are not less in the Mediterranean region. The Eocene is here but imperfectly developed, but the united thickness of the Italian Miocene and Pliocene is, according to Carl Meyer, between 22,000 and 23,000 feet. The great importance and duration of the Tertiary age in geology is becoming better understood.

Late borings at the Citadel at Charleston, S. C., have given us further information regarding the Tertiaries of the Atlantic coast. The Cretaceous beds were reached at 950 feet, and were still found at 1870, at which depth the presence of *débris* of decomposing granite indicates probably the base of the Cretaceous. It is there overlaid by 250 feet

of strata referred to the Lower Eocene or buhrstone group, succeeded by 300 feet of Upper Eocene, following which are the Cooper and Ashley beds, called by Vogdes, to whom we owe these details, Pliocene. The Lower Eocene at Aiken, S. C., has a thickness of 200 feet, and rests directly on crystalline rocks.

The dredgings made in connection with the United States Fish Commission have shown the existence along the eastern coast of North America of a submerged belt of Tertiary rocks, apparently of Miocene age. The evidence is afforded by numerous fragments of hard eroded calcareo-arenaceous rocks, obtained at various points along George's Bank at depths of from thirty-five to seventy fathoms. Other specimens have been got from the Grand Bank and at intermediate points, the whole having yielded a large number of species of fossil shells, besides portions of lignite and a sea-urchin. About one half of the species are now living on the coast, the remainder being probably extinct forms. Verrill concludes from this the existence of a submerged Tertiary formation, extending from off Newfoundland along the outer banks nearly to Cape Cod. This view had been anticipated by C. H. Hitchcock, who, from the consideration that the great Tertiary belt, which stretches along the Atlantic coast from the Gulf of Mexico as far as Massachusetts, is absent to the north and east, suggested that there had been a recent subsidence of the northeastern coast, and that Sable Island and the Great Bank might mark the place of submerged Cenozoic rocks.

LOESS FORMATION OF CHINA.

There is found over great areas in Northern China a deposit which has been compared to the formation known in the valley of the Rhine by the name of Loess. As seen in the former region, it is a fine brownish-yellow earth, extremely porous, very friable when dry, and more or less calcareous. It is for the most part distinguished from ordinary alluvial deposits by the absence of planes of bedding or lamination, presenting, however, at intervals, ordinarily of fifty feet or more, horizontal divisional planes, which are generally associated with calcareous concretions; and is, moreover, marked, like the loess of the Rhine, by vertical cleavage-joints, which cause the deposit, when eroded by water-

courses, to present perpendicular cliffs. Vertical tubes penetrate this deposit throughout, which apparently result from the decay of grass and roots. In addition to these, the remains of plants, land-snails, and the bones of terrestrial mammals occur in it. The thickness of this deposit is very great, being often 1000, and in some cases even 2000 feet.

Various theories have been proposed to account for this remarkable formation. Kingsmill regarded it as a deposit during a period of marine submergence; while Pumpelly, from his studies of parts of the region, supposed it to have been accumulated in a great inland lake, which received the drainage of a vast area. Belt imagined such a lake to have been formed by the damming-up of the rivers by an enormous glacier filling the North Pacific, applying a similar hypothesis to the loess of the Rhine (*Record* for 1877, p. 180). According to Von Richthofen, while it is true that certain limited areas of the loess are, as supposed by Pumpelly, deposits from water, and thinly laminated, these are distinct from the great mass of unlaminated loess which overlies them. This he supposes to be a sub-aerial formation due to the transport of dust by the winds, to which, in the vicinity of the hills, rain and small streams have contributed by bringing down coarser material. Such agencies, operating through long ages in an interior basin, in which, by reason of a small rainfall, there is is no outflow of waters, must result in an accumulation of material not unlike the loess of China, as described by Von Richthofen.

FOSSIL SPONGES.

S. J. Wallace has examined the geodes found in the Keokuk (Lower Carboniferous) limestone over a great area in the Upper Mississippi valley. They are shells of chalcedonic silica of from a few lines to two feet in diameter, sometimes empty, but at other times filled with agate, crystalline quartz, or calcite, and have long been suspected to be organic in origin. Wallace has confirmed this view, and shown them to be casts left by the decay of sponges, of which they often bear the outward markings. He has described several species which he refers to a new genus, *Biopalla*. These sponges are seen to have grown in some cases over and around projecting masses of rock, and, in one case, within a

large crinoidal column, which had been split open by the growth of the sponge. Hunt has called attention to the fact that the abundant agates in the argillaceous beds of the Keweenian or copper-bearing series of Lake Superior, on Michipicoten Island, are chiefly of two or three symmetrical forms, which he has referred to fossil sponges. They sometimes form geodes, or are wholly or in part filled with calcite or green-earth instead of agate. The same series of rocks exhibits slender cylindrical shapes of agate, which resemble Scolithus, but are often bifurcated, and are conjectured to be of organic origin.

RECENT FORMATION OF MINERALS.

Daubrée has continued and summed up his studies on the mineral species which have been formed in the masonry constructed by the ancient Romans around various thermal springs, at Plombières, Luxeuil, and Bourbonne, in France, and at Oran, in Algeria. The masonry in all of these consisted of a concrete of fragments of sandstone, limestone, and brick, in a cement of lime-mortar. In the interstices of the cement have been found crystallized apophyllite, gismondine, and scolezite, with opal or hyalite; and also a transparent gelatinous matter, which apparently changed in drying into mammillated fibrous masses of a hydrous silicate of lime, having the composition of okenite, mixed, however, with opal. Crystallized arragonite, calcite, and fluor-spar are also found, and a hydrous amorphous silicate of alumina, halloysite.

The bricks in the concrete are found infiltrated to a greater or less depth, the cavities occurring in the unaltered portions having become more or less filled with mineral species, in part different from those found in the cement. Among these are well-defined crystals of chabazite, mesotype, opal, chalcedonic quartz, and, probably, phillipsite and tridymite, all of which have been formed at temperatures not above 70° C. The changes effected in the bricks have been investigated both chemically and microscopically. In the infiltrated bricks the proportion of combined water was augmented from two or three to eight per cent., and the amount of soluble zeolitic matter was found equal to fourteen or fifteen per cent. of the mass. Daubrée concludes that the lime, alumina, and silica of the mineral species have been derived from the mortar and the bricks, the mineral waters

having served chiefly to furnish the alkalies. The waters themselves, in some of the springs at least, contain alkaline carbonates, which helps to explain their solvent action on the argillaceous silicate of the bricks.

As pointed out by Daubrée, the resemblances between these mineral species and the similar ones found in many rocks extend even to minor details of crystalline form and modes of association. The small geodes in many of the bricks, as the writer can testify, cannot be distinguished by the eye from many specimens found in amygdaloids.

ERUPTIVE ROCKS.

The so-called trappean rocks, chiefly doleritic, which occur in the Mesozoic red sandstone of Eastern North America, and are generally recognized as eruptive, occur, for the most part, in great beds or sheets interstratified with the sandstone. Of these, the underlying beds near the contact present clear evidences of the action upon them of the molten rock; but as the contact of this with the overlying sediments is more rarely seen, the question has been raised whether these eruptive masses were not contemporaneous outflows spread over the sea-bottom during the deposition of the sedimentary rocks. At Feltville, N. J., according to I. C. Russel, the relation of the trap to the overlying beds is such as to show its posterior origin. The igneous rock, which is hard, bluish, and crystalline, presents on its upper surface large bosses or apophyses penetrating the overlying shale beds, which are both disturbed and altered, so that near the contact they resemble somewhat the trap itself. At a distance of six or eight feet they are filled with small rounded masses of a greenish epidote-like mineral, but at twenty-five or thirty feet resume their normal aspect. The upper portions of the bosses of trap are scoriaceous on the surface, and amygdaloidal. In some places is seen what is described as a friction-breccia, irregularly interposed, and containing zeolites and calcite. A similar example was long since noticed by H. D. Rogers as occurring at Lambertville, on the Delaware, where in a sandstone bed near the trap have been developed short doubly-terminated crystals of black tourmaline. With these the writer has found specular iron, and in an overlying bed patches of epidote. The two localities just named occur in the same area

of sandstones, which have a pretty uniform dip of from twelve to fifteen degrees to the northwest.

The observations of Gilbert in the Henry Mountains of Southeastern Utah present a peculiar and somewhat similar type of intrusion. The ancient lavas there having failed to penetrate the upper portions of the horizontal strata, uplifted them for considerable areas, and, spreading out between the separated strata, formed subterranean lakes, the consolidation of which has given rise to interbedded lenticular masses of plutonic rock, now disclosed by erosion.

An area of over five thousand square miles of eruptive rocks in Southeastern Utah is found to be made up of successive flows, which do not include any sedimentary beds between, and present sections of from 4000 to 5000 feet in thickness. These successive eruptions, which probably extended over a long time, belong to the close of the Miocene period. The individual flows are very numerous, and represent all the chief groups of eruptive rocks. It is difficult to determine the openings through which these great sheets were extravasated, the more so as the wide-spread later eruptions have concealed the older vents. It is clear, however, from the irregularities of the sheets and their thickening and thinning-out, that there were several centres of eruption. The uplifting of the region, and the great faults which affect the strata, were posterior to the principal eruptions; though smaller eruptions, insignificant in amount, took place during the elevation, and were apparently connected with the faults. These later outbursts were not in the older volcanic areas, but around their borders.

Dutton, who has studied these rocks, finds the oldest eruptions of the so-called propylite followed by hornblendic andesite, confirming to this extent Von Richthofen's observations as to the succession. Higher in the series, however, occurs a great development of trachytes, showing much variety in their composition, and occasionally containing mica and hornblende. With these he finds repeated intercalations of dolerites, made up of triclinic feldspar with much augite and magnetite. The newest eruptive rocks of the region are rhyolites or quartziferous trachytes, followed by true basalts. These observations are to be compared with those in the *Record* for 1876 (p. xciv), which they confirm.

J. Arthur Phillips has continued his studies of the so-called greenstones of Cornwall. The rocks thus distinguished by De la Beche include some masses which are interstratified with, and graduate into, the crystalline schists of the region, and are believed by Phillips to be of sedimentary origin; besides others which he conceives may have been contemporaneous volcanic outbursts, which are, however, according to him, difficultly distinguished from the preceding; while others still are undoubtedly eruptive rocks intersecting the strata. All of these are in their turn, however, traversed and displaced by intrusive granites. These various greenstones, both coarse and fine grained, consist essentially of a plagioclase feldspar, with augite or hornblende, or of an association of these two, which, according to Phillips, is probably the result of a partial transformation of augite into hornblende, though in certain cases he conceives that this latter may have been an original constituent. Associated with these are viridite, occasionally with brown mica, epidote, and apatite. These bedded greenstones, with their associated crystalline schists, appear to have strong resemblances to the rocks of the Huronian series, to which further study will probably show them to belong.

Von Cotta has lately defined his views on eruptive rocks, the nature of which he maintains to be altogether independent of the geological age or period of their eruption, both acidic and basic magmas having in all times either overflowed or penetrated other formations, and having been accompanied by tufas. When consolidated at great depths, these magmas constitute plutonic rocks; but when nearer the surface, volcanic rocks. Thus the acidic materials give rise either to granites and porphyrites, or to trachytes and trachytic lavas; and the basic materials to diorites and greenstones, or to basalts and basaltic lavas, according to the conditions of their solidification.

Similar views have also been insisted upon by Hunt, who remarks that inasmuch as the more ancient neptunian formations, with their accompanying eruptive masses, have in most cases been subjected to great erosion, it results that the superior or volcanic portions of the latter have generally disappeared, the inferior or plutonic portions only remaining. Hence it has come to pass that granites and green-

stones are regarded as ancient, and trachytes and basalts as modern rocks.

INTERNATIONAL GEOLOGICAL CONGRESS.

The American Association for the Advancement of Science, at its meeting in Buffalo, August, 1876, appointed an International Committee, charged with the organization of an International Geological Congress, to be held in Paris during the Exhibition of 1878. This committee, which consisted of James Hall, W. B. Rogers, J. S. Newberry, J. W. Dawson, T. Sterry Hunt, R. Pumpelly, and C. H. Hitchcock, with the addition of T. H. Huxley, Otto Torell, and E. H. von Baumhauer, then present at Buffalo, chose James Hall for its chairman and T. Sterry Hunt for its secretary. A circular in various languages was at once issued, urging the importance of the proposed Congress, for the consideration of which various points were suggested, and recommending the bringing-together at the Exhibition of collections illustrating the geology of all countries. The assurances of co-operation received by the secretary were such that, after a few months, the Geological Society of France took up the matter in connection with the International Committee, and, naming a Local Committee, of which Hébert was president and Jannetaz, secretary-general, issued, July, 1877, a circular embodying the suggestions of the first committee. This was followed by a second circular, dated February, 1878, fixing the opening of the Congress for the 29th of August. The Local Committee also prepared a catalogue of all the materials of geological interest in the Exhibition, as well as of all the public and private collections of Paris, which were thrown open to the members of the Congress.

The Congress was opened on the day appointed in the Palace of the Trocadéro, the Minister of Public Instruction for France presiding on the occasion, and six daily sessions were held, with Hébert for president, assisted by numerous vice-presidents selected from the various nationalities. The whole number of members enrolled was 328, of which about 250 were present. American geology was represented by James Hall, G. H. Cooke, J. P. Lesley, T. Sterry Hunt, W. P. Blake, E. D. Cope, and T. C. Chamberlin, and by Selwyn from Canada.

The first session was devoted to Structural and Dynamical Geology, and included, among others, papers by Daubrée and by Alphonse Favre, both giving results of experiments relative to the origin of fractures and foldings of the earth's crust. These were followed by Lory, on the Structure of the Alps; by De Chancourtois, on the Co-ordination of the Lines of Faults and Veins; and by De Lapparent on the Foldings of the Chalk as Disclosed by the Examinations for the Tunnel beneath the Strait of Dover.

In the second session James Hall discussed the History of the Rise and Progress of the Nomenclature of the Paleozoic Rocks in North America, and of the various Geological Maps; while Renevier, De Chancourtois, and Hugenin submitted their plans for the Use of Colors and Signs in Mapping. Stephanesco and Rutot discussed the Value of Geological Subdivisions and the Bases of a Uniform Geological Nomenclature for all Countries; while Vilanova set forth his plan of a General Dictionary of Geology.

In the third session T. Sterry Hunt presented a memoir on the Upper and Lower Limits of the Cambrian Series, and was followed by Barrande on the same subject. Von Moeller then discussed the Constitution of the Carboniferous Series in Different Regions of Europe, and its Relations to Devonian and Permian; and was succeeded by Lesley on the same questions as presented in Pennsylvania, and by Vélain on the Relations of the Trias and Lias in France.

In the fourth session Cope discussed the Relations of the Horizons of Fossil Vertebrates in Europe and America, and was followed by Albert Gaudry and by Matheron on the same subject. De Mortillet presented his views on the Quaternary Formations, and Alphonse Favre discussed the Hypothesis of Former Glacial Periods. Van der Broeck and Buvignier considered the Agency of Meteoric Phenomena in the Alterations of Rocks; and W. P. Blake presented and described a Geological Map of the United States of America. The Origin of Volcanoes was then considered by Virlet d'Aoust, after which the Local Admixtures of Organic Remains of Different Horizons, giving rise to what have been called Colonies, alike in Jurassic and Devonian Strata, were discussed by Choffat, Renevier, and Gosselet.

In the fifth session Des Cloizeaux and Michel Lévy discuss-

ed various questions as to the Feldspars in Crystalline Rocks, their Chemical Composition and Microscopic Characters; and were followed by T. Sterry Hunt on the Constitution of the Plagioclase Feldspars; while Jannetaz treated of the Geological Importance of the Propagation of Heat in Rocks considered with reference to their Structure and their Origin. T. Sterry Hunt then gave a description of the Great Groups of Crystalline Stratified Rocks found in North America, including Laurentian, Norian, Huronian, Montalban, and Taconian, and compared them with similar groups in Europe. He was followed by Selwyn on the same subject. Szabo discussed the Eruptive Tertiary Rocks of Hungary, examining the question whether the Mineral Composition can serve to show the Ages of such Rocks. Vélain contributed an account of the Trachytes of Reunion Island, and Ribeiro one of the Tertiary Basalts of Portugal.

In the sixth and last session of the Congress, on the 4th of September, a communication by Bourjot was presented on the Supposed Eruptive Limestones of Algeria; and one on some Glacial Phenomena of the great Lake District of North America, by Chamberlin; while Fuchs resumed the views of several members of the Congress on the System of Coloring Geological Maps. The president then announced the decision of the Council that the acts of the Congress are to be published in a volume under the direction of the secretaries, the cost being generously defrayed by the national government. A second International Congress will be held at Bologna, in Italy, in October, 1881, under the honorary presidency of Sella, President of the Academia dei Lincei of Rome, and a Local Committee of ten Italian geologists has been named, charged with the organization of the Congress, of whom Professor Capellini, of Bologna, will probably act as secretary. The government of the King of Italy, through its ambassador at Paris, at once promised its high patronage to the future Congress, and the municipality of Bologna sent a message of welcome.

The work of the next Congress is referred to two International Committees; the first of which will be charged with the Unification "Des Figurés Géologiques," that is to say, of all colors or signs employed on geological maps and plans. The second is charged with the Unification of Geological No-

menclature, under which will be considered all questions relating to classification, as well as the value and significance of mineralogical, lithological and paleontological characters, embracing the most important problems in geology. For these two International Committees one member is named for each country, whose duty it will be to organize therein local committees, and to make known the composition of these as soon as possible, both to the secretary-general of the late Congress and to the Local Committee of the future one. Reports by these several committees are to be sent, before the 1st of January, 1881, to the Italian Local Committee of Organization, who will cause them to be printed and distributed before the meeting of the Congress.

The members of the International Committee on Maps are as follows: United States, Lesley; Canada, Selwyn; Great Britain, Ramsay; France, De Chancourtois; Belgium, Dupont; Switzerland, Renevier; Italy, Giordano; Spain and Portugal, Ribeiro; Hungary, Von Hantken; Russia, Von Moeller; Scandinavia, Torell.

The International Committee on Nomenclature and Classification is thus composed: United States, James Hall; Canada, T. Sterry Hunt; Great Britain, T. McKenna Hughes; France, Hébert; Belgium, Dewalque; Germany, F. Römer; Switzerland, Alphonse Favre; Italy, Capellini; Spain and Portugal, Vilanova; Hungary, Szabo; Roumania, Stephanesco; Russia, Inostranzeff; Scandinavia, Lundgren; Australia, Liversidge.

In addition to the above a Local Committee was named in France to discuss for the next Congress the rules to be observed in the nomenclature of species, consisting, for Paleontology, of Cotteau, Douvillé, Gaudry, Pomel, Gosselet, and De Saporta; and for Mineralogy and Lithology, of Des Cloizeaux and Jannetaz. The report of the Committee of the American Association in 1876, on Biological Nomenclature, presented by Cope to the Congress, was referred to the above-named committee. The general language of the proceedings was, of course, French; but communications made in English were interpreted by MM. Barrois and T. Sterry Hunt, and will be duly translated for the published acts of the Congress.

HYDROGRAPHY.

By FRANCIS M. GREEN,
LIEUTENANT-COMMANDER, U.S.N.

Hydrographic surveys have been prosecuted during the last year in nearly every part of the earth, increasing in fulness and accuracy our knowledge of the shores and islands of the various oceans, and constantly diminishing the very large extent of coast-line yet unsurveyed and only imperfectly known.

In this task American, English, French, German, Italian, Spanish, and Austrian naval officers have been engaged, the needs of commerce calling loudly for more exact knowledge of many channels of navigation which can only be made safe by systematic and exact government surveys.

When this information is required on the shores of half-civilized countries, such surveys must necessarily be made by the more enlightened maritime nations; and in such work Great Britain and the United States have always been ready to aid.

The exchange of hydrographic data between the governments of maritime nations, constantly and systematically carried on, adds a large volume every year to existing hydrographic information. So completely is this work effected that any alleged discovery of a rock or shoal, or a change in lights, buoys, or other aid to navigation which may be communicated to the hydrographic office of any maritime nation is instantly sent to all the others, thereby insuring the spread of the knowledge all over the world with the smallest possible delay. This custom has grown up so quietly and gradually that the world at large knows but little of a system which adds enormously to the safety of navigation.

Of these notices the United States Hydrographic Office, under the superintendence of Captain S. R. Franklin, U.S.N., has, during 1878, issued 85 relating to changes in the earth's

surface, as well as 120 others relating to changes in lights, buoys, etc. During the same period 15 new coast and harbor charts have been engraved and published, principally from the surveys of Commander Dewey, U.S.N., on the coast of Lower California, 15 new photo-lithographed charts have been compiled from recent foreign surveys, and 30 chart-plates have received extensive additions and corrections, besides minor corrections on many more. Of the publications of the Hydrographic Office, 4545 charts and 917 volumes of sailing directions, etc., have been sold.

A system of collecting and arranging materials for wind and current charts, which has already been productive of very excellent results, has been devised by Lieutenant T. A. Lyons, U.S.N., and has been, since 1876, carried on at the Hydrographic Office, under his immediate supervision. In this system the ocean is divided into squares of five degrees of latitude and longitude, with regard to each of which information is collected and arranged. Admirable charts of a portion of the Pacific Ocean from the equator to 45° N. lat., and from the coast of America to 180° W. long., have been already published, embodying the results of a vast amount of labor, and giving complete and accurate information as to winds, weather, currents, temperature of air and sea-water, barometric pressure, storms, magnetic curves, etc., of the ocean. Work is far advanced on similar charts of the Atlantic.

All the log-books of naval vessels from 1858 to 1877 are now undergoing examination and compilation; while in more recent log-books the required information is tabulated by the navigator ready for immediate use. To gather additional data, blank meteorological journals are furnished to merchant vessels, sailing-charts and other hydrographic information being furnished to ship-masters willing to keep and forward the journals. A large number of merchant captains under the United States, British, German, Italian, and Austrian flags are now keeping these journals.

The object of this work, which promises invaluable results, is to gather, discuss, and publish, in an intelligible form, accurate information regarding the winds and currents of the ocean.

Commander Philip, U.S.N., in the U.S.S. *Tuscarora*, has been engaged in completing the survey of the west coast of

Mexico, from Acapulco to the Tartar Shoal, where the mail-steamer *City of San Francisco* was lost, and west of Acapulco as far as Mangrove Bluff, besides making plans of Acapulco and Sihuantenejo harbors and the anchorages of Tequepa and Petatlan. These charts are now being prepared for publication. Commander Philip has also made a series of valuable deep-sea soundings off and on shore between San Diego and Cape San Lucas, and is now engaged in continuing the survey of the Pacific coast from Cape Corrientes to the Gulf of Fonseca.

Commander Selfridge, U.S.N., in the U.S.S. *Enterprise*, has made a most valuable track-survey of the Amazon River, from Para to the mouth of the Madeira, and of the latter river as far as the rapids of San Antonio, a distance of 1300 miles. The charts of this survey are being rapidly prepared for publication; the sheets of the Amazon on a scale of half an inch to the mile, and those of the Madeira River on a scale of one inch to the mile. At fifty-five stations, separated by only short distances, careful astronomical and hypsometrical observations were made. The general conclusions derived are, that no serious obstacles to navigation need be apprehended at any season below the rapids of San Antonio, a depth of ten fathoms for the Amazon, and of three to four fathoms for the Madeira, being the minimum.

A railway now being constructed round the rapids (which are nearly two hundred miles in extent) to the mouth of the Mamoré River will enable merchandise and passengers to reach Bolivia without difficulty, and will doubtless very materially stimulate commerce with this hitherto almost inaccessible region.

Lieut.-Commander Gorringe, U.S.N., has been engaged in the U.S.S. *Gettysburg* in collecting information for compiling sailing directions for the shores of the Mediterranean.

The officers of the U.S.S. *Guard* have continued the work undertaken by the United States Hydrographic Office, of determining secondary meridians of longitude by means of submarine telegraph cables, having measured from the Royal Observatory at Lisbon, by way of Madeira, Cape de Verde islands, Pernambuco, Rio de Janeiro, and Monte Video, to Buenos Ayres, connecting with the chain of longitudes measured by Dr. B. A. Gould, from the National Observatory at

Cordova. A preliminary discussion of these observations seems to indicate an error in the received longitudes of the east coast of South America of about twelve seconds of time.

An interesting chain of deep-sea soundings has been made by Commander Schley, U.S.N., in the U.S.S. *Essex*, from St. Paul de Loando, by way of St. Helena, to Cape Frio, Brazil. Thirty-nine satisfactory soundings were made at an average distance apart of one hundred miles, serial temperatures and bottom specimens being everywhere obtained. The depths and temperatures harmonize perfectly with those obtained by the *Challenger* and *Gazelle* in the same region. The bottom specimens have been sent to Professor Hamilton Smith, of Hobart College, for examination.

The profile of this cross-section shows that the depth increases quite suddenly on leaving the African shore, 2200 fathoms being found 160 miles west of St. Paul de Loando, between which point and St. Helena the greatest depth is 3063 fathoms. The island of St. Helena is a mere pinnacle of rock, rising from a base only 30 miles wide to a height of 16,000 feet. Five hundred and fifty miles west of St. Helena, the elevated ridge spoken of by Sir Wyville Thomson was found with a depth of 1365 fathoms on it, 2300 fathoms being found on its eastern and 2700 fathoms on its western limit.

From the large number of deep-sea soundings made within the past few years, Dr. Krümmel has attempted to make a new approximation to the mean depth of the sea, and has communicated an account of his labors in a note to the Göttingen Academy. Soundings are wanting for the Antarctic Ocean, and for a part of the North Polar Sea, embracing in all about 475,000 square miles, or about 7 per cent. of the entire sea surface. From available data, however, he deduces a mean depth of 1877 fathoms, the greatest depth yet measured in a trustworthy manner, and from which the bottom was brought up, being 4356 fathoms, found by Captain Belknap, U.S.N., off the coast of Japan.

Hydrographic work on the Atlantic, Gulf, and Pacific coasts of the United States has been carried on extensively by the United States Coast Survey; the actual work on board ship having been in nearly, or quite, all cases performed by officers and men of the United States Navy.

In the steamer *Blake*, Lieut.-Commander Sigsbee, U.S.N.,

has completed the physical examination of the Gulf of Mexico, with the Yucatan and Florida channels. The contour of the bottom has been thoroughly determined, and serial temperatures have everywhere been taken. Large quantities of bottom specimens and dredgings have been collected, and are now being examined under direction of Professor A. Agassiz, who is this season, for the second time, supervising the dredging operations on board the *Blake*, now under command of Commander Bartlett, U.S.N., who succeeded Lieut.-Commander Sigsbee in the command of the vessel and the charge of the physical and hydrographic work. This season's work will consist of a similar examination of the approaches to the Gulf Stream in the San Antonio and Bahama channels.

A chart of the Gulf of Mexico, embodying the results of Lieut.-Commander Sigsbee's work, has been published.

On the coast of Maine a great deal of sounding has been done, both inshore and offshore.

Changes in the bar at the mouth of the Merrimac River have necessitated a re-survey of Newburyport harbor, which has been completed. An examination has been made of the shoal ground near Block Island, and the southwest shoal between Block Island and Montauk Point has been re-surveyed.

In Delaware Bay and River, valuable observations on tides and currents have been made.

Lieutenant Moser, U.S.N., in the schooner *Endeavor*, besides a valuable series of soundings off the coasts of North and South Carolina, has made a survey of an excellent anchorage recently formed by the extension of the shoal off Cape Lookout.

The parties at work on the northern coast during the summer are transferred to southern waters for the winter, and have accomplished valuable results in and near the St. John's and Indian rivers, and off the east and west coasts of Florida, a new shoal having been discovered and located off Cape Cañaveral.

A photo-lithographed chart, in 13 sheets, of the Mississippi River, from Fort Jackson to about twenty miles above New Orleans, has been completed and published.

On the coast of Southern California, in San Pablo and Suisun bays and San Diego harbor, as well as on the coast of

Oregon and Puget's Sound, naval officers in charge of surveying parties have been constantly at work aiding to complete charts of the coasts.

In addition to the regular work of the year, a system of dredging and general examination of the oyster-beds of Chesapeake Bay has been carried on to obtain information for the promotion of this most valuable interest. The data obtained are being examined and discussed by Mr. W. H. Dall.

A review of the work accomplished by English hydrographers during the past year shows no falling off in either quantity or quality of results attained as compared with previous years. Besides a large amount of subsidiary work at various points on the shores of Great Britain, where changes in the bottom have necessitated corrections on the charts, the central part of the English Channel, from the neighborhood of Dungeness and the Varne Shoal to the Owers, has been re-sounded, the surveys made during the last century being very deficient in details. The river Shannon has been very completely re-surveyed, and the shoal ground in the neighborhood of the Smalls and Bishops rocks has been thoroughly examined.

In view of the increasing importance of the Red Sea as a thoroughfare, the surveys which have been going on there for some years have been continued, the charts of Musawwa' Channel having been completed during the past season by the officers of H.M.S. *Fawn*. Data obtained by the same officers regarding the approaches to the Suez Canal indicate that, while a depth of 28 feet may still be carried to within the breakwater on approaching the northern terminus of the canal, a deposit from the Nile is taking place, amounting to about one foot annually, and extending over the whole area of the approaches to Port Said.

In this connection it may be mentioned that M. de Lesseps has recently communicated to the French Academy of Sciences the results of tidal and current observations, made at several stations on the Suez Canal since 1871. It appears that from May to October the prevailing winds are from north and northwest, raising the mean level of the water at Port Said and depressing it at Suez. This difference of level which amounts at times to about 16 inches, causes a constant

current, which, although interrupted at times by tidal action, moves a large body of water through the canal from north to south. During the winter, on the contrary, the winds blowing violently from the south send the current in an opposite direction, the mean level of the Red Sea attaining a height of twelve inches over the Mediterranean. These currents cause an annual movement of 400,000,000 cubic meters of water from one sea to the other, and, with the tidal streams, tend to counteract the effects of evaporation from Lake Timsah and the Bitter Lakes, and to decrease the amount of salt in the latter. Between Port Said and Lake Timsah these currents have a rate of from $\frac{3}{10}$ to $\frac{8}{10}$ of a mile an hour; but between Suez and the Bitter Lakes they attain a rate of $1\frac{2}{10}$ to 2 miles. The deposit of salt, 40 feet thick, at the bottom of the Bitter Lakes, under these influences, aided by the passage of vessels, is being gradually diminished.

An excellent survey of Mauritius and the surrounding banks, on a scale of one inch to a mile, has been completed by Lieutenant Coghlan, R.N.; and Captain Wharton, R.N., whose labors in the Red Sea were noticed in last year's *Record*, has, during the past year, been engaged in a thorough survey of the intricate coast and islands north and south of Zanzibar, completing it from latitude 7° S. to 9° S., besides surveying several harbors and approaches, and making a series of deep-sea soundings for a projected telegraph cable from Zanzibar to the Cape of Good Hope.

In China, the coast between Hong-Kong and Foochow has been carefully examined by Captain Napier, R.N., in H.M.S. *Nassau*. This duty has included the survey of Hai-tan Strait with the approaches, and the execution of several plans of harbors and anchorages.

The officers of H.M.S. *Sylvia* have been engaged in an examination of the ship-channels between the islands off the southwestern part of Korea, lying directly between Japan and the northern ports of China, and making surveys on the coasts of Nipon and Kiusiu.

In the Fiji Islands, steady progress has been made in their survey by Lieutenant Moore, R.N.; the whole of the coast of Viti Levu, with its off-lying islets and reefs, and Kandavu passage, the main approach to the harbor of Savu, the new capital, being now completed.

In Newfoundland, the survey of the coast, with its innumerable bays and its irregular banks and shoals, has been energetically prosecuted. The discoveries of rich copper deposits on the shores of Notre Dame Bay vastly increase the importance of this region.

At the island of Jamaica, Lieutenant Pullen, R.N., has continued the survey of the south coast beyond St. John's Point, and has made excellent harbor-charts of Blewfields and Savanna-la-Mar.

The Admiralty surveys on the coast of Australia are being vigorously pressed on. The charts of South Australia and Victoria are nearly completed. No less than six complete surveying parties, under experienced officers, are engaged in this work. In addition to the superintendence of these numerous surveys, the English Hydrographic Office has, during the year, published 54 new charts, corrected 1940 old ones, and has printed 182,000 charts for the use of public vessels, and for sale.

The general results of the famous cruise of the *Challenger*, so far as relates to the Atlantic Ocean, have been given to the public by Sir Wyville Thomson. As regards the physical geography of the sea, the results may be briefly summarized as follows: The mean depth of the Atlantic Ocean is a little over 2000 fathoms. An elevated ridge rising to an average height of about 1900 fathoms below the surface traverses the basins of the North and South Atlantic in a meridional direction from Cape Farewell, probably as far south as Gough Island, lying to the southward of the Tristan d'Acunha group. With its two branches, which join the continents of South America and Africa, this ridge divides the Atlantic into two basins: an eastern, extending from Ireland to the Cape of Good Hope, with an average depth of 2500 fathoms; a northwestern basin, occupying the great bight of the American continent, with an average depth of 3000 fathoms, and a gulf running up the coast of South America as far as Cape Orange, with a mean depth of 3000 fathoms. The greatest depth found in the Atlantic was 3875 fathoms, a little north of the Virgin Islands, confirmed by a sounding made by the U.S.S. *Gettysburg* in 1876 in the same place.

The bottom everywhere at depths between 400 and 2000

fathoms is covered with the *débris* of shells of foraminifera, now everywhere known as *globigerina ooze.*

Nearer the coast the deposit consists chiefly of mud, washed down by rivers, or of disintegrated rock; while beyond 2000 fathoms a chemical change seems to take place in the globigerina by which the carbonate of lime is removed and a sort of red clay remains, frequently mixed with volcanic remains, such as felspar and pumice. The results from temperature observations would require too much room to be given in detail, but a very important fact was established, viz.: that a great many of the observed anomalies in bottom and serial temperatures may be accounted for by the fact that, as yet, no registering thermometer has been devised whose indications may be strictly relied upon. The Miller-Casella thermometer, where the bulb containing the expanding fluid is surrounded by another bulb containing diluted spirit and vapor, is by far the best, but its action leaves a great deal to be desired.

A vast number of interesting and valuable data were gathered regarding the currents of the Atlantic, and it seems as if the vexed question of the cause of the Gulf Stream might now be considered as settled. Nearly all intelligent navigators and physicists will agree with Sir Wyville Thomson in his theory that the permanent winds blowing eternally in one direction send the heated surface-water in a constant stream to the westward, and this stream, split by Cape St. Roque, directs its northern branch round the Gulf of Mexico, and becoming contracted and condensed by the Straits of Florida, it makes itself manifest as the Gulf Stream. At the same time it is considered probable that the general circulation of the water in the Atlantic is kept up by an excess of evaporation in the northern portion, balancing an excess of precipitation over evaporation in the southern, or water hemisphere.

It is too soon to generalize with regard to the chemical composition of the waters collected from every part of the ocean by the *Challenger*, but they are being carefully analyzed, and will doubtless give most valuable results.

An important exploring and surveying expedition has been despatched by the English Admiralty, under Sir George Nares, in his old ship the *Alert*, of Arctic celebrity. The officers of the *Alert* have been most carefully selected, and

among them is Dr. Cappinger, R.N., surgeon of the *Discovery* during the late Arctic expedition, and whose scientific attainments are of a high order. The *Alert* will first proceed to the Strait of Magellan, where the triangulation from Cape Froward to Cape Pillar and the survey of channels to the northward will be completed, the survey by Captain Mayne, R.N., in 1867 and 1868 only extending from Cape Virgins, at the Atlantic entrance, to Port Famine. The heavy weather generally prevailing at the western entrance of the Strait makes the use of the channels leading inshore to the Gulf of Peñas very desirable; but disastrous shipwrecks having taken place in consequence of sunken rocks and other hidden dangers, the *Alert* has been directed to explore the channels supposed to exist between some of the islands of the Archipelago, in order to afford a sheltered route for the numerous steamers running between the west coast of South America and Europe. The work in and about this region is expected to occupy from one to two years. Sir George Nares will then proceed to examine and fix the position of numerous alleged and doubtful dangers in the vicinity of the Society group. Some remarkable changes in the depth of the ocean, caused by volcanic action, in the vicinity of the Friendly Islands will then receive attention, as well as a ridge with less than twenty fathoms lying in an east and west direction north of the Fijis. After this, D'Entrecasteaux reef, northwest of New Caledonia, will be surveyed, and several reported dangers between New Zealand and the Fijis will be investigated. Soundings on the southwestern coast of Australia will complete the work, after which the expedition, which is expected to be absent for three years, will return to England through the Suez Canal.

The Marine Survey of British India has been vigorously pressed during the last year. The published report has an interesting index-map showing the progress already made in surveys of the coasts and harbors. Besides a large number of photo-zincographed charts of anchorages and portions of the coasts, three general charts are in preparation of the whole coast of India and the western side of the Malay Peninsula. A systematic record of tidal observations has been established by the Indian authorities, from which important results are anticipated.

Lieutenant Onasetvich, of the Russian Navy, has recently communicated to the Russian Geographical Society an account of his hydrographic labors on the eastern coast of Siberia in 1876. He executed several surveys in the vicinity of Vladivostock Bay, and connected the longitude of that town with Hakodadi, Hong-Kong, Yedo, and intermediate positions. He also made an excursion to Behring's Strait, determining astronomically the position of Petropaulovsk and other points on the northeast coast of Asia, and surveying various parts of the coasts, including that part of the Arctic Ocean between Behring's Strait and 70° N. lat.

An expedition in which great interest is felt has attempted, under the command of Professor Nordenskjold, to traverse the northeast passage from Europe through the Arctic Sea to Japan and China. Professor Nordenskjold considers that the great volume of comparatively warm water flowing from the Obi and Yenisei rivers, under the influence of the earth's rotation, forms a northeasterly current, which, flowing along the coast of Siberia, tends to create, between the coast-line and the ice, an open channel through which a steamer might find a passage.

With this end in view, the cost of the expedition being defrayed by the King of Sweden, Mr. Oscar Dickson, a merchant of Gottenburg, and a Russian, M. Sibiriakoff, the steamer *Vega* was purchased, provisioned, and fitted for a two years' absence, and provided with officers and crew and a scientific staff. The *Vega* is of about 300 tons, and was built for the whale-fishery among the ice, and has been accompanied by the *Lena*, a smaller steamer, as tender. The *Vega* is commanded by Captain Palander, of the Swedish Navy, and the scientific staff is composed of Messrs. Kjillman, Stuxberg, Almquist, Lieutenant Hovgaard of the Danish Navy, and Lieutenant Bove of the Italian Navy. The expedition sailed on the 15th of July from Gottenburg, and after touching at a Norwegian port to obtain seamen used to Arctic navigation, proceeded on its way on July 25, and arrived at the mouth of the Yenisei August 6. The Kara Sea was nearly free of ice, only a few scattered fragments being met with near White Island. On the 17th of October Mr. Dickson received from Irkutsk a telegram announcing that the explorers had rounded Cape Cheljuskin,

the most northerly point of Asia, and had safely reached the mouth of the Lena, the news having been conveyed by a small steamer up the river Lena to Yakutsk, and thence by Russian post to Irkutsk, a distance of 2400 miles. Letters from the members of the expedition, dated August 27, confirm this information, and state that during the voyage many islands were discovered and located, the coast-line of Siberia examined and the charts corrected, numerous meteorological observations made, and other valuable scientific information collected. It was then hoped by Professor Nordenskjold and his officers that a few weeks would suffice to reach their next point, in Japan; but it appears that the ship has been stopped by the ice and compelled to spend the winter to the westward of Behring's Strait, some of the Tchuktchi Indians having reported a vessel embayed about forty miles from East Cape. If the expedition has really reached as far as reported, there is hardly a doubt that by July, when the ice usually breaks up, the eastern passage will be an achieved fact. As they were well fitted for encountering an Arctic winter, no anxiety need be felt for their safety. The passage of Cape Cheljuskin has been vainly attempted for centuries, but always hitherto by sailing-vessels.

The labors of the Norwegian North Atlantic Expedition in the *Vöringen*, which have continued during the last three years, have been brought to a close. Commencing the work of the summer by sounding, trawling, and dredging in some of the northern fjords of Norway, the first line of deep-sea soundings was made towards Bear Island, returning when necessary to Hammerfest for coal; two more cruises were made during the summer, making numerous soundings, temperature observations, and dredgings in the neighborhood of Spitzbergen and Bear Island. On September 4 the *Vöringen* returned to Bergen, having, during the three summers, made 375 soundings and 113 serial temperature observations.

The officers of the expedition speak highly of a new deep-sea thermometer made by Messrs. Negretti & Zambra. The general results of the current observations for the three years have not yet been published; but Dr. Mohn states that on the 80th parallel of latitude the warm Atlantic current was found still running to the northward, while north and

east of Bear Island the ice-cold Spitzbergen current runs southward over a very shallow bottom. The soundings show a sort of connecting ridge from 1200 to 1300 fathoms deep between Bear Island and Jan Mayen. During this most successful cruise the members of the expedition were the same as last year—Captain Wille, of the Norwegian Navy, being in command of the *Vöringen;* Dr. H. Mohn, meteorologist; Drs. Sars, Danielssen, and Friele, zoologists; Messrs. Tornœe and Schmelck, chemists; and Mr. Schiertz, the landscape-painter, as artist.

A Dutch Arctic expedition has, during the last summer, been engaged in the exploration of the Barentz Sea, lying between Spitzbergen and Novaya Zemlya. The small schooner specially constructed at Amsterdam for the purpose was fitted out and placed under command of Captain de Bruyne, of the Dutch Navy, who has been assisted by a small staff of scientific observers. The expedition, after performing the intended work, has returned in safety; but a detailed account of the results has not yet been received. Valuable experience of the ice-movements in the Barentz Sea was acquired, deep-sea soundings and dredgings were made, and a systematic record was kept of meteorological and magnetic observations.

The preliminary Polar expedition, sent from the United States in the schooner *Florence*, under command of Captain Tyson, has returned, Congress not having seen fit to authorize the necessary expenditure for carrying out the plan proposed by Captain Howgate, U.S.A., of locating one or more colonies within the Arctic regions to make scientific expeditions as opportunity should occur. The *Florence* was frozen in, during the latter part of November, at the head of Cumberland Gulf, a point never before visited by a naturalist. The fauna was found to be nearly identical with that of Baffin's Bay.

In August, 1878, an island, hitherto unknown, was discovered between the northern end of Novaya Zemlya and Cape Cheljuskin by Captain E. Johannesen, commanding a Norwegian whaling-vessel. The island, which its discoverer has named *Lonely Island* (Ensómheden), is about eleven miles long, north and south, and four miles east and west, its centre lying in lat. 77° 36′ N., and long. 86° W. Its height

is about one hundred feet. Only meagre vegetation was found on it, but great quantities of drift-wood lay along the shores. Arctic birds were numerous; and the visitors succeeded in killing three bears and forty walruses. A strong current was found setting the drift-ice to the southward. By the bearing of the sun at noon, the magnetic declination was determined as 30° easterly.

GEOGRAPHY.

By FRANCIS M. GREEN,
LIEUTENANT-COMMANDER, U.S.N.

The marked and rapid increase in the number of geographical societies and in the membership of those already established indicates the general sense entertained among civilized nations of the importance of geographical research in countries still imperfectly known. Many governments have within the last year granted considerable sums in aid of exploration, and private individuals have, in many cases, assisted in the outfit and maintenance of expeditions.

Among the new geographical societies, one of especial interest to this country is the Canadian Geographical Society, which proposes to concern itself especially with matters connected with the geography of British America.

The consolidation of the government surveys of the United States, which is to be carried into effect according to a plan prepared and recommended by the National Academy of Sciences, will be of great service to geographical science by systematizing and arranging the work more efficiently than it could be done in any other way. Until the requisite legislation is effected, it is impossible to state what form the consolidation will take; but it is evident that the anomalies and inconveniences consequent upon several departments of the government being engaged in the same work are no longer to exist.

In the prosecution of the surveys of the territories of the United States, three government expeditions have been in the field during the past year—one under the direction of the War Department, conducted by Lieutenant G. M. Wheeler, of the United States Engineers; and two under the Interior Department, in charge respectively of Dr. F. V. Hayden and Major J. W. Powell. The first of these expeditions, the work of which has been conducted for several years under the title of "United States Geographical Surveys West of

the 100th Meridian," during the last season was composed of nine main parties and three astronomical parties, which operated in the States of California, Colorado, Nevada, Oregon, and Texas, and Arizona, New Mexico, and Washington Territories. Forty-six observers took the field, leaving a small force at the Washington office engaged in the preparation of maps and reports. The astronomical parties in charge of Professor T. H. Safford at the Ogden Observatory, Mr. J. H. Clark in the California section, and Mr. Miles Rock in the Colorado section, made observations at Walla-Walla, Washington Territory; the Dalles, Oregon; Fresno, California; Fort Bliss, Texas; and Fort Bayard, New Mexico, connecting with Ogden as the initial meridian.

In California, topographical parties occupied points in the Cascade Mountains and ranges to the eastward within the great interior basin extending towards the Blue Ridge, reconnoitring a large area. Operations were carried southward from Lake Tahoe along the Sierra Nevada, one party occupying the White Mountain range and connecting with the triangulation which joins the astronomical station at Austin, Nevada. A contour survey of the Washoe mining region was completed, and numerous details gathered relating to the operations of the vertical and meridional sections of the lodes.

Work for completing the topography of the section between the Sierra Nevada and Cascade ranges was also carried on. From the southern end of the Sierra Nevada a party transferred from the Utah section connected with the work of 1875 from Los Angeles east and north, and operated along the coast range to lat. 30° 30′ N.

In Colorado, one party, following the Rio Grande northward, filled in details of new routes of communication and of incomplete meanders, and was further employed upon detailed work. A detachment meandered north and westward from the Rio Grande at Los Lanos, opposite Fort McRae, through the basin of the Little Colorado to Camp Apache, Arizona, and thence eastward again to the Rio Grande, making meanders of considerable precision along three natural routes of communication from the drainage basins of the Gila Salt River and Colorado Chiquito to the Rio Grande.

Another party extended the triangulation southward to

connect with the astronomical station at Fort Bliss, Texas, also connecting with the astronomical monument of the Mexican Boundary Survey at El Paso, Texas, and the monument on that part of the boundary-line on the western bank of the Rio Grande.

The following list shows the number of the principal observations made:

Sextant latitude stations	90
Bases measured	5
Triangles about bases measured	64
Main triangulation stations occupied	62
Secondary " " "	21
Miles measured on meanders	10,298
Cistern barometer stations occupied	1,141
Aneroid " " "	7,057
Magnetic variations observed	165
Mining camps visited	12
Mineral and thermal springs noted	20

The estimated area occupied by the survey during the season, including main triangulation and preliminary reconnoissance work, was 35,000 square miles. The area from which detailed topographical data were gathered sufficient for a map on a scale of one inch to four miles was approximately 27,500 miles.

Besides the topographical work, one party in the Colorado section was devoted entirely to geological examination, under the charge of Professor J. J. Stevenson, assisted by Mr. J. C. Russell. Its area of operations was along the Spanish ranges between the Rio Grande and Canadian rivers, in the northern part of New Mexico, where its labors were greatly facilitated by the use of the completed topographical maps. The section of the lignitic group was worked out, and twenty-six beds of lignitic coal were recognized as present at most localities within the area where their horizon was reached. Much labor was bestowed upon a study of the mountain axes, the structure of which was found to be exceedingly complicated, requiring further detailed examination. Quite large collections were made of igneous rocks and fossils, about three hundred specimens of the former being obtained from seventy localities, forming a complete series illustrating the lithology of the injected dikes, volcanic overflows, and extinct craters of the region. The fossils, numbering over thir-

teen hundred specimens, are from rocks of the carboniferous age, from cretaceous strata Nos. 2, 3, and 4, and from overlying beds of the lignitic group.

From the carboniferous formation about seven hundred specimens were obtained; from the cretaceous, five hundred, illustrating its invertebrate fauna; and from the coal-bearing lignitic group resting on the black shales of cretaceous stratum No. 4, about two hundred specimens of fossil leaves.

Zoological collections were mainly made by the party operating from Northern California northward, and illustrate the zoology of the area extending from Camp Bidwell, California, to the Columbia River, Oregon. To this party Mr. H. W. Henshaw was attached as naturalist. The collection made comprises upwards of three hundred specimens of birds, specimens of fishes from most of the lakes and streams encountered with *Lepidoptera*, *Orthoptera*, and numerous reptiles and Batrachians.

The field season ended early in December. The work of this survey has now covered, since its commencement in 1869, connected areas reaching from the Columbia River on the north to the Mexican border, and from the 100th meridian, near Fort Dodge, to the Pacific coast, near Los Angeles, an area now exceeding 350,000 square miles.

The publications during the year are as follows: Vol. II., quarto series, Astronomy and Barometric Hypsometry: "A Catalogue of 2018 Stars, for Latitude Work West of the Mississippi," and ten of the regular atlas-sheets. Vol. VI., quarto series, was in stereotype at the close of 1878; a "List of Distances, Positions, Altitudes," etc., was well advanced in printing; and Vols. I. and VII., of the quarto series, awaited the appearance of Vol. VI. Seventeen atlas-sheets, also from work prior to 1878, are in various stages of progress.

During the past season the work of the United States Geological and Geographical Survey, under the direction of Professor F. V. Hayden, was continued northward into portions of Wyoming and Montana territories.

The season for field work was very short, in consequence of the appropriation of money not being made by Congress till July; yet the results were of considerable magnitude and importance. The expedition was divided into four surveying parties, one of which extended the primary triangulation to

the northward; two were engaged in topographic and geologic work; and the fourth performed special geologic and photographic duty. All the parties left the Union Pacific Railway, from Point of Rocks and Green River stations, about July 25, and proceeded northward towards the Yellowstone National Park.

The primary triangulation party, under charge of Mr. A. D. Wilson, occupied eight of the most important peaks as stations, besides some minor ones. Among the stations were Wind River, Fremont, Grand Teton, and Sawtelle's peaks, near Henry Lake, and several of the more conspicuous points in the Yellowstone Park.

This is now the most extensive unoccupied area in the West, and, surrounded by great chains of mountains, it has become a resort for hostile bands of Indians, some of whom robbed Mr. Wilson's party of all their animals and a large portion of their outfit, thereby decreasing very materially the work of the season.

Under the charge of Mr. Henry Gannett, the second division secured material for a detailed map of the park. This division was divided into two parties, one, with Mr. Gannett as topographer, and Mr. W. H. Holmes as geologist, made the general survey of the park; while the other, consisting of Dr. A. C. Peale and Mr. J. E. Mushbach, made detailed studies and plans of the geyser and hot-spring localities, with especial reference to the production of an exact model in plaster of the whole group. In the survey of the park, forty-seven stations were occupied for secondary triangulation and topography, besides a large number of less importance, stone monuments for future reference being erected on the principal stations. Several groups of hitherto unknown geysers and hot springs were discovered.

The area of the Yellowstone Park is, in round numbers, 3500 square miles. Its surface is in large part level or rolling, with several groups and short ranges of mountains diversifying it. In the eastern part, extending its whole length and forming the water-shed between the Yellowstone and the Bighorn, stand the rugged volcanic peaks of the Yellowstone range. Nearly all of the park is covered with a dense growth of magnificent pine timber; indeed, west of the 100th meridian there is no area so densely timbered with the ex-

ception of Washington Territory. The mean elevation of the park above sea-level is between 7000 and 8000 feet, which implies too cold a climate to admit of agriculture, except in certain very limited localities. It is safe to say that not more than one per cent. of this area can, by any possibility, be used for agricultural purposes. Except along the northern border, grazing-land exists only in small patches of a few acres each. There are not, so far as is known, any mines or mineral deposits within the park.

The only occupied buildings within the park are at the White Mountain Hot Springs. A good wagon-road extends from Bozeman, Montana, to this point. From these springs, which form the usual point of departure for excursionists, there are excellent trails to all points of interest within this region—to Amethyst Mountain, Yellowstone Falls and Lake, the Mud Geysers, and other objects of interest on the Yellowstone River and the Geyser basins. It is unnecessary to specify these trails, as they traverse the country in all directions. In his campaign against the Nez Percés, in 1877, General Howard constructed an excellent wagon-road up the Madison to the Lower Geyser Basin, and thence across to the Yellowstone. His road up the Yellowstone is impassable at present for wagons.

The third division, under Mr. F. A. Clark, surveyed the Wind River Mountains, a portion of the Wyoming range, and the Gros Ventres range, with a large tract in the Snake River valley. The area lies between lat. 43° and 44° and long. 109° 15′ and 111°, including the upper portion of the Wind River Mountains, with portions of the Wyoming range, the Gros Ventres range, and portions of the Shoshone Mountains and the Owl Creek range; also the sources of Green River, Hoback Basin, and the upper waters of Wind River. Mr. St. John acted as geologist, and Mr. N. W. Perry as mineralogist to this party. Their reports will prove of general interest. Mines of gold, silver, iron, and vast beds of gypsum, as well as many other minerals, were found.

The peak named by the survey Fremont's Peak was found to be over 14,000 feet above the sea, with no trace that any human being had ever previously reached its summit. Three complete glaciers were discovered on the east side of the Wind River Mountains, the first ever known to exist east of

the Pacific coast. The old glaciated rocks and morainal deposits were found on a remarkably grand scale in both the Wind River and Teton ranges.

The numerous lakes have been the beds of glaciers, and their shores are walled with morainal ridges.

All of these interesting features were carefully studied, and the results will be elaborated for the twelfth annual report of the Survey.

The atlas of Colorado, in twenty sheets, has been recently published from the labors of this survey. This atlas consists of two series of maps, the one of a general, the other of a detailed kind. The first series, on the scale of twelve miles to one inch, comprises four sheets, each embracing the whole State of Colorado and part of the neighboring territory. The first of these illustrates the system of triangulation adopted in the survey; the second shows the drainage-system of the area; the third, by a simple and clear arrangement of colors, exhibits at a glance the economic features of the whole region—the agricultural land, pasturage, forests and woodlands, sage and bad lands, mineral tracts, and the portions rising above the limit of timber-growth; and the fourth contains a condensed and generalized geological map of the same territory. The second series consists of six topographical and six geological maps. In the topographical maps the configuration of the surface is plainly shown by means of contour-lines of 200 feet of vertical distance. The geological maps are identical sheets with the topographical maps, the geological features being represented in colors—glacier moraines, lake-deposits, drifts, sand-dunes, and recent alluvia all finding adequate expression. Two sheets of geological sections, and two large sheets of sketches complete the atlas.

Under the direction of Major J. W. Powell, the labors of the United States Geographical and Geological Survey of the Rocky Mountain Region have been continued during the past year. From the return of the field-parties in the autumn of 1877, till July, 1878, the entire corps remained in Washington preparing the results of the field-work for publication. In July, 1878, a division was sent to the field, but a force was also retained at Washington to continue the ethnographic work, and to complete and edit certain unfinished reports.

The office-work thus acquired an exceptional importance as compared with the field-work, which, for the season of 1878, was placed in charge of Mr. C. K. Gilbert, his principal assistants being Messrs. J. H. Renshaw, O. D. Wheeler, and S. H. Bodfish.

Taking the field at Gunnison, Utah, in the early part of August, the work was carried on by four independent parties till the middle of December, when the advance of winter made it necessary to disband them.

The Kanab base-line, four and one-third miles long, has been carefully remeasured, with a probable error of 1.5 inches, as well as the southern portion of the chain of triangles connecting it with the Gunnison base-line. The main chain of triangulation, consisting of eight quadrilaterals, one triangle, and one pentagon, is now ready for discussion. At each end of the chain a base-line has been measured, and an astronomical determination has been made of latitude, longitude, and azimuth. The most southerly points visited were Mount San Francisco and Mount Floyd, volcanic peaks on the Colorado plateau south of the Grand Cañon. Southern Utah is not well adapted for triangulation. Its principal eminences are table-lands or plateaus covered with timber, there being very few sharp peaks readily distinguishable from all directions.

The work of Mr. Renshaw's party with plane-table and orograph embraces all of the region lying south of the Grand Cañon in Sections 105 and 106, covering about 7500 square miles. This field comprised a portion of what is known as the Colorado Plateau, a high table-land lying immediately south of the Colorado River, which there runs westwardly at the bottom of a deep chasm. On the southern edge of the plateau there are innumerable extinct volcanoes, the ground being covered by a forest of pine, the most valuable tract of timber in Arizona. The northern edge is lower, and is bare of timber. Near the Colorado Cañon it is broken by gorges, and is difficult of access, but in other directions there is little impediment to travel. Water is scarce, and is found only in pockets and small springs, there being none available for irrigation. The only wealth of the country lies in timber and grass. West of the plateau, Mr. Renshaw's map includes a portion of Hualapai valley and the adjacent mountains. This region is almost an absolute desert, water being so

scarce that in some places it is sold by the gallon. Agriculture is out of the question, and there is no timber. Grazing is practicable to a limited extent. The only important industry, present or prospective, is mining, and only the richest of the numerous gold and silver deposits can now be worked with profit, owing to the remoteness of all sources of supplies.

Mr. Wheeler worked with plane-table and orograph in the western half of the region comprised by atlas-sheet No. 106, and estimates his total area at 5000 square miles. Through the centre of his district there runs, from north to south, a natural barrier called the Echo Cliff. The escarpment faces westward, and the plateau at the west of it is 1000 feet lower than that to the eastward. The eastern plateau is a broad desert of sand, scantily watered, and useful only for grazing purposes. The western plateau is equally barren and worthless, but presents more variety of surface. A portion consists of naked "bad lands," soft strata carved by the elements into hills of picturesque beauty, and tinted with a variety of brilliant colors, which warrant the title of Painted Desert bestowed by Lieutenant Ives. Another portion is extremely rocky, and divided by a net-work of impassable cañons. Through this region runs the Little Colorado River, a stream of considerable magnitude, but, on account of the character of its banks, of no service to agriculture. Echo Cliff is interrupted at one point by a cross-line of drainage, and there are a few springs available for farming. No other spot invites settlement. Maps, on a scale of four miles to one inch, showing the geography of the entire region embraced in the survey, are being constructed; and, under the direction of Major Powell, a map is also under construction intended to represent the distribution of the various tribes of Indians when first discovered by Europeans.

GREENLAND.

It has been supposed that an extent of country existed in the interior of Greenland comparatively free from the perpetual ice and snow which covers the coast, and many attempts have been made to explore the interior; but until last summer all such attempts have been in vain. Lieutenant Jensen of the Royal Danish Navy, with two companions,

while engaged in a survey of the coast between Godthaab and Frederikshaab, undertook a journey into the interior, commencing the arduous task on July 14, and having for their objective point some mountain-peaks about forty-five miles inland. Their baggage and instruments were transported on three small sledges with great difficulty. After two days' journey their progress was much retarded by the loose snow covering the surface of the ice, which was so full of holes and crevasses that for safety the travellers were obliged to attach themselves to each other by a rope, as in Alpine climbing. Several rapid streams, abounding in fish, were met in the valleys, and were crossed with difficulty. Foggy weather and snow-storms hindered their advance, but on the 24th the foot of the mountains was reached, the ascent being delayed by stormy weather till the 31st, when, just as the party was about returning, the weather cleared off, and they succeeded in attaining the summit of the peak at a height of 5000 feet above the sea-level. No signs of bare ground were visible, but as far as the eye could reach ice-sheets and glaciers covered the country. On the 5th of August the explorers regained the coast after an absence of twenty-three days.

CENTRAL AMERICA.

Lieutenant L. N. B. Wyse, of the French Navy, has made a report to the Société Internationale du Canal Interocéanique of the results of the explorations made by himself and his associates. Putting aside routes which he considers impracticable, Lieutenant Wyse urges that a choice must finally be made between the following projects:

1. A canal, with locks and a tunnel, by way of the Atrato and Napipi rivers, from the Gulf of Uraba to the Bay of Chiri-Chiri.

2. A canal, with locks and a tunnel, from the Gulf of Uraba to the Gulf of San Miguel, by way of the Atrato, Coquirri, and Tuyra rivers.

3. A canal, without locks, but with a tunnel, from the Bay of San Blas to the mouth of the Bayano River, by way of Nercalegua and Mamoni.

4. From Acanti to the Gulf of San Miguel, by way of Tiati, Tupisa, and Chucunaque, with a tunnel, but without locks.

5. From Colon or Aspinwall to the Bay of Panama, by way of the Chagres River.

6. From San Juan de Nicaragua (Greytown) by way of Lake Nicaragua to Brito on the Pacific.

Of all these routes Lieutenant Wyse prefers the third; but in an address read before the American Geographical Society on November 12, 1878, Rear-Admiral Ammen, U.S.N., seriously called in question Lieutenant Wyse's conclusions, and demonstrated the superior advantages of the Nicaragua route, both as regards engineering facilities and cost.

SOUTH AMERICA.

In a paper read before the Royal Geographical Society, Mr. Clements R. Markham calls attention to the large extent of unexplored territory in South America, especially the region of the Andes and their eastern slope. In Bolivia, Peru, and Brazil, there are extensive territories where little or nothing is known of the rivers and mountains. The journeys of botanists and naturalists are constantly adding to our knowledge, but there is evidently valuable work for explorers and discoverers to perform for at least the next generation. The Amazon, draining millions of acres of fertile territory, is today almost as much of a mystery as it was 300 years ago; but there is every reason to hope that here, as elsewhere, increased facilities of transportation will soon enable surveyors to make accurate maps of this valuable region.

At a meeting of the Berlin Geographical Society, Dr. Sachs gave a description of his recent journey to Venezuela, and corrected, in some points, Humboldt's statements regarding the Llanos. This great plain, formerly an inland sea, is 600 feet above the sea-level in the upper part, but only 200 in the lower part, this difference accounting for the much more luxuriant growth of the grass in the lower region. The decrease in the number of cattle during the last few years has led to a largely increased growth of trees.

Herr Werthemann's explorations of the Peruvian rivers Perené and Tambo in 1876 are described by Mr. W. Reiss in the *Verhandlungen der Gesellschaft für Erdkunde zu Berlin.*

The beautiful topographical chart of Paraguay, by Fr. Wiesner von Morgenstern, which received a premium at the

Vienna Exposition, has now been lithographed, and is for sale. It is on a scale of 1:355,000.

Dr. Crevaux, in 1877, made a most arduous and interesting exploration of the interior of French Guiana. Accompanied at first by two missionaries, the obstacles to travel soon caused his companions to return, and Dr. Crevaux, with one negro, traversed about 1500 miles of territory, 675 miles of which was new ground. After ascending the river Maroni, he crossed the northern slope of the Tumac Humac chain of mountains, returning by the southern slope, and, descending the river Yary, reached the Amazon after a march of 142 days. Numerous explorers have in vain tried, during the last three centuries, to cross the Tumac Humac range of mountains; and, in addition to his success here, Dr. Crevaux has delineated correctly, for the first time, the course of the river Yary. He has been, during the past year, and is now, engaged in fresh explorations under the direction of the French authorities. Leaving Paramaribo on August 8, he ascended the Oyapock River to its source, intending to cross the mountains again and to attempt to reach the head-waters of the Surinam River. A recent letter from him, however, indicates that he may return by way of the Purus and Amazon rivers.

Two attempts have been made during the last year to explore the Roraima range of mountains lying between Guiana and New Granada. The first attempt was made by Messrs. Eddington and Flint, who, after an arduous journey, reached the base of the overhanging cliffs, 7000 feet above the sea, and found further progress impossible. A second attempt was made by Mr. Boddam-Whetham, who, with a small party, ascended the Essequibo, Mazaruni, and Carubung rivers to the Macrebah Falls. Thence by a toilsome march they approached the mountains, making the best of their way towards Mount Roraima. This huge pile is described as a parallelogram, eight miles by six, rising in a precipitous wall nearly 2000 feet above its lower portion. Eight days were spent in vainly trying to climb it. There is some reason to believe that a lake exists on the top of the plateau, which is well wooded, but the question of its existence has yet to be decided.

In Brazil the explorers connected with the Madeira-Mamoré Railway are busily engaged in examining the surrounding

region; and Dr. Edwin R. Heath, of Wisconsin, has undertaken the exploration of the Beni and Madre de Dios rivers in continuation of the work which the untimely death of Professor James Orton left uncompleted.

Before the French Geographical Society, Professor C. Wiener has given an account of his explorations in Peru and Bolivia, undertaken at the cost of the French government. He journeyed about 9000 miles, crossing the western chain of the Cordilleras five times at considerable heights, and ascended to the summit of Illimani, a height of 20,118 feet above sea-level. M. Wiener's collections were mostly archæological, and were of great interest. They will be placed in the Palais d'Industrie at Paris.

Original maps of a part of Bolivia, in seven sheets, on a scale of fifteen inches to a degree, have been made by Mr. J. B. Minchin, C.E., and the late Commander Musters, R.N., the latter of whom communicated to the Royal Geographical Society, shortly before his death, the results of observations made during three years' residence and journeying, mostly confined to the Altaplanicie, or great table-land of the Andes, and the spurs and valleys of the Eastern Cordillera.

An abstract of late Chilian surveys in the Chonos Archipelago, by Dr. Martin, is given in Petermann's *Mittheilungen*, No. 12. The islands are described as over 1000 in number, and as very mountainous and separated by channels more than 100 fathoms deep.

For several months past Mr. F. A. A. Simons has been exploring the cluster of mountains known as the Sierra Nevada de Santa Marta, near the coast of New Granada, a little to the eastward of the mouth of the Magdalena River. Although his special object is the study of natural history, he has done, and is still doing, valuable work in determining heights of various mountain-peaks, with hypsometrical instruments furnished by the Royal Geographical Society.

AFRICA.

One of the most striking features in connection with African geography during the past year is the discovery of an old globe at Lyons, showing the course of the Congo and Nile rivers very much as they are laid down now on modern maps from the labors of recent explorers. Besides this, a

Spanish globe of copper, probably made about 1530, has been found in the National Library at Paris, which shows with wonderful closeness the course of the Congo as discovered by Stanley. In *Nature* for June 6, 1878, are given sketches from these old globes, and an interesting account of this discovery, which, however, does not in the slightest degree detract from the credit due to Speke, Baker, Burton, Livingstone, and Stanley, of being the discoverers of the great African lakes, and of the course of the Nile and the Congo.

Mr. H. M. Stanley has published an account of his journey across Africa, entitled "Through the Dark Continent," in two volumes, but the geographical results are to be contained in a third volume not yet published.

At a meeting in May, 1878, of the subscribers to the African Exploration Fund, an interesting report of the committee was read, giving a history of exploration in Central Africa, and discussing various proposed routes for further exploration.

It has been decided to commence the exploration of the country between the caravan-road now building from the seaport of Dar-es-Salaam, a few miles south of Zanzibar, and the northern end of Lake Nyassa. This region offers great attraction in the grandeur of its physical features, and is likely to yield discoveries of great geographical interest independently of its practical importance in connection with the question of the best trade-route to the lakes. Should the expedition reach Lake Nyassa, a distance of 350 miles from Dar-es-Salaam, without much difficulty, the position thus gained would serve as a starting-point for a more important exploration to the southern end of Lake Tanganyika, a farther distance of 190 miles. The indication of a line of communication from north to south through the great chain of lakes, by supplying the missing links in geographical knowledge, as well as pointing out the best line of travel between the lakes and the coast, is of very great importance, and both these results are to be expected from the proposed expedition.

Mr. Keith Johnston has been selected to command it, and, with his assistant, Mr. Joseph Thomson, left England for Zanzibar on the 14th of November. Mr. Thomson will pay spe-

cial attention to the geology and natural history of the country traversed.

Mr. Johnston has been instructed, in addition to gathering data for the construction of a correct map of his route, to make all practicable observations in meteorology, geology, natural history, and ethnology. He is to observe and note the routes best adapted for more extended communication in the future, and to use every exertion to examine the range of mountains at the northeastern end of Lake Nyassa, ascertaining their extent and elevation and the condition of their passes. He is also to inquire into the practicability of a telegraph line from north to south. The remarkable rise of Lake Tanganyika, as reported by Mr. Stanley, is also to be a subject of inquiry.

The German government has appropriated $125,000 to enable the German Society to continue their African explorations. Portugal has made a grant of £20,000 for the exploration of Western Africa beyond the Portuguese possessions; and France has voted a credit of 100,000 francs for a Central African expedition. In Belgium a nearly equal amount has been contributed by subscribers to the international scheme for the exploration of Africa.

Only a very general account of the progress of these expeditions can be given. The death of two of the principal officers of the Belgian expedition shortly after their arrival at Zanzibar seriously hindered the prosecution of the work; but two other officers, MM. Wautier and Dutrieux, proceeded to take their places. The expedition, under command of M. Cambier, its chief, left Zanzibar for Lake Tanganyika about the end of May, but was seriously detained by mutiny among the porters. Advices from the expedition dated in October indicate that more satisfactory progress has been made, Urambo, the capital of King Mirambo of Unyamwesi, having been reached.

The Portuguese expedition started from Benguela, under charge of Senhor Serpa Pinto, on the 12th of November, 1877, and was at Bihé on May 18. Here the members of the expedition separated, Senhores Capello and Ivens going northward, and Senhor Serpa Pinto towards Zumbo on the Zambesi and the east coast. The area of country chosen for the operations of this expedition includes the head-waters of three

important rivers—the Zambesi, the Kassai, and the Cuñene. It is considered that the journey between Bihé and Zumbo will be very hazardous, the fierce tribes of Chuculumbé, who occupy the left bank of the Zambesi in lat. 15° S., objecting to strangers entering their territories.

Senhor Serpa Pinto reports that as far as Quillengues, lat. 14° 3′, long. 14° 5′, the rivers flow to the west, but only contain water in the winter, the first permanent water met with occurring after the first affluent of the Cuñene. The monotony of the plateau is only broken in Huambo by a mountain range trending to the northeast, and at the southwest of which flows the river Calaé. The Cubango has its source at a great distance west of Bihé, near the source of the Cuñene at Bailundo. All these rivers rise in the vast marshy depression of country between lat. 12° 30′ and 13° S.

The Catumbella flows westward to the sea, and the Cutato runs into the Tuanga, having its source within the angle formed by the Cubango and its eastern affluents.

M. Bragga and Dr. Ballay, members of the French expedition for exploring the Ogowé, have returned to France, and a map showing their discoveries is now being constructed. It will show that the Ogowé has its source in a large chain of mountains, and is formed by a number of rivulets. MM. Bragga and Ballay suppose that the Congo River is to be found on the other side of this range of mountains, and that a large portion of the water in the bed of the Ogowé proceeds by subterranean infiltration from the Congo. These assumptions, however, they could not verify on account of the ferocity and hostility of the native tribes, from whose hands the explorers escaped with difficulty.

M. Bragga and Dr. Ballay have been awarded the great gold medal of the Paris Geographical Society for their labors.

Under the auspices of the French government, an important expedition has been organized under the direction of a French priest, M. l'Abbé Debaize, who is spoken of as eminently qualified for the undertaking, which is to be purely scientific in its aims. He sailed for Zanzibar on the 21st of April, intending to cross the continent from the coast near Zanzibar to the mouth of the Congo. Arriving safely on the coast, he left Bagamoyo for the interior on the 6th of

August, and later letters from him state that although he is the only white man of his party, which numbers over 400 members, he has every reason to expect success in his undertaking.

Lieutenant De Semellé, a French officer, has undertaken the exploration of the great blank in Central Africa between the Congo, the Albert Nyanza, and the southern tributaries of the Niger, by ascending the latter river, proceeding by land along the south bank of the Binué, and thence striking across the unknown regions towards the equatorial lakes. He sailed from Bordeaux on April 5.

In the *Proceedings* of the Royal Geographical Society for July 6 is a valuable account, by Mr. H. B. Cotterill, of the hitherto unknown lands between Lake Nyassa and Ugogo, accompanied by a map showing the route traversed by the late Captain Elton and Mr. Cotterill. Captain Elton, an officer of great worth and promise, fell a victim to exposure, dying from sunstroke at Usekhe after a long and toilsome march.

Two Italian expeditions are engaged in explorations in Eastern Africa. One of them, under the command of the Marquis Antinori, has been assisted by government funds, and has for its object the examination of the wide tract of unknown country lying between Shoa and Victoria Nyanza. The other expedition, under the leadership of MM. Gessi and Matteucci, is proceeding, by way of the Nile and Kaffa, to Lower Abyssinia.

Dr. G. Schweinfurth has published in the October number of the *Esploratore* an account, in a condensed form, of his three journeys through the desert, with an excellent map on a scale of 1 : 1,500,000.

During the past year an account has been published in Petermann's *Mittheilungen* of the travels through Equatorial Africa of Dr. Emin Effendi, who, leaving Lado, ascended the Nile to Duffli and Magunga on the Albert Nyanza, thence to Mruli and Rubahga on the Victoria Nyanza. The narrative is accompanied by a fine map on a scale of 1 : 1,400,000, by Petermann, giving the routes of eight different explorers of this part of Africa between 1862 and 1877.

Colonel A. M. Mason, of the Staff-Corps of the Egyptian Army, has made a careful reconnoissance of the shores of the

Albert Nyanza, and his report is published in the *Proceedings* of the Royal Geographical Society for May 9, 1878.

Colonel Mason, whose observations seem to have been carefully and accurately made, agrees with M. Gessi in placing the southern end of the lake in lat. 1° 11′ N.; but Sir Samuel Baker, in a letter to the President of the Geographical Society, calls in question the accuracy of this determination, insisting that the southern end of the lake lies much farther south. Dr. Behm, in the *Mittheilungen*, concludes that, judging from the accordance of Mason's and Gessi's observations, Stanley, who reported the same place as being in lat. 0° 11′ N., could not have been at the Albert Nyanza, but at some more southern lake.

Dr. G. Nachtigall publishes, in the *Mittheilungen*, a short description of the route between Tripoli and Fezzan, accompanied by a track-chart. He speaks of the desert of Sahara as lying generally at a considerable elevation above the sea-level, forming a plateau, with the coastwise mountains as its limiting terraces.

Under the auspices of the German Geographical Society, the well-known explorer Herr Gerhard Rolf has undertaken a journey across Africa, from north to south. Starting from Tripoli, Herr Rolf intends to proceed first to the neighborhood of Lake Chad, and thence to traverse the great unknown country between Lake Chad and the middle course of the Congo.

Under the auspices of the French government, Captain Roudaire, of the French Army, is engaged in an examination of the Algerian and Tunisian *chotts*, or depressions, in the Sahara Desert, with a view to ascertain the practicability of forming an inland sea by admitting the waters of the Mediterranean through an inlet to be cut through the Isthmus of Gabes. In recent communications to the *Académie des Sciences*, through M. Ferdinand de Lesseps, Captain Roudaire states that careful levellings and numerous borings made by him indicate the feasibility of the scheme, which has the support of the Bey of Tunis.

ASIA.

A new map of Russian Turkistan and adjacent countries, in twelve sheets, prepared at the Russian Topographical De-

partment in St. Petersburg, is interesting as embodying the results of the recent Russian surveys on the Alai plateau. Colonel Przewalsky's explorations are not shown on this map; and it may be here remarked that it is now seriously doubted whether this officer has ever succeeded in reaching Lob Nor, as has been affirmed, the discrepancies between his descriptions and information obtained from Chinese sources seeming irreconcilable. In the *Verhandlungen der Gesellschaft für Erdkunde zu Berlin*, Professor von Richthofen discusses this question, and arrives at the conclusion that Colonel Przewalsky mistook some other lake for Lob Nor. In addition to the wild camels found by Przewalsky on the plains in the southern part of the desert of Gobi, large herds of these animals, numbering from ten to sixty, have been seen by a Russian official travelling from the military post at Zaissan to Gutschen. The camels have a double hump, and differ but little from the tame ones. The meat is said to be of agreeable flavor (*Journal de St.-Pétersbourg*, September 25 and October 7, 1878).

M. Severtsoff, the geologist who explored the Tian Shan Mountains in 1864 and 1865, has been engaged in an examination of the Alai and Trans-Alai range, the results of which are now being prepared by him for publication. For the first time, magnetic observations were made on the Pamir plateau, heights were carefully measured, and positions astronomically determined, so that very valuable geographical results may be expected from the labors of the expedition.

In Röttger's *Russische Revue* (1878, No. 8) are some notices of the travels last year of the geologist Herr J. W. Muschetow. He approached the region of the Kara-Kul from the northward, and describes the formation of the Pamir and Alai. No meridional elevation whatever could be detected along the whole route which could confirm the existence of a mountain-chain ranging north and south like the Bolor, as reported by Humboldt and others.

Russian officers are engaged in various directions in surveying and exploring Central Asia, and the results of their labors are being constantly received and published by the Russian Geographical Society. In this way the maps each year approach more nearly to correctness, but no accurate account of each expedition can be given.

At the May meeting (1878) of the Russian Geographical Society, M. Potanin gave an account of his recent travels in Mongolia. He states that the Mongolian or Altai range of mountains is separated from the Tian Shan range by the Gobi depression; and that the main body of the mountains has the character of a continuous plateau without culminating summits; and that its passes, the lowest of which is 8000 feet above the sea-level, are separated from each other by deep ravines.

Detailed topographical information was given by M. Potanin regarding a portion of the Altai Mountains, and interesting particulars regarding the population.

Colonel Przewalsky is preparing for a second journey to Lob Nor, and intends to reach Lhassa by the Hami and Shachan road, a most arduous undertaking. Colonel Przewalsky will be accompanied, as before, by Lieutenant Eklon, and by an artist.

The reports of the Great Trigonometrical Survey of India are always interesting, and the volume recently issued (1876–77) is more so than usual, as containing an account of the consolidation of the three hitherto independent surveys — the Great Trigonometrical, the Revenue, and the Topographical. The amalgamation now being carried out under the direction of Colonel J. T. Walker, R.E., Surveyor-General of India, will enable any officer to be transferred from one post or survey-party to any other, and will doubtless conduce to greater efficiency.

Since 1845 more than 800,000 square miles, comprising more than one half of British India, have been surveyed and mapped. As in the case of our own Coast Survey, it has been found that the latitudes and longitudes determined astronomically differ sensibly from the geodetic determinations.

The remeasurement of the southern portion of the great Indian arc and its extension to a length of 24° have furnished Colonel Clarke, R.E., with data for a fresh determination of the figure of the earth. As the data are added to, Colonel Clarke finds that the fraction expressing the earth's ellipticity becomes larger, the value obtained by Airy and Bessel, forty years ago, being $\frac{1}{299}$, which was replaced by $\frac{1}{294}$ on the completion of the English and Russian arcs in 1858; and the re-

cent work in India gives a still larger fraction, assimilating to the value heretofore obtained from pendulum observations.

The data on which the recent investigation is founded are: (1) the latitudes of 13 stations in the Russian arc of 25°; (2) latitudes of 15 stations in the Anglo-French arc of 22°; (3) latitudes of 14 stations in the Indian arc of 24°; (4) the longitudes of 7 stations in India; and (5) the Cape of Good Hope and Peruvian arcs. From these data equations of condition are derived, which by the method of least squares give

$$a=20926202,$$
$$c=20854895,$$

a and c being the equatorial and polar semi-axes in feet of the spheroid most nearly representing the figure of the earth. If, however, the more probable hypothesis of an ellipsoid instead of a spheroid be assumed, the following are the values of the semi-axes in feet:

$$a=20926629,$$
$$b=20925105,$$
$$c=20854477;$$

and taking the ellipticity as the ratio of the difference of the semi-axes to half their sum, the ellipticities of the two principal meridians are $\frac{1}{289.54}$ and $\frac{1}{295.77}$.

Three well-determined secondary meridians—Aden, Bombay, Madras—have been established by the Indian Survey through the submarine telegraph cables; telegraphic time-signals having been exchanged by Major Campbell and Captain Heaviside between Bombay, Aden, and Suez, the longitude of the latter station having been determined telegraphically under direction of the Astronomer Royal on the occasion of the transit of Venus in 1874.

The whole work of the Indian Survey is carried on with energy. Besides the geodetic work, a report is made of explorations by the native officials. During 1876 one of the survey explorers, known as the Mullah, made an examination of the only part of the course of the Indus which remained unexplored, from the point where it enters the plains of Attok to where it is joined by the river Gilghit. Here the river traverses a distance of about 220 miles, descending

from a height of about 5000 feet to about 1200 feet above the sea-level. The peaks of the great mountain-ranges through which the river runs are rarely less than 15,000 feet in height, and culminate in Mount Nanga Parbat, whose height, 26,620 feet, is hardly excelled among all the peaks of the Himalayas. The crooked channel of the river is hemmed in so closely by these great ranges that its valley is but a deeply cut, narrow gorge. No European has ever penetrated this region, and the Mullah only succeeded in doing so by travelling as a privileged trader. Very difficult of access from all quarters, it is inhabited by a number of hill-tribes independent and suspicious of each other, and protected from each other by natural barriers and fastnesses. Each community elects its own rulers, and has little intercourse with its neighbors, and with the outer world only by means of privileged traders.

Captain Cameron, R.N., the celebrated African traveller, has undertaken the exploration and survey of the Euphrates valley, to determine the best practicable route for a railway from the Mediterranean to the northwest provinces of India.

Captain Cameron sailed from Portsmouth for Cyprus on the 18th of August, and will proceed by way of Latakieh, Aleppo, Urfa, Mardin, Mosul, Bagdad, and Bassorah, through South Persia and Baluchistan to Karachi, on the Arabian Sea.

An extensive journey by Captain Gill, R.E., has furnished for the first time a knowledge of the vertical configuration of parts of Western China and Thibet. Starting from Shanghai in January, 1877, he ascended the Yang-tse River to the province of Se-chuen, and struck across northwardly to the Thibetan frontier. Thence, after traversing the province in various directions, he crossed into Thibet, continuing southward to Tali-fu in Yunnan, travelling from there in the footsteps of the expedition sent to inquire into the murder of Consul Margary, over the long and rugged mountain-paths to Bhamo, on the Irrawaddy River, and ending his long and toilsome journey by descending the river by steamer to Rangoon. Throughout his journey careful observations were made for latitude, longitude, and elevation, the traveller having the unusual good fortune to bring his instruments home without injury, to be tested. The very interesting account

of this journey, with a description of the people and country visited, will be published in the *Journal* of the Geographical Society for 1878.

A valuable contribution to Chinese geography is also made by the report of Mr. Baber "On the Route followed by Mr. Grosvenor's Mission between Tali-fu and Momein." The journey was made in 1876, but the report, with the accompanying maps, has just been published.

Throughout the section from Yunnan-fu to Momein, very numerous astronomical and hypsometrical measurements have enabled Mr. Baber to construct a most valuable map. For a distance of nearly 400 miles the road followed was rarely less than 5000 feet above the level of the sea, and sometimes nearly 9000. The text of the report is most interesting, giving very graphic descriptions of both scenery and people.

The labors of the Dutch expedition for the exploration of Sumatra have been continued, notwithstanding the death of M. Santvoort, the leader, who was succeeded by Lieutenant Cornelissen of the Dutch Navy.

Several reports and maps have been received and published; and surveys have been made for a railway to connect the coal-fields of the Ombili River with the coast. Some members of the expedition ascended the Indrapoor, or volcanic peak of Korintje, the highest mountain in Sumatra, a feat never before performed. The edge of the crater was found by barometric measurement to be 12,000 feet above the sea. Traces of elephants are said to have been found at a height of 5000 feet, and of the rhinoceros at nearly 8500 feet above the sea. Recent advices indicate that, owing to the opposition of some of the native chiefs, further exploration will be for the present abandoned.

Very interesting information about Sumatra is to be found in a work by Mr. C. B. H. von Rosenberg, entitled "The Malay Archipelago," published in Leipsic during the last year, the data for which were collected by the author during thirty years' residence in the Dutch colonies.

In Petermann's *Mittheilungen* (1878, No. 2) is given an excellent map of the island of Nias, lying off the west coast of Sumatra, with a description by Dr. A. Schreiber. The island belongs to Holland, is about 70 miles long N.W. and

S.E., very hilly, and very fertile, with about 250,000 inhabitants.

In the *Deutsche geographische Blätter* of Bremen, No. 4, is a long and interesting description of the island of Timor, by Professor Th. Studer, who visited Kupang and the interior in 1875. He describes the flora and fauna of the island as assimilated in some regions to those of India, and elsewhere resembling those of Australia. The high volcanoes, generally common to the Malay group, are here missing.

Trustworthy information regarding the climate, temperature, air-pressure, winds, and rainfall for the Russian settlement of Vladivostock, on the Japan Sea, has been given by Mr. E. Hansen, recently director of telegraphs at that place, in the *Geografisk Tidskrift* of the Royal Danish Geographical Society (1878, Nos. 7 and 8).

The numerous voyages made to Siberia during the past summer have been so successful that a regular summer trade-route to the rivers Obi and Yenisei may be said to be established. The principal difficulties to be encountered seem to arise from hazy weather and faulty charts.

In a paper read by Mr. Henry Seebohm before the Royal Geographical Society, it is stated that the Yenisei River is 4000 miles long, with a width of from 1¼ to 20 miles.

There is every indication of an immense trade in the future, but, like the Mississippi, the river cannot be ascended very far with safety by the steamers which come from sea, the difficulty being principally in the return trip down the river, the stream setting strongly on to the numerous sand banks. The commerce of the river is carried on by the Russians in steamers drawing about 32 inches of water, and carrying cargoes of wheat, hemp, flax, furs, etc., to depots at the mouth of the river, whence they are shipped to European ports.

The fifteenth volume (August, 1878) of the *Mittheilungen der Deutschen Gesellschaft für Natur- und Völkerkunde Ost-Asiens* has an extended treatise on Earthquakes and Volcanic Eruptions in Japan, by Dr. Edward Naumann, accompanied by a chart of the volcanoes of Japan, both active and extinct, several special plans, and a large diagram showing the earthquakes from A.D. 680 to 1872, the volcanic eruptions and tidal waves, with curves of simultaneous periods of sun-spots, as well as the periods of November meteors.

Of volcanoes active at present, the chart shows seven on the island of Niphon, three on Kiusiu, and six on small isolated islands.

NEW GUINEA.

Shortly before his death, Mr. A. Petermann published a small chart on a scale of 1 : 180,000, showing the results of the explorations of Signor d'Albertis in New Guinea. The Fly River is shown to be navigable to the foot of the mountains in the centre of the island, a distance of 500 miles, and flows through a country well adapted for raising tobacco, cotton, coffee, and sugar. The depth of the lower part of the river is from five to six fathoms, gradually decreasing to two and three fathoms as the river is ascended. At the farthest point reached, lat. 5° 30′ S., long. 141° 30′ E., progress was arrested by the rapid current of seven miles an hour. A large tributary of the Fly River was discovered and named the Alice, its mouth being in lat. 6° 10′ S. Its course was examined for about 40 miles.

The south coast of the island has been examined during the past year by Mr. James Chalmers and Captain Dudfield, in the missionary steamer *Ellangowan*. Mr. Chalmers communicated with about 200 villages, visiting 105 personally, in 90 of which no white man had previously been seen. Several bays, harbors, rivers, and islands were discovered and named; and the country between Meikle and Orangerie bays, together with that lying back of Kerepuna, was explored.

Mr. Chalmers thinks that the inhabitants of the inland villages are the aborigines, and have been driven to the hills by the more warlike tribes now occupying the coast.

Mr. Andrew Goldie, who has been engaged in making natural-history collections, has explored some parts of New Guinea never before visited by Europeans. He discovered a river, to which he has given his own name, a tributary of the Usborne, which flows into Redscar Bay. He penetrated the country to a distance of 100 miles from the coast, but was stopped by the dense undergrowth. He has collected about 1000 skins of birds, and among them are some entirely new species, besides 23 specimens of the *Paradisea raggiana*. Mr. Goldie describes the four tribes of natives through whose country he passed as in mutual terror of each other.

Various parties from Australia have been busily engaged in exploring certain localities in New Guinea for gold, but their search has not as yet proved very successful.

In a recent number of the *Bulletin* of the Paris Geographical Society, Dr. E. T. Hamy shows that nearly every part of the coast of New Guinea was visited by the old Spanish navigators between 1528 and 1606; but on the maps derived from their observations, its shape was very inaccurately laid down.

CARTOGRAPHY AT THE FRENCH EXHIBITION.

The official reports relating to maps and charts at the late International Exhibition are not yet published, but one or two geographical periodicals have given short reviews of the cartographical collections, among the best of which is that by Mr. C. Vogel in Petermann's *Mittheilungen* (1879, No. 12).

None of the government departments of the United States contributed either charts, maps, or plans, so that there was no exhibition from this country worth mentioning.

The admirable maps and charts of the English Ordnance Survey and of the Admiralty were not shown, and the English exhibit was not at all extensive. Terrestrial and celestial globes, shown by Messrs. Newton & Co., are spoken of, however, very highly.

Canada sent an immense map of the Dominion, nearly 40 feet long, prepared for the exhibition, showing the location of the principal products, fields, forests, mines, fisheries, etc.

The most prominent and striking map in the exhibition was a military map of France, on a scale of 1 : 80,000. In this enormous map 258 sheets were joined together, attaining a height of more than 42 feet. This map has been in course of publication for 45 years, and stands foremost, not only for its size, but for its clearness and uniformity, and as being the only completed military map of any of the large countries of Europe.

The general exhibit, by France, of maps, charts, and globes was very excellent and extensive.

The maps and charts shown by Holland were among the finest and best collections. As in France, the most striking map was one by the Bureau of Topographical Engineering,

a military topographical map of the country, on a scale of 1 : 50,000, in 62 sections joined together, corrected to the present time, and highly executed. The Dutch Colonial Government contributed a very large map of Java, on a scale of 1 : 500,000, constructed at Batavia, in 1877, by Lieutenant-Colonel Havenga, of the Engineers. Among other great merits, it shows very clearly the various routes and roads through the island.

The private establishments of Holland, so famed for their excellence in cartography, were very scantily represented.

The maps shown by Belgium were very interesting and of high quality. Among the most important were a topographical map of the whole country, in 437 sheets, on a scale of 1 : 20,000, to be completed in 1880; a relief map of Belgium, on a scale of 1 : 160,000; and a map, on a large scale, showing the progress of the geological survey now in progress. The interest excited by the Belgian project of African exploration has caused the publication of numerous maps of Africa, several of which, very carefully and accurately executed, were shown.

The Danish maps made by the topographical engineers were of very high excellence, clear and precise, with especially fine lettering.

This was also the case with the Swedish and Norwegian maps, which compared favorably with similar productions from any other country. Maps of the southern part of Sweden, in 102 sheets, on a scale of 1 : 100,000, and of Norway, in 54 sections, on the same scale, are praised very highly.

The Austrian Government made no contribution, but large quantities of maps and plans were shown by private establishments.

Among Italian maps and charts, the hydrographic charts contributed by the Admiralty are highly commended for accuracy and clearness.

The famous map of Switzerland, executed under the direction of General Dufour, in 25 sections, attracted general attention. Another map is in progress, to be published in 546 sheets, on a scale of 1 : 25,000 to 1 : 50,000. The specimens of a new process of printing in colors from copperplates, shown by M. Müllhaupt, of Berne, were very attractive.

On the whole, while no marked novelty seemed to present itself, the whole department of maps and charts at Paris was satisfactory, as indicating a constant improvement both in the clearness with which physical features are shown and in artistic excellence.

MICROSCOPY.

By Professor HAMILTON L. SMITH,
HOBART COLLEGE, GENEVA, N. Y.

IMPROVEMENTS IN MICROSCOPICAL OBJECTIVES AND MICROSCOPICAL APPARATUS.

The New Oil-immersion Object-glass of Carl Zeiss.

Dr. Dallinger publishes a letter in *Nature* highly commendatory of this objective. The spherical and chromatic aberrations are beautifully corrected, and all the most crucial tests readily mastered. He states that he has not been able to do more with it than with the new formula one-eighth of Powell and Lealand, but that the same results are accomplished much more readily, as there is no correction to be brought into operation by the German glass, which has simply to be brought into focus. A drawback upon the use of this objective is the fact that the oil is a solvent of most varnishes and gums used in the mounting and finishing slides, except shellac-varnish; and he further remarks that immersion objectives are of very limited service in observations continuously conducted upon minute living organisms in fluid. We may gladly call in their aid in determination of a delicate change of form, or in the more perfect detection and definition of an obscure point of structure; but for steady and constant work we are bound to avoid them; for the fluid under the delicate cover is in danger every moment of being "flooded" by coming into contact with the water (or other fluid) on the top of the cover and between it and the lens; because the movements of the organism have to be counteracted by the movements of the mechanical stage, in order to keep any form that may be studied in view constantly. Since, then, there are these difficulties in the use of immersion-lenses in biological investigations, Mr. Dallinger expresses the hope that the English, the Continental, and the American opticians will not abandon their efforts for the still

greater improvement of dry lenses. Another notice, especially of the oil-immersion one-twelfth of Zeiss, by Adolf Schultze, in a recent number of the *English Mechanic*, states that the field is perfectly flat, and that the brilliancy and definition leave nothing to be desired. This author states that he has failed to see, both with the one-eighth and one-twelfth oil-immersion lenses, more than with the Powell and Lealand excellent new formula, or some other first-class water-immersion lenses; yet, considering that no adjustments were to be made to the Zeiss objectives, he could, upon the whole, see everything better and easier with these. We have been informed that the results obtained by Dr. Woodward, U.S.A., in photographing by aid of these new objectives, are quite equal to anything he has accomplished with any other first-class modern objectives. The result of a comparison of the one-eighth oil-immersion with the new one-tenth and one-sixth water- and glycerin-immersion objectives of C. A. Spencer & Sons showed that the Zeiss objective, though pressing very closely, was nevertheless somewhat inferior to the Spencer objectives, especially by daylight, and when using very high oculars; still, the manifest advantages of the oil-immersion were so great that the latter firm are now perfecting a system on this plan, and microscopists are under great obligations to Professor Abbe and Mr. Carl Zeiss for this new departure, which promises so much.

Immersion Condensers.

In utilizing the increased angle of aperture obtained by the new immersion objectives, an immersion illuminator is required, and that devised by Professor Abbe is said to have a balsam angle of 138°. The reflex illuminator of Mr. Wenham has also been used with great advantage, also Dr. Woodward's arrangement of prisms, the under surface of the slide being connected with these illuminators by means of glycerin. Mr. Tolles long ago suggested the use of a hemispherical lens thus cemented or attached to the under surface of the slide; and Mr. George Wale, of Paterson, N. J., simplifies the whole matter by attaching a small prism, three eighths by a quarter inch, without any mounting whatever, to the under surface of the slide, by means of glycerin.

A New Cover-adjustment for Microscopical Objectives.

The well-known optician, Mr. E. Gundlach, has proposed a new cover-adjustment for objectives, which, he claims, has some great advantages over the old method. These advantages, as he states them, are: (1) The adjustment exerts no deleterious influence on the corrections of the aberrations, and is equally as efficient for any thickness of the covering-glass as for uncovered objects. (2) The working distance is the same for any cover-thickness, except for immersion objectives. For this reason objectives of very short working distance will, with this adjustment, admit of even the thickest covering-glass. (3) The magnifying power is unchanged. (4) The image is placed but slightly out of focus. (5) The adjustment is very sensitive. (6) It can be made to indicate exactly the thickness of the cover. All these advantages, with others, are obtained, he claims, by discarding the old method of adjustment by moving one or more of the systems of lenses, and by placing a movable front of plane glass before the anterior lens of the objective, filling the space between with glycerin. A thinner or thicker stratum of this glycerin, according to the distance between the plane glass and the lens, gives the required adjustment (*American Journal of Microscopy*, June, 1878).

Professor Abbe's Apertometer.

This apparatus is intended to enable an exact measurement of angular aperture of any object-glass, dry or immersion, to be made; and to afford a definition of aperture which is not limited by the maximum air-angle, which is independent of the medium in front of the lens, and which, at the same time, by its theoretical signification, may give a direct indication of the resolving power of an objective. It has long been evident that the expression "angle of aperture" is deceptive as an indication of resolving power, since this is proportional, not to the angle itself, but to the sine of the semi-angular aperture; in other words, in large angles the ratio of resolving power can bear no proportion to the mere number of degrees, the sines of such angles having very small progressive increase. Professor Abbe proposes a new name—*numerical aperture;* and by means of this "numeri-

cal aperture" all objectives, dry, water-, or oil-immersion, can be directly compared. The apparatus cannot well be described without a diagram. Suffice it that it is mainly a semicircular disk of thick crown-glass, with polished edges. On one of the faces of the disk two scales are engraved. The inner one reads off the largest possible angle from air into the medium (crown-glass) of which the disk is made, or twice the "critical angle." The other reads off the corresponding "numerical aperture," which is a number that is always *the product of the index of refraction of the medium in front of the objective multiplied by the sine of half the angle of aperture.* Knowing this number, and also the index of the medium in front of the objective, we can from these get the equivalent angle of aperture *for* that medium. The internal scale is graduated from 0 in the middle to say 82° (or double the critical angle for crown-glass) on either side; and this, as already said, reads off the air angle. The external scale, concentric with, but outside of, the other, commences with 0 in the middle, and reads 1 on either side, *coincident with the* 82°+ of the inner scale; but the divisions extend much beyond this—say to 1.3 or 1.4. Suppose, now, the objective to be dry, and, as near as possible, 180° air angle, using the apertometer, the angle would be read 82°+ on the inner scale—*i. e.*, 82°+ *in glass*, which is equivalent to 180° in air. On the outer scale we would read 1 (=sine 90°, half the air angle). This is the equivalent *numerical aperture;* and since this is a number which is *equal to the sine of the semi-angle of aperture multiplied by the index of refraction* of the medium (in this case air = 1 nearly), we have 1 = sine semi-angle × 1, or sine of semi-angle of aperture = 1; *i. e.*, semi-angle = 90°, twice which = 180°, or air angle, as before; and this is the utmost any objective *could read with only air in front.* Applying, now, a medium—say water (whose index is 1.33)—the outer scale, with the same objective, would read off—say 1.1. This is the *numerical aperture*—an aperture which, if taken in air, would be imaginary—*i. e.*, surpass 180°; but to get *water* angle we proceed as before: sine $\frac{1}{2}$ aperture = $\frac{1.1}{1.33}$ = 0.827 = sine 55° 30′; and twice this, 111°, is the water angle of the objective. If, instead of water, balsam (with index 1.5) had been used, and yet the scale had only read

off 1.1, we should have for balsam angle: sine $\frac{1}{2}$ aperture= $\frac{1.1}{1.5}$=0.733 = sine 47° 15′; twice which, or 94° 30′,= balsam angle. If the objective had, instead of 1.1, given 1.25 as *numerical aperture*, its balsam angle would have been 113°. We have, then, in these two cases of 1.1 and 1.25 a resolving power in the first 10 per cent., and in the last 25 per cent., greater than the possible limit of a dry lens (sine 90°=1) (*Journal of the Royal Microscopical Society*, March, 1878).

New Form of Micrometer.

Mr. G. I. Burch has described a micrometer based upon a comparison of the reflection of a scale with the image of the object, and which he claims is equal in accuracy to all other micrometers except the Cobweb. It consists of a cap, fitting over the eye-piece, containing a piece of neutral-tint glass (or looking-glass, with the amalgam removed in the centre), set diagonally, so as to reflect to the eye the image of a scale, which is carried by an arm ten inches long, attached to the cap, the object being observed in the usual way, through the eye-piece, but looking through the diagonal glass. To adjust the scale so that it may read decimals of an inch, etc., it is moved on the arm nearer to, or further from, the eye, till, on adjusting the focus so that the apparent distance of the two images may coincide, every tenth division on the scale shall cover the $\frac{1}{100}$ or the $\frac{1}{1000}$ of the stage micrometer, according to the power used (*Journal of the Quekett Microscopical Club*, No. 37, 1878).

New Test-object.

Professor Ranvier recommends as a test for objectives intended for histological work ("which are required, not for flat bodies presenting only fine striæ, but for objects of irregular and varying forms—rough, concave, or convex") the isolated muscular fibrillæ of the wings of the *Hydrophili.* With a power exceeding 300 diameters, the alternately thick and thin dark disks which characterize the fibrillæ may be seen. Although Professor Ranvier, from whose book on "Practical Histology," just published, the preceding is taken, is the leading histologist of the day, yet he seems to be quite ignorant of the principle involved in the con-

struction of the binocular microscope, since he states, in his book, that in the binocular microscope there are not two different images, but the same image, presented to each of the eyes of the observer. However true this may be of Powell & Lealand's "binocular for high powers," it is not true either for the Wenham, Nachet, or Stephenson binocular, or for the Tolles binocular eye-piece. Indeed, with the Nachet form, which has some advantages, the instantaneous conversion of a relief into a depression, or vice versa, according to the manner in which the images are made to enter the eyes, is quite striking; and the very fact of orthoscopic or pseudoscopic vision thus produced, by alteration of the position of the prisms, proves that the images are not similar. M. Ranvier states that he has found the penetrating power or focal depth of the binocular superior to that of the monocular. The reason for this is, that each eye uses only its own half of the objective; and any objective, when half the front is covered, will, even with the ordinary monocular, have increased focal depth.

A moist chamber of very simple construction is described by Dr. Strassburger. It consists of a ring of card-board soaked in water, on which the covering-glass is placed. The drop of water containing the *Spirogyra*, the copulation of which was to be observed, must be suspended from the under surface of the covering-glass, and may then be preserved for several days; whereas, if placed under the covering-glass in the usual way, the plants will invariably die.

Self-centring Turn-table.

A self-centring turn-table is described by Mr. C. F. Cox, in which the slide is grasped at the two opposite corners by right-angled clutches, which are moved simultaneously by one milled head, turning a right- and left-handed screw. As this device centres the slips only lengthwise, Mr. Cox proposes, when it is necessary to make several cells in the same slip, to hold the slide between two right-angled triangles of brass, which are grasped by the clutches, the slide being between them, and thus allowing several cells, if necessary, to be made on one slide, by simply slipping it along (*American Journal of Microscopy*, Jan., 1878).

Theoretical Limit of Aperture.

In an able paper on the Theoretical Limit to the Apertures of Microscopical Objectives, Professor G. G. Stokes, D.C.L., etc., after alluding to Professor R. Keith's elaborate computation relative to Tolles's one-sixth microscopic objective, which is given in full in the *Journal* of the Royal Microscopical Society, July, 1878, and fully endorsed by him, states that the reason for scepticism as to the results of such calculations seems to be a notion derived from *a priori* considerations, that it is impossible to collect into a focus a pencil of rays emanating from a radiant immersed in water or balsam of wider aperture than that which in such a medium corresponds to 180° in air, or, in other words, than twice the critical angle; and this he disproves by showing that in certain particular instances it is untrue, so that the aperture in the case of a medium with a refractive index 1.525 may, at the extreme, exceed the supposed limit by over 16°.

MICRO-ORGANISMS, BACTERIA GERMS, SPORES, ETC.

Anaerobiosis of Micro-organisms.

M. Gunning, in a note read July 1, at the French Academy, states that he has repeated his experiments on *Anaerobiosis*, or life without oxygen, under conditions to which no exceptions can be taken, and proves conclusively that such life is impossible.

Admitting the practical impossibility of obtaining spaces where the absolute absence of oxygen could be proved, he used glass flasks, hermetically sealed, in which as large quantities as possible of putrescible matter were placed in contact with the smallest possible quantities of oxygen. The details of his mode of doing this are published in the *Annals* of the Academy of Sciences, Amsterdam, vol. xii., 1878, and in the sixth part of the *Journal of Practical Chemistry*. He found that when the flasks were sealed and exposed to a temperature of 38° to 40°, putrefaction was immediately established—to be definitely arrested, however, in all the flasks after a longer or shorter period; often very short, but always sensibly proportioned to the quantity of oxygen supposed to be present. After two years some of these flasks had lost

little or nothing of their primitive freshness. When the flasks containing the putrescible matters terminated in tubes provided with cotton-wool, or which were recurved many times upon themselves, and whose tapered points were hermetically sealed—so that at any given moment, by breaking the points, their contents could be exposed anew to contact with the air deprived of germs—he found that, by waiting until the contents had arrived at a state of complete inertia before establishing this contact, the air no longer produced the least phenomenon of putrefaction or appreciable alteration; proving that the *Bacteria*, as well as their germs, were not only dead, but that the organic matters are not susceptible of spontaneously producing others.

Organisms Suspended in the Atmosphere.

M. P. Miquel, after alluding to the statements of M. Charles Robin, that the atmosphere contains (besides all kinds of *débris*) spores, pollen, skins of insects, and (rarely) eggs of Infusoria, and also to the experiments of Drs. Maddox and Cunningham, describes his own newly contrived "aeroscopes," by means of which he collected from 500 to 120,000 organized cellules per cubic meter of air; thus showing the atmosphere to contain at least 100 times more germs than Drs. Maddox and Cunningham have stated. M. Miquel states two general facts as applicable to all organized corpuscles of the atmosphere whose diameter is greater than the $\frac{1}{500}$ of a millimeter:

1. The average number of *Microbia* of the air, small in winter, augments rapidly in spring, remains nearly stationary in summer, and diminishes in autumn.

2. Rain always provokes the recrudescence of these *Microbia*. The increase brought about by rain is not simply sensible, it is often surprising. For example, in summer, when to great heat succeeds a storm, or a rain somewhat sustained, the instruments, which the day before recorded 5000 to 10,000 germs, record more than 100,000 the next day. Temperature and moisture seem the principal causes of variation in micro-germs in our atmosphere. The cellules most diffused in the air are undoubtedly spores of the *Mucedinæ;* then fructifications of certain fungi; then come pollens of variable size and color; and, lastly, green algæ, voluminous

quantities of which are sometimes transported in the air (*Comptes Rendus*, vol. lxxxvi., p. 1552).

Schulze's Mode of Intercepting the Germinal Matter of the Air.

In 1836 Schulze described an experiment which has obtained considerable celebrity. Placing in a flask a mixture of vegetable and animal matters and water, he inserted in the cork closing the flask two glass tubes, air-tight, but bent at right angles above it. The infusion was boiled, and while steam was issuing from the two tubes, he attached to each a group of Liebig's bulbs, one filled with a solution of caustic potash, the other with concentrated sulphuric acid. Applying his mouth on the potash side, he sucked air daily through the sulphuric acid into the flask. But though the process was continued from May till August, no life appeared. The germs diffused in the atmosphere are supposed to have been destroyed by the acid in this experiment, but others have failed to obtain the same results. Professor Tyndall has recently stated that the success of the experiment depends upon passing the air-bubbles so slowly through the acid that the floating matter, up to the very core of every bubble, must come into contact with the surrounding liquid; and that water may be substituted for both acid and potash. His crucial experiment was as follows: Two large test-tubes, each about two-thirds filled with turnip infusion completely sterilized, were so connected together that air could be drawn through them in succession. Two narrow tubes passed through the cork of each test-tube in the same manner as in Schulze's flask; and it was so arranged that the tube which delivered the air should enter near the surface of the fluid, the exit tube in each case ending immediately under the cork. Two series of Liebig's bulbs, charged with pure water, were attached to the two tubes of this arrangement, one being connected with a large receiver of an air-pump, the other left open to the air. The connection between the receiver and the adjacent bulb being first cut off by a pinch-cock, the receiver was exhausted, and, by carefully loosening the pinch-cock, a very slow passage of the air through the test-tubes was secured. The rate of transfer was, however, such that the air above the infusions was renewed twenty or thirty times in twenty-four hours. At the end of twelve

days the turnip-juice was perfectly pellucid and free from life. Two days' exposure to ordinary air sufficed to render it muddy. After twelve days the pinch-cock was opened, so as to allow a momentary inrush of the external air, which was immediately checked by the reclosing of the cock. Three days after, the infusion of the test-tube into which the air first entered was muddy, and crowded with life. The contamination did not reach the second test-tube. These experiments completely verify the conclusion that, in Schulze's experiment, water may be substituted for sulphuric acid and caustic potash without any alteration in the result (*Proc. Roy. Soc.*, No. 185).

Action of very Low Temperatures on Bacteria.

While the action of high temperature on *Bacteria* has been frequently studied, few observations have been made as to their behavior at low temperatures, but it has been found that they stiffen at 0 C., and are not killed at $-18°$ to $-25°$ C. Herr A. Frisch, by means of solid carbonic acid and ether, exposed some putrefactive fluid *Bacteria*, and some forms of *Coccus* and *Bacterium* in the morbid products of living organisms, to $-87.5°$, and allowed them in the course of $2\frac{1}{2}$ hours to rise to 0°. The result was, that the *Bacteria* in the fluid withstood this low temperature, and grew rapidly when transferred to a suitable nutritive fluid (*Der Naturforscher*, No. 5, 1878).

Staining and Preparation of Bacteria.

The difficulties which are involved in the study of *Bacteria* arise partly from the gaps which appear in the classification of these minutest of all living organisms, and the new forms which are continually cropping up, and partly from the microscopes employed possessing little power of illumination and definition, although furnished with sufficiently high powers; and their investigation is a matter of enormous difficulty on account of their extreme minuteness, their weak refracting power, and their motion. Dr. W. A. Haupt proposes to stain the whole fluid which contains the *Bacteria*, at the patient's bedside, or the dissecting-table, the microscopical examination to be made at any convenient time. For the purpose of staining, he prefers aniline-violet, fuchsine,

and erythrusine. A trial can be made on *Bacterium termo*, which is one of the most difficult of preparation. It is easily procured by exposing a piece of raw meat, placed with water in a porcelain cup, to the sun for an hour or two, or letting it stand near a warm oven. When an opal-like scum has formed on the fluid, every drop is seen under the microscope to contain millions of these bodies. This, or any other fluid containing *Bacteria* (urine, serum, blood, etc.), should be put in a 10-gram glass which has been carefully washed and rinsed in alcohol. The bottle should be a fourth or a fifth part filled, and the same quantity of a solution in water (well filtered) of the staining material added, and then, after being well shaken, corked and labelled. From five or ten minutes to forty-eight hours are required, according to the nature of the object. When examination with the microscope shows the result is satisfactory, a drop is taken from the bottom by means of a pipette and spread out well on a glass slide, and dried in a warm place, protected from dust. A drop of dammar varnish, or Canada balsam, is applied, the covering-glass is pressed down, and the preparation is ready for examination, and may be preserved indefinitely (*Zeitschrift für Mikroskopie*, vol. i., p. 175).

Examining, Preserving, and Photographing Bacteria.

The principal difficulties which arise in investigating *Bacteria* are connected with their small size, their movements, their simplicity of form, and their want of color or power of strongly refracting light. Dr. Koch proposes, in order to obviate these difficulties, the following process: A drop of the fluid containing the *Bacteria* is spread out in as thin a film as possible on the covering-glass and dried. In this condition they may remain for months, if kept from dust, etc., without any change to the dried *Bacteria;* and, as they dry without shrinking or changing their form, there is no objection to this part of the process. The next step is to moisten the film with acetate of potash (one part in two parts of distilled water); the *Bacteria* resume perfectly their original form, and the fluid answers as a special preservative from further change. They are yet too pale for photographing; for this purpose they must be stained with aniline dye, which they take quickly and completely. Methyl-violet and fuchsine

are especially suitable, or aniline-brown. After the staining, they must be dried and mounted in balsam in the usual way. Photographs from specimens thus prepared show the most delicate details, as, for instance, the *flagella* (*Zeitschrift für Mikroskopie*, vol. i., p. 119).

Measurement of the Diameter of the Flagella of Bacterium Termo.

(A Contribution to the Question of the "Ultimate Limit of Vision" with our Present Lenses.)

The Rev. W. H. Dallinger, already so well known for his observations and studies of Monads, contributes a paper on the above-named subject to the September number of the *Journal* of the Royal Microscopical Society, full of interest, but of which we can here give only a meagre outline. The paper is illustrated with two fine plates, on one of which are reproduced two of Dr. Koch's photographs, mentioned in the preceding article. *Bacterium termo* is the smallest of all the group, and although Kock, Warming, and others, had detected the *flagella* on the larger specimens of other *Bacteria*, they had never been seen on *B. termo*, though from analogy they were supposed to be present. The average length of *B. termo* is about $\frac{1}{10000}$ of an inch, and on this minute object, by the most skilful manipulation of Powell & Lealand's most recently improved objectives, and, also, with those of Mr. Tolles, Mr. Dallinger and his coadjutor, Dr. Drysdale, have not only succeeded in demonstrating the *flagellum*, but have actually measured this fine organic fibre, with the following results: (1.) The mean value of fifty measurements made with the one-twelfth inch objective gives, for the diameter of the *flagellum*, 0.00000489208. (2.) The mean value of fifty measurements made with the one-sixteenth inch objective gives 0.00000488673. (3.) The mean value of fifty measurements made with the one-twenty-fifth inch objective gives 0.00000488024. The mean value of fifty measurements made with the one-thirty-fifth inch objective gives 0.00000488200. We thus get, for mean value of the whole, expressed in vulgar fractions, $\frac{1}{204700}$ of an inch; so that we may safely state that an atom of a semitransparent structure $\frac{1}{200000}$ of an inch in diameter may become visible under proper conditions of illumination and manipulation.

Life History of a Minute Septic Organism.

The Rev. W. H. Dallinger's paper on this subject, in the *Proceedings* of the Royal Society, No. 187, 1878, is one of exceeding interest, and is accessible to American readers in the admirable reprint in the *American Journal of Microscopy* for August, 1878. The story is clearly and conscientiously told, and one feels assured at every step that the author is not only stating facts that hereafter cannot be questioned, but that he is admirably fitted in every way to conduct such delicate investigations. It is impossible in our limited space to do any justice to this paper by an abstract.

Bacteria in Splenic Disease.

M. H. Toussaint claims that in splenic disease death results not from a virus, but from obstruction of the capillaries of essential organs, as the brain and lungs, by the rapid multiplication of *Bacteria.* Fresh *Bacteria* blood, received in tubes, and preserved from contact with the air and from putrefaction, loses its contagious properties in six or eight days, or sooner if kept at a temperature of from 38° to 40° C.; but such a method would be adopted to preserve virus (*Comptes Rendus*, March 18, 1878).

INFUSORIA, DIATOMS, RADIOLARIA, ETC.

Trembley's Experiments in Turning a Hydra Inside Out.

Professor Engelmann, of Utrecht, has repeated Trembley's celebrated experiment with negative results. With animals of suitable size, and a hog's bristle of proper size and shape, the experiment was easily performed; they were taken from both slow-running and stagnant waters. He found that the turned body, when it did not soon resume its normal position, always perished within a short time; the cells, and first of all those of the entoderm, swelled very much, gradually loosened themselves from their connection, and were found after a day or two, like a small white cloud, at the bottom of the glass. The experiments in clipping off small pieces of the tentacles, which developed into perfect five-armed *Polypi*, and with *Hydræ*, which had been slit longitudinally, and readily grew together, proved that the conditions were not

unfavorable for success, and he concludes, therefore, that Trembley sometimes describes things most minutely of which in reality he has seen the least (*Zoologischer Anzeiger*, vol. i., p. 77).

The Foraminifera and Polycystina of the North Polar Expedition, 1875-76.

The soundings from depths of 10 to 220 fathoms, brought home by the expedition, have been examined by Mr. H. B. Brady. The area is altogether new, and about half a dozen species of Foraminifera may be considered as essential constituents of the Mesozoic fauna of these high latitudes, and these constitute about 95 per cent. of the entire collection. They are, *Globigerina bulloides*, *Cassidulina lævigata*, *C. crassa*, *Truncatulina lobatula*, *Pulvinulina karsteni*, *Polystomella striatopunctata*, and sometimes a few forms of *Nonionina*. The almost complete absence of the Milioline genera is an unexpected feature, as no approach to a full-sized mature specimen has been met with in the North Polar material. Only a few *Radiolaria* were observed, and these, according to Professor Haeckel, to whom they were submitted, appear to be identical with those found in the *Challenger* soundings in the Middle Pacific, at depths of 2400 to 2900 fathoms, from about 8° N. to 8° S. of the equator. By these soundings, our knowledge of the sea-bottom extends to latitude 83° 19′ N., a distance of 6° 49′ more than half the interval between the most northerly point of previous researches and the actual North Pole. The facts which have been elicited appear to indicate that there is no very striking diminution in the number and variety of the *Rhizopoda* as we approach the North Pole (*Annals and Magazine of Natural History*, June, 1878).

Radiolaria.

Mr. St. George Mivart's paper on the Radiolaria, printed in No. 74 of the Linnæan Society's *Journal*, may be commended to all interested in the study of these organisms. It is a condensed treatise on the group.

Multiplication of Rhizopods.

Professor Leidy has successfully observed the mode of multiplication of the test-covered Rhizopods, which is analogous to

the mode of production by division of the Desmids. He observed the process in *Euglypha alveolata*, and found it similar to the multiplication of *Chlamydophrys*, as already noticed by Cienkowsky.

Supposed Radiolarians and Diatomaceæ of the Coal-Measures.

At the Dublin meeting of the British Association, Professor W. C. Williamson called attention to the *Traquariæ* of Mr. Carruthers, which were found in the lower coal-measures of Lancashire and Yorkshire, with small spherical objects supposed to be Radiolarians. After thorough examination, Professor Williamson rejects the idea of their Radiolarian character; while their close organic resemblance to some obviously vegetable conceptacles found in the same coal-measures suggested that the *Traquariæ* are also vegetable structures.

Count Castracane having published an account of a process by which he reduced numerous specimens of coals to very minute quantities of coal-ash, in which he found numerous marine and fresh-water *Diatomaceæ*, Professor Roscoe detailed one of his ablest assistants, in his laboratory at Owens College, to prepare analyses of a number of coals according to Count Castracane's method. The residual ashes were mounted microscopically and examined by Professor Williamson, and in no one of them could a trace of a diatom be discovered. It has long been suspected by microscopists interested in the study of these minute organisms that the Italian observer was misled by the accidental introduction of modern forms somewhere during the treatment. It is well known that, even after repeated washings and rinsings of test-tubes and bottles, diatoms will still cling to the sides, and becoming afterwards dislodged, make their appearance in other preparations placed in the same tubes or bottles.

Revivification of Diatoms.

M. Paul Petit states that, having collected diatoms at various times of the year, with their substratum of mud, and allowed them to dry in the sun for six or eight months, he had placed them in distilled water well aerated, and found that in four days many of the frustules, which showed before only large brown granules, began to have these granules aug-

mented in volume, and at the end of five days the frustules were half filled, and the characteristic yellow tint of the endochrome appeared; on the eighth day the revivification was complete, and soon after they began their curious motions, and the multiplication by division (*Journal de Micrographie*, Dec., 1877).

In connection with the above, Mr. Fred. Habirshaw, of New York, states that in 1871 Capt. Mortimer brought from San Francisco, in his ship, a large bottle of diatoms (from fresh water). When he arrived in England they were still alive, but afterwards dried up, and remained in that state in his cabin until the summer of 1877—a period of six years. "Having found the old bottle, which we knew very well, we refilled it with water, and on examining it several days later we found some living specimens in it."

That living diatoms were found as stated there can be no doubt, but that they were *revivified* yet needs proof. It is contrary to experience hitherto; indeed, it is well known, and one of the means employed to procure purer gatherings, that oftentimes apparently pure water will, if allowed to stand quietly, show an abundant crop of diatoms. In many cases that we have noted of the appearance of living diatoms, after wetting long-dried material, they have been, *not the forms originally in the gathering*, but those evidently derived from the water. Just at present, while we may—nay, perhaps must, admit that, up to a certain limit, diatoms, like the rotifers, may be dried, with power of revivification or reproduction, there is yet lacking sufficient evidence that this drying may extend over a series of years.

Parasites on a Diatom.

M. Guimard, while observing a gathering of diatoms, mostly *Pinnularieæ*, saw great numbers of them covered by small bodies of a yellowish-brown color, and moving with great rapidity. With a No. 5 of Nachet, they were seen to have a rectangular body, and contained in their interior a yellowish-brown matter, with globules of a deeper color, and resembling the ordinary endochrome of the diatoms; at each of the four angles was a long hyaline arm, of great mobility. Seen in profile, the body presented the form of an elongated oval (*Bulletin de la Société Belge de Microscopie*, vol. iv., p. 304).

Diatoms in Colored Liquids.

Professor H. L. Smith states that the communication which exists between the internal protoplasmic substance and the exterior does not take place along the sutures of the connectives, but in *Navicula* (properly so called) it exists along the raphé, or median line of the valves, and in *Surirella* and *Nitzschia* along the edges of the wings or carinæ. The absorption of the indigo, when the diatoms have been left for some days in liquid charged with this substance, is quite apparent, and principally at the ends of the median line, near the central nodule. Something similar was seen by Ehrenberg. In a field blue with indigo, the little particles can be seen running along the median line of a large *Navicula* (*Pinnularia*) on that half of the valve which is in the direction of the forward motion of the diatom; these particles accumulate at the end of the raphé, near the central nodule, where, in the large *Pinnularieæ*, a minute dot may be discerned, forming there a ball, which rotates precisely as though encountering a little stream of liquid issuing at this point. When the motion of the diatom is reversed, the particles traverse along the raphé of the other half of the valve to the centre, forming there a ball as before; these balls, after acquiring a certain size, are ruptured, and the particles stream off precisely as though moved by the cilia of a rotifer. There appears to be a gelatinous external hyaline envelope, the presence of which is not only demonstrated by the indigo particles, but by its becoming rapidly colored or stained by a weak solution of fuchsine (*Bulletin de la Société Belge de Microscopie*, Nov., 1877).

Isthmia Nervosa: a Study of its Modes of Growth and Reproduction.

Two very interesting papers upon this subject have been published in the May and June numbers of the *American Journal of Microscopy*, by the Hon. J. D. Cox, United States Senator, and they show how much can be accomplished by patient working and study of even imperfect materials. To study growth and reproduction one would suppose that living forms would be necessary; yet Senator Cox has arrived at many facts quite valuable by using only the dried or pre-

pared material. A study of living forms would have shown, however, that the cushion, or gelatinous stipes, by which the frustules of the Isthmia are attached, and which constitutes in another form the stalks of *Gomphonemeæ* and *Cocconemeæ*, is in fact a closed gelatinous tube, out of which the diatom is constantly slipping. When the tube is not closed we have the fronds of *Schizonemeæ* and *Colletonemeæ*. All the diatoms secrete a more or less gelatinous sheath, over the whole surface of the frustule; it is not exuded at one end. What Mr. Cox calls the earlier view, viz., that the sporangial frustule becomes "the parent frustule of a new and vigorous generation, by recommencing the cycle of self-division," is not the earlier view, but is the later, accepted by all who have studied this subject in recent times, excepting perhaps Dr. Wallich, whose article, alluded to by Senator Cox, has many misjudgments and wrong statements. Thwaites himself did not express an opinion clearly. W. Smith, his intimate friend and the well-known British authority, in his classical work, supposes the cell-contents of the sporangium to break up and form broods of small individuals. Rabenhorst has even figured something of this kind in *Melosira*, and this was Kutzing's view in a general way. There is not a shadow of doubt that the opinion expressed by Senator Cox is the correct one. It has been advocated by Mr. Carter and others, and especially by Professor H. L. Smith (see the *Lens*, vol. i., p. 73), who has not merely observed the conjugation in some fifty genera, but has kept the sporangial frustules living until the self-division has been completed.

TISSUE-STAINING, BLOOD, ETC.

Structure of the Colored Blood-Corpuscles.

Dr. H. D. Schmidt, of New Orleans, states that the colored blood-corpuscles of the *Amphiuma* represent organic cells consisting of homogeneous protoplasm surrounding a nucleus, that part of the protoplasm forming the outer surface being of greater density than the rest, and so a membranous layer is formed, and may be seen in the form of a clear, narrow border of a greenish tint, and by the action of reagents it assumes the appearance of a distinct cell-wall. The coloring matter (hæmoglobin) of the blood-corpuscle does not seem

to be chemically united with the protoplasm, and it escapes readily, even by the action of very weak reagents. The nucleus represents an oval vesicle containing most probably a more or less dense liquid, with a number of larger and smaller granules. These first expand and then dissolve in water, increasing the volume of the whole contents and expanding the walls of the nucleus. The colored corpuscles of the frog resemble in form, as also in chemical and physical properties, those of the *Amphiuma*, but are less than half their size; when they are treated with water the coloring matter gradually disappears, but their outline is still visible, appearing in the form of a delicate double contour, which is the membranous layer of the corpuscle. The examination of the colored blood-corpuscles of man and the other mammalia is more difficult, in consequence of their smaller size. Those of man represent minute bi-concave disks with rounded margins, and a diameter of about $\frac{1}{100}$ mm. In a state of rest the outline is perfectly round; but when this outline is most distinctly in focus, the centre to about the extent of one third the whole diameter appears light. Between this and the bright margin is a varying shade caused by the form of the corpuscle. No trace of a membrane or a membranous layer can be discovered in the fresh blood-corpuscle of man. In the paper is a full discussion of the various changes in form and appearance of the blood-corpuscles due to external causes, and especially in connection with varying temperatures; also to the manifestation of spontaneous motion, due, as is stated, to living protoplasm, so that they have an inherent power of contracting and again resuming their original form. The changes in form, which increase rapidly in proportion to the length of time after removal from the living tissue seem to be the result of the last vital actions of the blood-corpuscle, and portend its death. Dr. Schmidt concludes that the function of the colored blood-corpuscles is at least partly secretory; he considers them as true glandular cells, engaged in appropriating certain materials from the plasm of the blood, in order to transform them into other bodies by virtue of their secretory power, and finally to return them to that fluid, in the condition required for the subservience of other purposes, such as the preservation of the normal constitution of the blood, as well as the nutrition of the vari-

ous tissues (*Journal of the Royal Microscopical Society*, July, 1878).

Rapid Staining by means of Carmine.

Dr. H. Obensteiner states that sections of the nerve system (brain and spinal marrow of man and animals) may be rapidly stained by placing the sections in a watch-glass containing the carmine solution, and suspending them in the steam of boiling water; from two to five minutes are required. After the staining is completed the sections are washed twice in distilled water, placed for a few minutes in common alcohol, and for the same time in absolute alcohol, and, finally, in oil of cloves for examination. The preparations thus treated are colored in a specially sharp and distinct manner—*e.g.*, the connective-tissue corpuscles, together with their long continuations into the substance of the brain, which insert themselves into the adventitia of the vessels, come out with a distinctness which it is difficult to obtain by other means (*Archiv für Mikroskopische Anatomie*, vol. xv., 1).

Gold Staining, and the Termination of the Nerve in the Unstriated Muscles.

Professor Ranvier recommends the following modification of the gold method in a recent communication to the French Academy. The preparation is placed for five minutes in fresh lemon-juice, filtered; then it is put, for fifteen or twenty minutes, in three cubic centimeters of a 1 per cent. solution of chloride of gold; then in twenty-five to thirty grams of distilled water, to which is added one or two drops of acetic acid. Two or three days afterwards, when under the influence of sunlight and the slightly acid medium the reduction of the gold has been effected, the preparations are ready for examination. Fragments of striated muscles, treated as above, or, better, when, after having been subjected to the action of the gold, they have been placed for twelve hours, sheltered from the light, in a 20 per cent. solution of formic acid, and then prepared by teasing, show the terminal nervous arborizations admirably clear, and colored a deep violet. The author finds: (1) In the unstriated muscles, the nerves terminate, as in the striated muscles, at the surface of the muscular elements by an expansion, more or less ar-

borized, of the cylinder-axis. (2) The nervous net-work of the involuntary unstriated muscles is in connection, not with the elementary nervous action which sets the muscle in activity, but a more complex action, on which depends the functional energy of an organ whose activity is derived from the direct action of the nervous centres.

MISCELLANEOUS.

New Acarus.

A new acarus, *Cheyletus flabellifer*, is described by A. D. Michael, F.R.M.S., which he found feeding upon the rare acarid *Glyciphagus palmifer*. But one species of *Cheyletus* was before known, and from it the present form differs in being more thick-set and powerful, and the hairs, instead of being fine, are developed into fan-shaped expansions. The color is yellowish-white (*Journal of the Royal Microscopical Society*, July, 1878).

Insect Dissection.

Mr. W. T. Loy uses the following simple apparatus for insect dissection. An upright iron rod is fixed into a heavy metal foot; round this rod is coiled one end of a stout wire, the other end being bent into a ring to hold a watchmaker's eye-glass. This arrangement, by pressing the head down, focuses the lens upon the work, while both hands are at liberty. With this simple apparatus Mr. Loy has made some very beautiful dissections. A very good condenser may be made out of a Florence oil-flask, cleansed and filled with water, and then securely corked. The medium most suitable for dissecting in is glycerin (*Jour. Quek. Mic. Club*, Jan., 1878).

Pedesis.

Professor Stanly Jevons, in objecting to the names "Molecular movement," "Brownian movement," and "Dujardins titubation," for the movement of particles suspended in liquids, suggests *pedesis* from the Greek—leaping, or bounding. The best exhibition of this motion is to be got by grinding up a particle of pumice-stone in an agate mortar, and mixing it with distilled water. The minute particles will be seen under the microscope to leap about with an in-

cessant quivering motion, so rapid that it will be impossible to follow the course of a particle. The most convenient substance is kaolin, which, when shaken up with pure water to make a milky liquid, shows the motion in great perfection. This motion, he states, is not due, as has been suggested, to rays of light or heat; nor is it connected with the shape of the particles; nor yet is it due, as Tyndall has supposed, to surface-tension. Pure water exhibits pedesis in the highest perfection, even the air, and carbonic acid usually dissolved in it, producing a perceptible difference; by the slighest addition of sulphuric acid the movement is almost entirely destroyed, and, as a general rule, by all salts and soluble substances. The exceptions are, pure caustic ammonia (but not its compounds), boracic acid, and silicate of soda—gum arabic even possessing the power of increasing the motions. The Professor draws a parallel between Faraday's experiments in the production of electricity by the Armstrong electrical boiler and his own in pedesis, and finds that those substances which prevent or modify the production of electricity operate in the same manner in preventing or modifying pedesis; and hence he considers it as an electrical phenomenon. In attempting to explain the exact *modus operandi*, we can only speculate that the action upon minute irregular fragments will never be exactly equal all round. In order that a particle shall rest motionless in a non-conducting fluid or poorly conducting one, as pure water is, it must be in exact equal and chemical electric relation to the fluid on all sides. It is almost infinitely improbable that this should happen, and a condition of unstable equilibrium within limits is the result. The Professor concludes by pointing out that there is probably a close connection between pedesis and the phenomena of osmose (*London Quarterly Journal of Science*, April, 1878).

Since the publication of the preceding investigations, Professor Jevons, in making some experiments with a view of testing the opinion of Professor Barrett and some other physicists, that pedesis was due to surface-tension, and who have suggested soap as a critical substance, inasmuch as it reduces the tension of water, in which it is dissolved, without much affecting (as is said) its electric conductibility, found that, with a solution of common soap, the pedetic mo-

tion was considerably more marked than before, and he bases on this his explanation of the detergent power of soap. It seemed unaccountable that for cleansing purposes the comparatively neutral soap should be better than the alkaline carbonate itself. The fact is, the detergent action of soap is due to pedesis, by which minute particles are loosened and diffused through the water, so as to be readily carried off. Pure rain or distilled water has a high cleansing power, because it produces pedesis in a high degree. The hardness of impure water arises from the vast decrease of pedesis, due to the salts in solution; hence the inferior cleansing power of such water. By the addition of alkaline salts and soap, we have the alkali dissolving and the pedetic cleansing power. At the same time we have a clear explanation why silicate of soda is now largely used in making soap, this being one of the few universal substances which increase the pedetic and suspensive power of water.

New Journals.

Two new journals devoted to microscopical science and kindred subjects have been commenced during the past year—*Brebissonia*, published in France, and the *American Quarterly Journal of Microscopy*, published in New York. The former is a spicy little journal, published monthly, and devoted principally to Algology and Microscopical Botany. The latter is more extensive in its aims, and promises to be an honor to American journalism.

National Microscopical Congress.

A so-called National Microscopical Congress was held at Indianapolis, August 14–17, 1878, to which most of the leading microscopists of the United States were invited, and in which many of them participated. Some sixteen microscopical societies were represented by delegates, and many creditable papers were read. Of course, in this first meeting there was much informality, and some resolutions were introduced, and some adopted, which, no doubt, will be reconsidered at the next Congress, which is to be held at Buffalo, N. Y., and will be much better attended.

The Limit of Accuracy of Measurement with the Microscope.

Professor W. A. Rogers, of Cambridge, presented a paper at the meeting of the National Microscopical Congress at Indianapolis, on the Limit of Accuracy of Measurement with the Microscope. He finds that two experienced observers can measure the distance between two lines, and obtain figures agreeing within such narrow limits that they are almost identical. The following conclusions are drawn by Professor Rogers: 1. Two equally skilful observers can measure the same space within about $\frac{1}{3000}$ of an inch, if the space does not exceed $\frac{1}{500}$ of an inch; for a space of $\frac{1}{100}$ of an inch, the deviation will probably amount to $\frac{1}{8000}$ of an inch, in case the measurements are made with a filar micrometer. 2. The average deviation for accumulated errors, under similar conditions, is not far from $\frac{1}{5000}$ of an inch for eleven intervals. For a large number of intervals the deviation will be somewhat larger, but it will not be proportioned to the number of intervals.

Microscopic Tracings of Lissajous Curves.

Mr. R. G. West has been successful in tracing these curves on glass, in lines 55,000 to the inch, and in some respects they are considered better fitted for microscopical tests than parallel rulings. Aside from their great beauty, and the necessity for skilful illumination to display them well, the intersection of some lines and the gradual approximation of others, arising from the variation in the figures, where every degree of the sharpness of a curve is obtainable, from a line returning almost upon itself at an exceedingly acute angle, to curves so flat as to present in parts virtually the appearance of parallel straight lines—all this, combined with a knowledge up to a certain point of the nature of all lines cut in glass, makes these rulings more instructive, perhaps, than the markings on diatom valves, about which their is so much question. A curious feature of some of these figures is, that though all the lines would seem to be in the same plane, it sometimes happens that an alteration of focus is requisite to bring out the transverse lines. The same fact has been noticed in observing the transverse markings of the *Diatomaceæ* (*Journal of the Quekett Microscopical Club*, July, 1878).

ANTHROPOLOGY.

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The year 1878 has been a remarkable one for anthropology. Although no startling discovery has revealed the antiquity, or the zoological and geographical origin of man, yet the boundaries of the science have been better defined, the laborers have been more thoroughly organized, the work has been more zealously prosecuted, and the intelligent patrons of science have become more deeply interested.

In presenting the results of the year's work, the same order will be followed that has been observed in former volumes of the *Annual Record*. The investigation of the remains of those races which became extinct without leaving any intelligible inscriptions is generally called *Archæology*. The term is subject to a slight objection from its application to the study of the relics of classical and mediæval times. In France the word *Paléoethnologie*, equivalent to the English Prehistoric Archæology, is employed, and divided into three periods, viz.: Geological Archæology, both tertiary and quaternary; Neolithic Archæology; and Archæology of the Bronze Age and of the first Age of Iron. Much controversy has arisen concerning this terminology, and it is best, therefore, to regard it as provisional, to say the least.

The term Archæology is used in this summary to indicate the science or study of the priscan history of any locality previously to the introduction of written records there. This will constitute the first part of our *résumé*.

The second part, called *Ethnology*, in the absence of a more definite title, will relate to those tribes of men which are now in existence, or which have passed away in recent times. In describing a race of men we may regard them as passive objects of investigation—as organized beings simply—and thus study their natural history; or we may view them

as thinking and social beings, the fabricators and elaborators of their own culture and destiny. The former inquiry—that which contemplates man as a creature—is sometimes called Anthropology proper, and is divided into anatomy, or anthropotomy; biology, including comparative physiology and psychology; and comparative pathology. In the investigations conducted by the most eminent anthropologists, the object has been to ascertain man's place in space and time, and in the animal kingdom, quite as much as to settle the boundaries of the several divisions of the human family.

The latter part of ethnology, or that which views man as a creator rather than as a creature, may be descriptive of a group of consanguinii, occupying the same area, speaking the same tongue, and having the same customs and rites. It is then called *Ethnography.* Language is so peculiarly a human creation and heritage, and the preparation to study its history and laws successfully so laborious and special, that the department of comparative philology, both descriptive and deductive, stands apart as a separate branch of anthropology.

The multiplication of accurate observations relating to civilized and uncivilized races has enabled anthropologists to reduce many of their facts concerning birth, inheritance, marriage, disease, environment, decay, and death to statistical form, and even to predict the recurrence of phenomena which have been regarded as the offspring of caprice. This has been called Demography, and will form the third part of ethnology.

M. Comte invented the term Sociology for the science of society. This subject, first systematically discussed by Dr. Gustav Klemm, in his "Culturgeschichte," has been more thoroughly elaborated by Spencer, Lubbock, and Tylor in later times. It will constitute the fourth and last part of ethnology.

In addition to archæology and ethnology, a summary of anthropology should include the instrumentalities—mechanical, literary, and social—by means of which the science has been advanced.

ARCHÆOLOGY.

AMERICA.

The Smithsonian Institution has published a quarto pamphlet of forty pages, by Mr. Wm. H. Dall, on the Remains of Later Prehistoric Man, obtained from the caves in the Catherina Archipelago, Alaska Territory, and especially from the caves of the Aleutian Islands. The work is descriptive of a group of mummies presented to the National Museum in 1874, and is elegantly illustrated by ten heliotype plates. The annual report of the Institution contains the usual amount of archæological matter. Professor Charles Rau, the Curator of the Museum of Ethnology, describes the Stock in Trade of an Aboriginal Lapidary, which illustrates the subject of the division of labor among the earliest inhabitants of this continent. The paper is based on a large collection of jasper objects, mostly unfinished, ploughed up in Lawrence County, Miss. Professor Rau also contributes a paper on a Gold Ornament from a Mound in Florida. The author is inclined to think that mound-building was continued in this country after its occupation by Europeans. Indeed, the analysis of the ornament proves it to be an alloy of which Spanish coins were made not much more than a century ago. Dr. C. C. Jones, of Atlanta, Ga., contributes to the report three papers. The first is descriptive of Bird-shaped Tumuli in Putnam County, they being the first animal mounds discovered so far south; the second relates to Tumuli on the Savannah River, visited by William Bartram in 1776; and the third is upon Ancient Tumuli on the Oconee River. The description of Polychrome Beads in Relation to American Archæology, by Professor Haldeman and Mr. A. M. Harrison, approaches a subject which has an important bearing upon the age of many of our mounds and earthworks. There are descriptive papers upon Mounds, Earthworks, Shell-heaps, and Relics, in California, Colorado, Wisconsin, Iowa, Arkansas, Missouri, Illinois, Ohio, Kentucky, Tennessee, Alabama, Florida, Pennsylvania, and New York. The Smithsonian Institution has issued a pamphlet of directions to collectors and observers for the purpose of illustrating the forms and dis-

tribution of aboriginal relics, and of locating on an archæological map the permanent remains of every kind in North America.

The eleventh annual report of the Peabody Museum at Cambridge is an important addition to our archæological literature. The inauguration of the new building offers an occasion for the history of the institution. Dr. Charles C. Abbott makes his second report upon the Palæolithic Implements from the "Drift," in the valley of the Delaware, near Trenton, N. J. Dr. Hoffman has collected a great number of similar implements from the gravel beds near Uniontown, in the District of Columbia; and Mr. A. F. Berlin, of Reading, Pa., has made similar discoveries in that place, an account of which is printed in the first number of the *American Antiquarian*. The subject of Implements in the Drift is also discussed by Mr. Thomas Belt, in the *Quarterly Journal of Science* for January. The Peabody Museum Report has a detailed account of Archæological Explorations in Tennessee, by F. W. Putnam, the curator of the museum. The paper is profusely illustrated and accompanied by a map of an earthwork on the Lindsley estate, Lebanon, Tenn., which the author believes to be the remains of an aboriginal settlement. Paul Schumacher describes the Manufacture of Stone Implements in Southern California, where he has labored so long and successfully. Professor Blake contributes some notes on a Collection from the Ancient Cemetery on the Bay of Chacota, Peru.

The Davenport Academy, Iowa, has not been idle in archæological matters. The forthcoming report, in addition to the usual amount of mound literature, will contain the account of another tablet.

Quite a number of archæological papers were read at the American Association, St. Louis. Indeed, owing to the proximity of the city to the material, section B was nearly absorbed by discussions upon Prehistoric Man. Two papers of enduring interest were read. One, by Ad. F. Bandelier, was on the Sources for Aboriginal History of Spanish America; the other, by Hon. J. G. Henderson, upon Ancient Mounds in Illinois. Mound Explorations in Southeastern Missouri are described by Mr. C. Croswell in the *Transactions* of the St. Louis Academy. In the October number of the

Kansas City Review, Mr. Conant describes Ancient Mound Pottery, of which the author has a fine collection. Mr. Conant is the author of the archæological portion of the work entitled "The Commonwealth of Missouri."

The State Archæological Association of Indiana met at Indianapolis, August 29.

In the State of Ohio we have an illustration of the necessity of a proper environment to mental activity. The Cincinnati Society of Natural History has published several communications upon the Archæology of the State. A paper by Dr. Howe on American Antiquities, and one by Dr. Metz upon the Mounds and Earthworks of the Little Miami Valley, are especially worthy of mention, the latter being the first attempt to apply the symbols of Messrs. Mortillet and Chantre to American remains. The final report of the Ohio State Board of Centennial Managers contains illustrated papers of great permanent value by Colonel Whittlesey and Professor M. C. Read. The Western Reserve and Northern Ohio Historical Society has published several papers on antiquarian subjects. Number 41 of their papers is by Colonel Whittlesey, the president. The establishment of the *American Antiquarian*, by the Rev. S. D. Peet, of Unionville, O., is the first attempt to publish a periodical purely in the interest of American Archæology and Ethnology. The first number contains papers on Ancient Garden-beds of Michigan, Mounds and Earthworks, Ancient Trails, Modern Indian Tribes, the Discovery of the Ohio River, and the Dighton Rock Inscription. The second number has communications on the Comparison of Pueblo Pottery with Egyptian and Greek Ceramics, Traditions of the Deluge, Mounds and Earthworks, the Location of the Tribes of the Northwest Territory, Leaf-shaped Implements, and Perforated Tablets.

A good summary upon Prehistoric Copper Implements in North America, by Dr. Emil Schmidt, will be found in the *Archiv für Anthropologie*, Parts I. and II. (see also an article by Dr. Max Rothauer in the *Correspondenzblatt* for June).

The popular and scientific journals of our country have done a great deal to foster the study of man. The *Popular Science Monthly* is especially good in foreign notes. *Harper's Monthly Magazine* contains every month notes on Anthropology. The *American Naturalist*, in addition to the

publication of articles on anthropological topics, has a department on this subject, where notes and reviews of works in all parts of the world are published. During the last year valuable papers have appeared by Dall, Schumacher, Bowers, Palmer, Barber, and others of equal merit. The *Kansas City Review* is very useful in disseminating a taste for this branch of study in the West. The *American Journal* gives us two papers of great value—one by Professor Asa Gray, on Forest Geography and Archæology; the other by Mr. McGee, upon a Standard of Measure among the Ancient Mound-builders.

The only mention of the Archæology of the United States in the report of the Committee at the Paris Exposition is of a Collection of plaster-of-Paris Models of the Pueblos and Cliff-dwellings of Arizona, made by Mr. William H. Jackson, and sent by Professor F. V. Hayden.

Mr. James C. Southall, of Richmond, Va., is the author of a work entitled "The Epoch of the Mammoth and the Apparition of Man on Earth." Although relating chiefly to European materials, it refers also to our own stone age. The author contends for an extremely brief residence of man on earth.

On Mexican archæology, the pamphlet of Professor Valentini, entitled "Vortrag über den Mexicanischen Calenderstein," translated by Mr. Stephen Salisbury, in the *Proceedings* of the American Antiquarian Society, No. 71, is a work of rare merit, and may be reckoned among the permanent productions of the year. In the same number of the *Proceedings* is a long communication upon the Antiquities of the Isla Mujeres, on the northeast coast of Yucatan. The relics were discovered by Dr. Le Plongeon, who has been very successful among Maya remains.

A very creditable publication entitled *Anales del Museo Nacional de México* has reached the fourth part, and contains in each number communications on Mexican Antiquities.

In the *Zeitschrift für Ethnologie*, 1876, p. 322, Professor Bastian announces the discovery of interesting sculptures at Santa Lucia, near the city of Guatemala, which he purchased for the Berlin Museum. But more than ten years previously, Dr. Habel, of New York, travelling at his own expense, discovered the sculptures, and copied and described them with

the greatest accuracy. An account of his travels and work will be found in the "Report of the Secretary of the Smithsonian Institution" for 1877, and in a beautifully illustrated quarto, published by the same at the beginning of 1879. Papers on Central American Antiquities are also mentioned as found in the *Annales de Philosophie Chrétienne.*

In the *Revue d'Anthropologie* for October, Señor Estanislas Ceballos describes a Prehistoric Tumulus in Buenos Ayres. In the same journal, pp. 365–368, is a description of the Cemeteries and Paraderos of the Province of Entrerios. In the *Geographical Magazine*, No. 8, Don Francisco P. Moreno speaks of his researches in Patagonia. On South American archæology, consult also the *Revue d'Anthropologie*, p. 713. Professor Bastian, after enjoying rare advantages of travel and exploration, has published, in Berlin, "Die Culturländer des Alten Amerika," in two volumes.

EUROPE.

The *Journal* of the Anthropological Institute of Great Britain and Ireland is the official organ for English anthropologists. Owing to the extensive commerce of Britain, and the distribution of her colonies, the archæological department of anthropology is overshadowed by ethnology. Papers on Flint Implements in Ireland, at Cissbury, and in the valley of the Axe, occur in the numbers of the *Journal* for 1878. In *Nature*, for August 22, is a review of Greenwell's work on British Barrows; and in the same number, Professor Huxley's address before the Anthropological Section of the British Association at Dublin. The most meagre report of the meeting has reached America.

The best system of research, and of the preservation of antiquities, is to be seen in Denmark, where all relics are made the property of the government. The law has been modified on several occasions, but at present all "finds" are sent to Professor Worsaae, who has the whole matter in charge. Papers on Danish Antiquities are to be found in the *Correspondenzblatt*, especially in No. 3, pp. 18, 19; and in the *Proceedings* of the Society of Northern Antiquaries.

The accounts of the exhibit of Russian antiquities at the Paris Exposition represent the collections as very large and attractive. The Société Impériale des Amis des Sciences

Naturelles, d'Anthropologie et d'Ethnographie de Moscow, of which more will be said under Ethnography, has published in its *Bulletins* (*Izvestia*) a goodly number of archæological papers, especially referring to the Tumuli (*Kourganes*), 3000 of which have been opened, yielding over 10,000 objects. The Royal Archæological Commission of St. Petersburg have been engaged in making a systematic investigation of the antiquities of Russian territory. Their work is described by Dr. John Hawelka in the *Mittheilungen der Anthropologischen Gesellschaft in Wien.* The same journal is devoted to the archæology of Austro-Hungary.

The archæology of Germany finds its exponent in the *Archiv für Anthropologie*, published in Brunswick; in the *Zeitschrift für Ethnologie*, published in Berlin; and in the *Transactions* of the various branches of the German Anthropological Society, reported monthly in the *Correspondenzblatt*, published in Basle, by D. Kollman. The first number of the *Archiv* for 1878 contains a paper by Dr. Alf. Nehring, on the Quaternary Fauna of Thiede and Westregeln, together with Traces of Prehistoric Man. The *Correspondenzblatt*, No. 3, gives the report of Dr. Fraas on a Prehistoric Chart of Germany; and No. 9, a stenographic report of the ninth annual meeting of the German Anthropological Society, together with the address of the president, Dr. Schaffhausen.

Upon Swiss archæology, Dr. Ferdinand Keller's great work on the Lake-dwellings of Switzerland and other parts of Europe leaves nothing to be desired. The English translation, by John Edward Lee, gives to this work a deserved publicity in Britain and America. Dr. Much contributes to the *Mittheilungen*, vol. vii., p. 378, a paper on Prehistoric Architecture and the Ornamentation of Human Dwellings.

The archæology of France and the study of archæology in France would be difficult to summarize if French savans did not anticipate our wants in this direction. *Matériaux pour l'Histoire Primitive et Naturelle de l'Homme* (Toulouse), *Bulletins de la Société d'Anthropologie*, and especially the Revue Prehistorique of the *Revue d'Anthropologie*, conducted by M. de Mortillet, are indispensable alike to the student of local archæology and to the general inquirer. In addition to these, many French journals publish papers on the subject, notably the *Revue Scientifique.*

In the October number of the *Revue d'Anthropologie*, we have three papers, prepared with the greatest care, and giving a *résumé* of the subject of archæology at the French Exposition. The communications are entitled: Rapport sur la Paléoethnologie—Temps Geologiques, par M. Gabriel de Mortillet; Rapport sur la Paléoethnologie—Periode Neolithique, ou de la Pierre Polie, par M. Émile Cartailhac (this paper has a list of all the neolithic collections on exhibition); Rapport sur la Paléoethnologie—Periode du Bronze et Premier Âge du Fer, par M. Edward Chantre. Reports on the same subject will be found in the September number of the *Contemporary Review*, in the files of the *Revue Scientifique*, and of the *Athenæum*. The energy and skill with which the conductors managed the exhibition, as well as the promptness with which their demands were met, render this the greatest object-lesson on antiquity which the world will witness for many years. The work of M. Chantre on the Bronze Age in France is reviewed in the *Revue Scientifique* for April 6, pp. 933–941.

Archæology in Italy is reviewed in the *Academy* for January 12. The *Revue d'Anthropologie* also notices works and papers of merit on the same subject. Dr. Schliemann, not content with having brought to light two famous cities of antiquity, writes a letter to the *Times*, an abstract of which is in *Nature* for October 3, describing his search for the ancient capital of the island of Utica.

Mr. Julius Schubring has written several letters to the *Athenæum* during the year upon the Excavations at Olympia. In the number for November 23, he commences a series of papers on the Olympian Exhibition at Berlin. The same journal produces a number of interesting sketches upon the island of Cyprus, concerning which a renewed interest has been awakened through its acquisition by the British government.

The subject of archæology, and of prehistoric man in general, has been the theme of many able discussions and treatises. Dr. Paul Boca delivered an address upon the Fossil Races of Europe at the opening of the French Association at Havre; Dr. A. Ecker contributes to the *Archiv*, I. and II., a paper on Prehistoric Art; Professor Max Müller treats of Ancient Times and Ancient Men in *Macmillan's Magazine* for June;

in the *Annales de Philosophie Chrétienne*, January and February, is a paper by H. J. Anselm, entitled La Terre Antediluvienne sous le nom de l'Atlantide; Dr. George Fischer discusses Mineralogy as the Handmaid of Archæology in the *Archiv*, vol. x., No. 4; Mr. Hodder M. Westropp publishes, through Bohn, a Hand-book of Egyptian, Grecian, Etruscan, and Roman Archæology; and Mr. C. F. Keary, a work entitled "The Dawn of History, an Introduction to Prehistoric Study," through Mozley & Smith.

AFRICA.

On African archæology there is very little to mention outside of Egypt. The republication of Sir Gardiner Wilkinson's work on the "Manners and Customs of the Ancient Egyptians," under the editorial supervision of Dr. Samuel Birch, leaves little to be desired in this direction. In the *Journal* of the Anthropological Institute, vol. vii., p. 323, Captain R. F. Burton describes a Collection of Flint Flakes from Egypt. M. S. Berthelot contributes to the *Revue d'Anthropologie*, p. 232, a paper on New Discoveries of Antiquities at Forteventura, Canaries. In the *Cape Monthly*, p. 257, is an article by Dr. Theophilus Hahn, on the Graves of Heitsieibit.

ASIA.

If Africa, outside of Egypt, has little to attract the archæologist, Asia, by the abundance of her antiquities, completely overwhelms him. To commence with Palestine, the Exploration Fund of England, and the labors of Dr. Merrill, accounts of which appeared in the *Athenæum* from time to time, are the principal researches. Lieutenant Conder has published a volume on Palestine, from materials collected while laboring for the Fund. The endless discussion about the value of the Shapira pottery has narrowed down to a personal controversy concerning human veracity. For the Mesopotamian valley, the papers read before the Society of Biblical Archæology are of the first importance. In addition to these, valuable material is to be found in the publications of the Royal Asiatic Society and its branches, of the Morgenländische Gesellschaft, and of the Société Asiatique, not only concerning Mesopotamian antiquities, but also for the whole Asiatic continent. Mr. Layard has sent to Eng-

land the sole relics of bronze art-work from Lake Van. Mr. W. St. Chad Boscawen gives us a compendious account of the primitive culture of Babylonia in the *Journal* of the Anthropological Institute, p. 21. The *London Quarterly Review* for January has an epitome of the Study of Assyriology.

For India, the reader is referred to Trübner's *American and Oriental Record*, and to the three great societies mentioned above. Major-General Cunningham publishes Vol. I. of "Corpus Inscriptionum Indicarum," Inscriptions of Asoka. The *Journal* of the Royal Geographical Society frequently contains archæological papers. In Vol. XLVII. will be found papers by Sir T. Douglas Forsyth, on the Buried Cities in the Shifting Sands of the Great Desert of Gobi.

Abbé Petitot, whose works on Eskimo and the Tinne Indians have become celebrated, contributes to the *Revue d'Anthropologie* a paper upon Tahan et les Pays des Femmes, de l'Historien Chinois Li-you-Tcheou, which is an attempt to connect the Chinese with the early settlement of America. The same journal, p. 666, contains a communication on the Ruins in Cambodia called *Khmers*. At the Paris Exposition, in the hall of Missions, Trocadero Palace, there was a fine exhibit of these ruins. Of them Dr. Bordier says: "These antique structures, the Khmers of Angkor, to which should be added the ruins of Bouro-Boudor in Java, exhibit a boldness of construction, with a *finesse* in handling the Arabesques, which recalls the Renaissance. These monuments, erected in honor of Buddha, and to-day filled with fallen leaves, await the light of scholarly science."

Professor Morse, who has been employed by the Japanese government to work up the geology and natural history of the country, has discovered shell-heaps near Tokio, and in them pottery referred to a prehistoric race, whose ornamentation resembles the patterns on the dress of the Ainos.

OCEANICA.

The island of New Zealand boasts an Institute, whose *Transactions* contain many archæological papers from the pen of Mr. Hector and of Mr. Von Haast. In the *Journal* of the Anthropological Institute, p. 50, the latter gentleman describes a series of rock-paintings in New Zealand.

ETHNOLOGY.

ANATOMY, PHYSIOLOGY, AND PSYCHOLOGY OF RACES.

This branch of anthropology, as before mentioned, regards man as a member of the animal kingdom, amenable to zoological laws. By Dr. Topinard, this portion of the subject is divided into two parts: Zoological Anthropology, or the Comparison of Man with other Animals; and Special Anthropology, or the Study of the Natural Divisions of the Human Race. In an analytical point of view he divides the study into three subdivisions: 1. Anatomical anthropology; 2. Biological anthropology, including racial psychological phenomena; 3. Pathological anthropology, an appendix to the second, treating of the relation of disease to race. To anatomical anthropology belong craniometry and anthropometry. To biological anthropology many subsidiary questions belong, such as the character and color of the hair and the skin, the origin and nature of the intellectual faculties, the influence of environment, and the effects of hybridity. To pathological anthropology are relegated such subjects as teratology, prehistoric surgery, malformations, microcephaly, and the like.

The Army Medical Museum at Washington, under the charge of Dr. George A. Otis, has now 1952 entries in the department of skeletons, crania, and calvaria. Most of these are North American. The specimens are all carefully prepared, numbered, and mounted; and the principal measurements made and recorded. The publication of the "Medical and Surgical History of the War" has absorbed the appropriations of this department hitherto, and deferred the report upon these objects.

In the eleventh annual report of the Peabody Museum at Cambridge, the measurements of the crania received during the year are carefully recorded and published by Mr. Lucien Carr, Jr.

There are several fine private collections of mound-builders' crania in the possession of our Western archæologists. Members of the American Association, at St. Louis this summer, had the pleasure of inspecting those of Dr. George Engelmann, Jun., and Dr. J. H. Patrick.

Dr. A. J. Parker read before the Academy of Natural Sciences, Philadelphia, a communication on the Convolutions of the Negro Brain. Upon the subject of cerebral convolutions, additional references will be given further on.

In the *Popular Science Monthly* for August, Mr. A. R. Grote has an article on Man and his Structural Affinities. In the same number the subject of Composite Portraits is discussed by Mr. Francis Galton. The object of this study is to combine in one photograph several faces, so as to eliminate individual characteristics, and bring out those that are typical.

Murray, of London, publishes a work by Wm. J. Thoms on the Longevity of Man. In the *Journal* of the Anthropological Institute is a paper by Professor Rolleston, read May 14, describing a Skeleton found at Cissbury. The Anthropometric Committee of the British Association have issued instructions for the measurement of individuals in the British Isles. A manual on the same subject is announced by Mr. Charles Roberts, of London. Kaltbrunner's "Manuel du Voyageur," published by Wurster & Co., Zurich, contains nearly 300 pages of anthropological instructions.

Mr. H. C. Sorby contributes to Vol. VIII. of the *Journal* of the Anthropological Institute a memoir of extraordinary interest on the Coloring Matter in the Human Hair. Consult also Dr. Schwalbe's article entitled Ueber die Menschliche Haare, in the *Correspondenzblatt*, No. 1.

Chapman & Hall, of London, issue an English edition of Topinard's work on Anthropology; the same work appears as Vol. III. in the "Library of Contemporary Science."

A review of the whole subject of Brain-weight is given in the *Revue d'Anthropologie*, pp. 277–285, by Dr. Samuel Pozzi. The paper is accompanied by tables and copious references to authorities, which make it a desirable work of reference to comparative anatomists. In the same journal, Dr. Paul Broca makes several very important communications concerning the brain. In No. 1, pp. 1–47, is a discussion of the Brain of the Gorilla. In No. 2, pp. 193–237, Dr. Broca treats of Cerebral Nomenclature, Names of the Divisions and Subdivisions of the Hemispheres, and of the Anfractuosities on their Surfaces. In No. 3, pp. 385–499, the subject of the memoir is the Comparative Anatomy of the Cerebral Convolutions: the great limbic lobe and fissure in the series of mammals.

In the fourth number is the address of Dr. Broca before the International Congress of Anthropological Sciences.

The great work of MM. de Quatrefages and Hamy, entitled "Crania Ethnica," in which are figured and described the Skulls in the Museum of Natural History and in the Museum of the Société d'Anthropologie, of Paris, and in the principal collections in France and foreign countries, has reached its sixth part. The subject of Pathological Anatomy is discussed by Dr. Bordier in the *Revue d'Anthropologie*, p. 76. In the same periodical, p. 703, Dr. Topinard makes a report on the Anthropological Collections exhibited at the Paris Exposition. The same author gives, pp. 499–509, "Essai de Classification des Races humaines actuelles."

The subject of Craniology has not been neglected in Germany. Dr. Gildmeister, in *Archiv*, I. and II., investigates the form of the skull in the northern Germans. In the same journal, III., 1877, Dr. Heftler and Dr. Ecker discuss the methods of comparing the skull with the surface of the brain. In No. 7 of *Correspondenzblatt* is a report on the Craniometric Conference in Munich, 1877. With reference to the great variety of methods in measuring and orienting the skull, by which a great amount of painstaking is vitiated, Dr. Topinard, in his report above alluded to, observes that the method of cubage employed by Morton, and perfected by Broca, is by far the simplest. He also advises uniting upon the alveolo-condylian plane as the basis for orienting the skull, since the plane of the two eyes, or orbital cavities, is horizontal in man and all other mammals. A critical review of the papers of an anthropological nature which have appeared in the *Archives de Medicine Navale* from 1874 to 1876, by Dr. Bordier, will be found in the *Revue d'Anthropologie*, pp. 319–327.

In the *Archivio per l'Antropologia*, vol. viii., fasc. 2, pp. 267–442, Professor Paul Mantegazza publishes an elaborate memoir on the Third Molar in Different Races of Men. In many respects, this is the most thorough anthropological publication of the year. The conclusions stated at the end, based on the examination of 277 crania, are not altogether favorable to the theory of evolution. Dr. Lambert treats the same subject in the *American Journal* for October, 1877. The Teeth of the Mound-builders is the subject of a paper in

the *Dental Cosmos* for September. C. Lambroso discusses the Influence of Orography upon Stature in the *Archivio di Statistica*, Rome, fasc. 3.

In the *Archivio*, pp. 189–266, Dr. Paul Ricardi describes a Skeleton from Acheen, in the northwest of Sumatra. M. E. Callamand makes a communication to the *Revue d'Anthropologie*, pp. 607–625, upon the Skulls of the Black Races of India. Dr. Stuart Eldridge read a paper before the Asiatic Society of Japan, on the Crania of the Botans of Formosa, which is printed in Vol. V. of the *Proceedings*.

ETHNOGRAPHY.

Ethnography, or the description of races, is the connecting link between Biological Anthropology, on the one hand, and Sociology on the other. It is that division of the subject which is most attractive to the mass of intelligent people, and to which they can most easily contribute. The greater part of its facts and materials have been gathered by travellers or business men, who visit every corner of the world in pursuance of their duties. The navies of the various leading nations, the merchant marine, foreign troops, missionaries, newspaper reporters, and diplomats have all rendered important service to Ethnography. The work accomplished during the year includes organized expeditions for the purpose of gathering materials, as well as the description and exhibition of what was already in hand.

America.

The *Geographical Magazine* for February, March, and April publishes the memoirs of Hans Hendrik, the Greenland Eskimo, who served in the expeditions of Kane, Hayes, Hall, and Sir George Nares. The Greenland Eskimo are the subject of an article in *Das Ausland*, Nos. 1 and 2. A group of them were on exhibition at the Jardin d'Acclimation, during the Paris Exposition. In the *American Naturalist* for January, Mr. Dall gives a sketch of the Eskimos of Norton Sound, reproducing two very charming romances to illustrate the scope which savage life affords for individuality. The Hon. J. G. Henderson read a paper before the American Association, on Ancient Names—Geographical, Tribal, and

Personal—in the Mississippi Valley. In Nos. 1 and 2 of the *American Antiquarian*, the editor works up the location of ancient tribes in the States formerly called the Northwest Territory. Volume III. of "Contributions to North American Ethnology" is the most important addition to the knowledge of our aborigines issued during the year. It is one of a series to be published by Major J. W. Powell, under the auspices of the Secretary of the Interior. The first part of the volume is by Stephen Powers, on the Tribes of California. The second part is a collection of linguistics of the following families: Ká-rok, Yú-rok, Chim-a-rí-ko, Wish-ŏsk′, Yú-ki, Pó-mo, Win-tun′, Mut-sun′, Santa Barbara, Yó-kuts, Maí-du, A-cho-mâ′-wi, and Shas′-ti. The vocabularies were collected mainly under the auspices of the Smithsonian Institution, and were edited by Major Powell. A good account of Major Powell's work will be found in the "Annual Report of the Smithsonian Institution" for 1877, pp. 82–86. The paper of Colonel Garrick Mallery, on the Present and Former Population of the United States, read before the Nashville meeting of the American Association, and published in the *Proceedings*, has elicited much comment at home and abroad, and has begun to bear fruit in shaping legislation with reference to savage races. Further discussions upon the Tribes of the United States, by Barber, Palmer, and Spring, will be found in the *American Naturalist*, and in *Globus*, 1877, vol. xxxii., pp. 281, 295.

Les Premiers Habitants du Mexique is the title of a paper by M. E. Hamy, in the *Revue d'Anthropologie*, p. 56; but the best account of the ancient Mexican civilization by far is the monograph on the Distribution and Tenure of Lands, and the Customs with respect to Inheritance among the Ancient Mexicans, by Ad. F. Bandelier, in the eleventh "Annual Report of the Peabody Museum." The work is crowded with references, and bristles with research. The author belongs to the Morgan school, and whether all his deductions are to be accepted or not, we can afford to have much of the ancient glamour removed from the study of Mexican history. M. Malte-Brun has reproduced, with improvements, Orozco y Berras' ethnographic map of Mexico, under the title "Tableau geographique de la Distribution ethnographique des Nations et des Langues au Mexique," published by Crepin-Leblond, Nancy.

On South American ethnography we have to notice the Travels of Dr. Habel, mentioned in "Smithsonian Report," 1877, pp. 13–16; the work of Mr. Bates, published in London, with an appendix by A. H. Keane; the Description of the Quichuas of Ecuador, in *Globus*, p. 380; a Sketch of the Zaparos, by Mr. Alfred Simpson, *Journal* of the Anthropological Institute, Oct.; the Indians of Peru, by F. L. Galt, "Smithsonian Report," 1877, p. 308; and Die Lebensweise und Geräthe der südchilenischen Indianer, *Correspondenzblatt*, No. 1.

Europe.

Scandinavian ethnography at the Paris Exposition, including the exhibit of the Stockholm Ethnographic Museum, the models of M. Sœderman, and the Finnish Group in charge of M. Aspelin, is spoken of in the highest terms. In addition to photographs and thousands of culture-historical objects, lay figures, in groups, were dressed in their appropriate costumes, and exhibited in cases fitted up to represent the appropriate environment.

In the early part of the year was organized at Paris, in the Palace of Industry, an ethnographic museum, bringing together the collections scattered in various departments throughout the city. On the occasion of the opening a series of twenty-six lectures were delivered upon ethnographic subjects by the most distinguished savans and travellers in Paris. The titles of the papers and the names of the lecturers are given in the *Revue Scientifique.*

The Ethnography of Germany is discussed by H. H. Howorth, in the *Journal* of the Anthropological Institute, pp. 211, 293. The distinguished author has made a series of communications to the same journal and others, upon the Tribes of Europe at the Dawn of History. An article in the *Edinburgh Review* for July is devoted to the Origin and Wandering of the Gypsies. Dr. Mehlis, in No. 4 of *Das Ausland*, has a paper entitled Studien zur Völkerbewegung in Mitteleuropa.

Since the breaking-out of the Russo-Turkish war, the greatest enthusiasm has been awakened concerning the ethnography of European Russia and Turkey. The 54th Ergänzungsheft of Petermann's *Mittheilungen* is devoted to the Ethnography of Russia, and is illustrated by a colored map.

The ninth number of the same journal has a chart of the principal races of Russia. No. 3 of Harper's Franklin Square Library describes "The Russians of To-day." At the Paris Exposition the Russian exhibit was especially praiseworthy. The Société Imperiale, of Moscow, having in view a grand exhibition of all the peoples under Russian dominion at Moscow, in 1879, were able to bring the material already gathered to Paris. Notice is also directed to Dr. Wilhelm Thomsen's work on the "Relations between Ancient Russia and Scandinavia, and the Origin of the Russian State," published by Parker, in London; to A. Rambaud's "History of Russia," published by Hachette, in Paris; and to the memoirs of Howorth, on the Spread of the Slaves, in the *Journal* of the Anthropological Institute, vol. vii., p. 324; vol. viii., p. 65. The Anthropological Society of Vienna exhibited at Paris several beautiful collections illustrative of Slavic races.

In the *Geographical Magazine* for April and September; Petermann's *Mittheilungen*, vol. iv., p. 125; vol. v., p. 192; vol. x., p. 365; the *Atlantic Monthly* for April; the *Athenæum* of March 30; and the *Fortnightly* for June, are papers on the Races included within the Dominion of European Turkey. Murray, of London, issues a volume entitled "The People of Turkey," by a Consul's Daughter and Wife; and a compend of the work constitutes No. 12 of Harper's Franklin Square Library.

Africa.

Stanley's "Through the Dark Continent," elegantly brought out in two volumes by the Harpers, in addition to being a graphic account of adventure and discovery, contains much of permanent ethnological interest. The Paris Exposition was especially rich in African materials. The French colonies in the north, the Cabyles or Berbers; the colony of Senegal, including the Moors, Yoloffs, Sarracolais, Bambaras, Mandingoes, Foulahs, and Toucouleurs; the Krumen, Pahouins, M'pongwes, and Congos of Central and Western Africa; the Buschmen and Cape tribes, were all exhibited, not only by their arts, but also in anatomical specimens and living individuals. Attention is further directed to Etude sur les Soninkes (of Soudan), by Dr. Ferand, in the *Revue d'Anthropologie*, pp. 584–606; to a paper on the Nyassa, by H. B. Cotterell, in the *Proceedings* of the Royal Geographical So-

ciety, vol. xxii., p. 233; and another on the Prospects and Future Government of the Transvaal, by G. P. Moodie, *Journal* of the United Service Institute, vol. xxii., p. 583.

Asia.

The *Fortnightly Magazine* for June has two articles on Asiatic Ethnology. One is by Mr. James Bryce, on the Future of Asiatic Turkey, and the other by W. R. Greg, on Asiatic Forces in our European Wars. The breaking-out of the Afghan war has made this region a field of renewed ethnographic interest. A commission of the Russian Geographical Society has been engaged in collecting materials for a work upon the geography, ethnography, and statistics of Asiatic Russia.

The explorations of M. Prejevalsky in Central Asia, from Kuldja across the Thian Shan to Lob Nor and the Allyn Tag, form the 53d Ergänzungsheft to Petermann's *Mittheilungen*, and are noticed, with a map, in the *Geographical Magazine* for May. Thanks to the University of Moscow, and the mission of M. Ujfalvy, Central Asia was well represented at the Paris Exposition.

Coming to British India, one is tempted to pass over it entirely on account of the embarrassing richness of the material. The *Geographical Magazine* for January and February contains a memoir by R. N. Cust, on a Language-map of India. In the January number the map relates to British India and the Border States, and in the February number to Further India and the Indian Archipelago. Without venturing to criticise the accuracy of the boundaries, it is but just to say that the method of administering the colors is very excellent. The following works and memoirs on India are worthy of attention: "Modern India and the Indians," by Monier Williams (Trübner & Co.); "A Statistical Account of Bengal," in 20 volumes, by W. W. Hunter, same publisher; "The Languages and Races of Dardistan," by G. W. Leitner, Lahore; "Notes sur les Bahmars," by Dr. A. Morice, in the *Revue d'Anthropologie*, pp. 626–665; and "The Inland Tribes of Great Nicobar," by Fr. de Rœpstorff, in the *Geographical Magazine* for February. The *Journal* of the Anthropological Institute for May contains a profusely illustrated paper on the Andamanese. Of the Indian exhibit in Paris, Dr.

Bordier says: "India is represented in our Exposition in such a brilliant manner as to demand not only the pen of a savant to describe it, but the taste and critical discrimination of an artist to appreciate it."

In the *Proceedings* of the Royal Geographical Society, vol. xxii., p. 255, is a description of Travels in Western China and the Borders of Eastern Thibet, by Captain W. J. Gill. The *Journals* and *Proceedings* of the Asiatic Societies of London, Paris, and Germany, together with their branches in China, must be our resource for progress of knowledge in Chinese ethnography. Trübner's *American and Oriental Record* is indispensable.

Oceanica.

Upon the ethnography of Oceanica several very important works have appeared. The Rev. S. J. Whitmee read a paper on the Ethnography of the Islands of the Pacific Ocean, before the Anthropological Institute, June 20, and publishes a paper on the Characteristics of the Malayo-Polynesians in the *Journal* of the same society, vol. vii., p. 372. The same number contains a report by the Rev. M. G. Turner, on the Ethnography of the Motu; and reviews a lecture of Professor W. H. Flower, before the Royal Institution of Great Britain, on the Native Races of the Pacific Ocean. Vol. VIII., p. 38, contains a discussion of the Original Range of the Papuan and Negritto Races, by Francis A. Allen. The collections from Australia and Polynesia at Paris were very instructive. The chart of M. de Quatrefages showed the slow migration towards the east of a people who, setting out from Bourou, peopled successively not only the Solomon Islands, Samoa, Tonga, and Taiti, but also New Zealand on the south, and Hawaii on the north.

DEMOGRAPHY.

To Achille Guillard is due the credit of applying the term Demography to the "natural history of society," the science which reduces to numbers the facts of the social life of different races. Under the direction of the Société d'Anthropologie of Paris, the study of demography is made a part of the anthropological course. Dr. Bertillon has the charge of this department, and he has succeeded in giving the subject shape and direction. The report on this subject at the

Paris Exposition is by Dr. Chervin, director of *Annales de Demographie Internationale*, and appears in the *Revue d'Anthropologie*, pp. 740–744. Among the statistics of various countries Dr. Chervin mentions those of Sweden, by Dr. Berg; and those of France, by Dr. Bertillon, as especially noteworthy.

At the November meeting of the National Academy in New York, Mr. A. Hyatt made some remarks on an Investigation of the Laws of Heredity, undertaken by the State Board of Health of Massachusetts. The Bureau of Education, at Washington, is collecting a mass of statistical information which will be valuable to ethnologists, especially with reference to the decrease of population, and the progress made in civilization by our Indians and Negroes. Ergänzungsheft 55, of Petermann's *Mittheilungen*, is devoted to "Die Bevölkerung der Erde," of Behm and Wagner, an elaborate report upon the population of the earth. The sum total of humanity is reckoned to be 1,439,145,300. Sir David Wedderburn discusses the Dying-out of the Polynesians, in an article reproduced in the 3d Supplement of the *Popular Science Monthly*, from the *Fortnightly*. As is customary, our new science has an organ entitled *Annales de Demographie Internationale; Recueil Trimestriel de Travaux Originaux et de Documents Statistiques, et Bulletin Bibliographique speciel*, published by Dr. Chervin. An excellent review of this journal, by Dr. Collineau, will be found in the *Revue d'Anthropologie*, pp. 118–124.

PHILOLOGY.

The object of this branch of anthropology is to subject all human languages to a comparative study, in the same manner as the zoologist investigates the animal creation, in order to ascertain their affinities and differences, and through them to trace the migrations of nations and the evolution of civilization. "In the present state of the science," says M. Hovelacque, "the natural classification of languages does not agree with ethnic classifications. The unfortunate axiom 'like language, like race,' has retarded the progress of anthropology proper, and of philology. The morphological division of languages is the only one that does not prejudge the question of ethnic origin."

All that could be reasonably expected in North American Indian philology is now being done under the direction of Major J. W. Powell, to whom the Smithsonian Institution has confided the linguistic material collected since its foundation. A brief sketch of this work will be found in the "Annual Report" for 1877, p. 82, and in the Report of Major Powell to the Secretary of the Interior. The Indians of North America are divided into 64 linguistic stocks. Some of these are very small, while others cover an immense area. Major Powell is especially conversant with the tribes of the Great Interior Basin, commonly known as Shoshonees or Numas. Other parts of the work are allotted to specialists in each department. Mr. Dall will superintend the publication of the Inuit manuscripts; Mr. Gatschet, the author of several linguistic papers, will contribute a great deal of material upon the Northern Californian and Southern Oregon tribes; Messrs. Riggs and Dorsey will take charge of the Dakota tribes; Mr. Trumbull will be the chief authority upon the Algonkin stock; Mr. Mason will have charge of the Cherokee and Chahta-Muskokee linguistic material, and will also prepare a synonymy of all the tribes. Mr. Powers has already worked up the Central Californian tribes in Powell's third volume. Colonel Mallery will collect the material for the historical and political portion of the work; and Mr. Pilling will compile the bibliography. In addition to these collaborators, the best available aid has been invoked to collect vocabularies and grammars from the tribes.

Only the most meagre outline of the immense amount of work done in philology by European scholars can be given. The sources to which the inquirer should go are the publications of the London Philological Society, the *Revue Linguistique*, and Lazarus and Steinthal's *Zeitschrift für Völkerpsychologie und Sprachwissenschaft.* The journals of all the great anthropological societies of Great Britain, France, Germany, Sweden, Denmark, Russia, and Italy also publish a great deal of matter relating to comparative philology.

Professor R. G. Latham has published, in London, "Outlines of General and Developmental Philology," and Mr. Sayce, an "Introduction to the Science of Language." In the *Revue d'Anthropologie*, p. 47, M. Hovelacque treats of the

Classification of Languages in Anthropology. Maisonneuve & Co., Paris, are preparing the Lord's Prayer in more than 1200 languages and dialects. The literature of the Servians and Croats is the subject of an article in the *Westminster Review* for April. Bagster & Sons publish "Lectures on Assyrian Philology," by the Rev. A. H. Sayce.

A most excellent graphic representation of the Distribution of the Languages of India is published by R. N. Cust, in the *Geographical Magazine* for January and February. Trübner & Co. publish a catalogue of manuscript and printed reports, field-books, memoirs, maps, etc., of the Indian surveys, deposited in the map-room of the India Office. There is a review of this paper in the *Geographical Magazine* for May.

The *Journal* of the Anthropological Institute publishes an admirable series of papers on the Languages of the Australians, as follows: On Kamilaroi, by the Rev. C. C. Greenway; on Wailwun or Zuimba, by Mr. Thomas Honery; on the Natives of the Page and the Isis, by Mr. McDonald; on the Language of George's River, by Mr. John Rowley; on the Languages of Sydney and Illawara, by Mr. Malone; on the North Coast, by Dr. Creed. Trübner & Co. announce a "Grammar and Dictionary of the Samoan," compiled by the Rev. George Pratt, and edited by the Rev. S. J. Whitmee.

CULTURE.

The last division of ethnology, or comparative culture, is called by Dr. Topinard "the science of the evolution of humanity," and includes all those social phenomena which constitute a science of human progress; such as aliment, edifices, vessels, implements of war and industry, æsthetic culture, the family, society, government, and religion.

Aliment.

The contributions of Dr. Edward Palmer to the *American Naturalist* for June, September, and October, upon Indian Food and Eating Customs; and Mr. Barber's article, in the same journal, upon Moqui Food, are of great value on this subject. Fritz Schultz discusses the Origin of the Culinary Art, in *Kosmos* for July, 1877.

Edifices.

The Reconstructions of Pueblos, by Mr. W. H. Jackson, of the Hayden Survey, form an attractive feature in several of our American museums, and won great applause at Paris. The whole subject will be discussed in an illustrated volume soon to be issued by the Survey. Mr. Powers, in "Powell's Contributions," vol. iii., gives considerable space to the description of Aboriginal Domiciles and Domestic Structures.

Vessels.

This subject includes whatever is used for collecting, transporting, storing, preparing, and serving liquid and solid aliment. The public taste is turned, just at this time, to pottery. In addition to the elegant and diversified materials in our public museums, there are many private collections of great value. The Harpers have published another creditable Ceramic Hand-book, by Jennie J. Young. Mr. J. Llewellyn Jewett has also published the "History of the Ceramic Art in Great Britain from the Earliest Times to the Present Day."

Implements.

The Reports of M. Girard de Rialle and Dr. Bordier upon Ethnology, at the Paris Exposition, contain many allusions to the superb exhibitions of aboriginal implements from all parts of the world. The remark of Dr. Bordier upon the entire absence of the bow throughout Polynesia, although it is the favorite weapon of the Papuans, is one of more than passing interest. *Apropos* of the assertion of Major Powell, that the North American Indians never used poisoned arrows, Dr. Messer contributes a paper to the *Journal* of the Anthropological Institute, p. 259, on the Reputed Poisonous Nature of the Arrows of the South Sea Islanders.

Upon the implements and methods employed in valuing and measuring, attention is called to Mr. Trowbridge's article in the *Popular Science Monthly* for February, on Counting by Aid of the Fingers; to a paper by J. Flinders Petrie, before the Anthropological Institute, April 9, on Inductive Metrology, to deduce the unit of measure used by ancient peoples from the dimensions of existing remains; and to M. Lenormant's work, "La Monnaie dans l'Antiquité," Paris.

Æsthetic Culture.

Mr. E. B. Tylor read a paper before the Anthropological Institute in April, on the Game of Patolli in Ancient Mexico, and its probable Asiatic origin. Mr. W. S. Jevons contributes to the *Contemporary Review* for October an article on Amusements for the People. Mr. Edwin A. Barber, of Chester, Pa., is preparing a monograph on pipes and smoking, in all ages and nations. Art-weaving among the Ancients is the subject of an article by Mr. T. W. Dale, in the *Penn Monthly* for February. Rev. A. H. Sayce describes the Art of Prehistoric Greece in the *Academy* for March 2. A paper on the Influence of Climate upon the Development of Art, especially of Architecture, will be found in *Correspondenzblatt*, Nos. 1 and 2.

The Family.

Mr. C. S. Wake read a paper before the Anthropological Institute, April 25, on the Origin of the Classificatory System of Relationship among Primitive Peoples. In *Archiv für Anthropologie*, I. and II., Dr. Lothar Dargun discusses the problem of the Origin of Marriage. Mr. A. G. Sedgwick publishes an article on Primitive Communism in the *Atlantic Monthly* for September. The papers of Dr. Hoffman on Abortion and Prostitution, in the *American Naturalist*, are worthy of attention. The July number of *Kosmos*, for 1877, gives us a paper on the Subjection of the Old by the Young. Professor De Gubernatis publishes, in Milan, a work entitled "Storia Comparata degli Usi Natalizi in Italia e presso di altri Popoli Indo-Europei."

Social Life.

This portion of culture, so intimately connected with human happiness, engages the best minds of the world. Indeed, so thoroughly are legislators and jurists convinced of the close relation between social science and good government, that all prominent law-makers are students of sociology. Upon this point, attention is invited to a paper in *Das Ausland*, No. 10, upon Hospitality among Lower Races; to Mr. T. F. Dyer's work on "British Popular Customs;" to Du Bois Raymond's address on the History of Civilization, in the *Revue Scientifique*, January 19; to a paper in the *Proceedings* of the

Asiatic Society of Japan, on Japanese Heraldry, by Thomas R. H. McClatcher; but especially to Mr. Herbert Spencer's series of articles in the *Fortnightly Magazine*, on the Evolution of Ceremonial Government; and to M. Laveleye's work on "Primitive Property." The paper of Mr. Ad. F. Bandelier, on the Tenure of Land among the Ancient Mexicans, previously mentioned, is also valuable under this head.

Religion.

Mr. E. A. Barber discusses the Traces of Solar Worship in North America, in the *American Naturalist* for April; and Mr. Owens, the Folk-lore of the Southern Negroes, in *Lippincott's Magazine*. In England, a Folk-lore Society publishes a journal entitled *The Folk-lore Record*. In the *Contemporary Review*, the subject of Forest and Field Myths is discussed by Mr. W. R. Ralston. M. Emile Cartailhac publishes, in Paris, "L'Âge de Pierre dans les Souvenirs et Superstitions Populaires," a short review of which is given in the *Athenæum* for March 2. In the *Nineteenth Century* for August is an article on the Religion of the Greeks as Illustrated by Greek Inscriptions. In the first four numbers of *Das Ausland*, F. von Hellwald treats of the Eastern Question as a culture problem. A good source of supply for Indian mythology is the *Indian Antiquarian*. Professor Max Müller discusses the Origin and Growth of Religion in the *Contemporary Review* for May. A work in two octavo volumes on the "Evolution of Morality," by C. S. Wake, is published by Trübner & Co.

INSTRUMENTALITIES.

The real progress of any science, and anthropology is no exception, is commensurate with the instrumentalities by which its facts are ascertained and verified. Indeed, there is no branch of knowledge where the personal equation is so complicated and perplexing.

APPARATUS.

The mechanical devices for anthropological study relate mainly to ethnology in its anatomical operations, but charts and diagrams are used in every portion of the science. The Paris Exposition furnished an excellent opportunity for com-

paring methods of research, inasmuch as "Germany, Austria, England, France, and even America, figured side by side." Dr. Topinard, who prepared the report on this subject, insists upon the absolute necessity of having anthropometric methods reduced to uniformity, and to this end suggests that mutual concessions be made. On the whole, the method of ascertaining the cubage of the skull invented by Morton and perfected by Broca is most convenient. To this, as well as to the proper method of orienting the skull, attention has been called already. Mr. Charles Roberts has published, in London, a "Manual of Anthropometry" for practical use.

MEETINGS AND TRANSACTIONS.

At the American Association in St. Louis, and in the Nashville volume of *Proceedings*, many valuable anthropological papers are reported. The subject of American aboriginal philology is not neglected by the American Philological Society. Important contributions to archæology are to be found in the *Transactions* of the American Antiquarian Society of Worcester. The Peabody Museum of Cambridge is foremost among our American institutions to foster anthropology. Reference must also be made to the publications of the American Geographical Society, and the Ethnological Society, of New York; the American Philosophical Society of Philadelphia; the Smithsonian Institution, the Army Medical Museum, the Powell and the Hayden Surveys, and the Report of the Indian Bureau, in Washington; the Western Reserve and Northern Ohio Historical Society, the Central Ohio Scientific Association, and the Cincinnati Society of Natural Sciences, in Ohio; the State Archæological Association of Indiana; the Chicago Academy of Sciences; the Wisconsin Academy in Dubuque; the Davenport Academy in Iowa; the St. Louis Academy in St. Louis; the California Academy in San Francisco. In addition to these, the *American Antiquarian*, the *American Naturalist*, the *American Journal*, the *Popular Science Monthly*, *Harper's Monthly*, *Harper's Weekly*, and the *Kansas City Review*, among our periodicals, give more or less space to the subject. The *American Bookseller and Index* publishes monthly a list of papers and articles in nearly all first-class periodicals upon all subjects relating to anthropology.

Anales del Museo Nacional de México is a very creditable publication issued by the National Museum of Mexico. In the *Revue d'Anthropologie*, pp. 152–157, M. Ludovic Martinet reviews Brazilian Anthropology.

The *Journal* of the Anthropological Institute of Great Britain and Ireland continues to be the main reliance for British anthropology. In addition to this we should not overlook the British Association, the London Philological Society, the Royal Geographical Society, the Oriental Society and Trübner's Catalogues, the Society of Biblical Archæology, the Folk-lore Society, the Victoria Institute, and the Royal Society of Literature. Our chief sources of current notes and of information concerning the meetings of societies are *Nature*, the *Athenæum*, and the *Academy*.

Anthropology is better organized in Paris than in any other city of the world. The School of Anthropology, the Cours d'Anthropologie, the Société d'Anthropologie, with its quarterly *Bulletin*, the Museum Ethnographique des Missions Scientifiques, the Archæological Museum of St. Germains, the Museum of the Louvre, and the Bibliotheque Nationale complete the resources of our science and cover the entire ground of investigation. Besides these, the *Revue d'Anthropologie* is entirely devoted to the subject, and other journals publish occasional articles, as in this country and in England. *Materiaux pour l'Histoire Primitive et Naturelle de l'Homme*, published in Toulouse, has done more to foster archæological studies than any other journal with which we are acquainted.

If Paris has the best system of anthropological instruction among the cities of the world, Germany excels all other countries. The parent society, or Deutsche Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte, with its renowned organ *Archiv für Anthropologie*, migrates from city to city like our American Association, to encourage research and to awaken new interest in the subject. In many of the cities the branch societies publish creditable journals of their own. *Zeitschrift für Ethnologie*, the organ of the Berlin Society, and *Vorhandlungen der Berliner Gesellschaft* furnish very valuable aid to students. To crown the whole, and to make the system complete, Professor Kollmann, of Basle, edits the *Correspondenzblatt*, a monthly *brochure*, in which the

proceedings of all the societies, local and general, are faithfully reported. Our resources are not exhausted even then, for important matter is furnished by Petermann's *Mittheilungen*, *Globus*, *Das Ausland*, and, doubtless, by many other worthy publications of that land teeming with intellectual activity. To the fourth volume of "Jahresbericht über die Fortschritte der Anatomie und Physiologie," published by Professor F. Kollmann and Professor J. Schwalbe, Leipsic, 1878, Professor Kollmann contributes an excellent *résumé* of German Anthropology for the year 1877.

Mittheilungen der Anthropologischen Gesellschaft in Wien, published by a committee of the most distinguished specialists in Austro-Hungary, is the only organ devoted to our subject which has reached us from that empire.

Information upon Russian Anthropology comes to us at second hand, though valuable anthropological memoirs are published by the Imperial Academy of St. Petersburg, by the Academy of Sciences at Cracow, and by the Imperial Society of Moscow. The same is true of the Scandinavian countries, which are known to be keenly alive to archæological studies especially. Allusion has been made already to the efficient law for the preservation of the monuments of antiquity in Denmark.

The third meeting of the International Congress of Americanists is advertised to meet in Brussels, September 23–26, 1879.

A Review of Italian Anthropology is published in the *Revue d'Anthropologie*, pp. 125 and 542. The International Congress of Orientalists met in Florence, September 12–18. The organ of the Italian Society of Anthropology is *Archivio per l'Antropologia e la Etnologia*, published by Dr. Mantegazza, in Florence.

Revista de Antropología is the official organ of the Spanish Anthropological Society.

The most important convocation of the year was the Anthropological Congress, held in connection with the exhibition of human anatomy and primitive industry, at the Paris Exposition, August 16–20, and partially reported in the *Revue d'Anthropologie*, pp. 692–753. It is safe to say that the world has never before witnessed such rich and varied material from so many lands brought together for the study

of man; and that never before have so many distinguished students assembled to investigate this most absorbing of all problems as constituted the International Congress of Anthropological Studies. The committee contemplate the preparation of a voluminous report, in which every paper and every discussion will be published.

ZOOLOGY.

By Dr. A. S. PACKARD, Jr.,

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GENERAL ZOOLOGY.

From a review of the year's progress in general zoology, it appears that more and more attention is being paid to the embryology and histological anatomy of animals, especially in Germany and England. The most important discoveries in embryology are the elaboration, by Salensky in Germany, of the embryology of the sturgeon, his researches confirming Gegenbaur's view of the vertebrate theory of the skull. In this country, Agassiz has cleared up the early history, after hatching, of the gar-pike. In England, Parker has worked out the development of the snake. Important results in zoogeography, especially of birds, have been published by Coues and others.

Mr. Francis Darwin has lately been discussing the analogies of plant and animal life. Some of the points of resemblance are purely analogical; nevertheless he attempts to show that "a true relationship exists between the physiologies of the two kingdoms. Until a man begins to work at plants he is apt to grant to them the word 'alive' in rather a meagre sense. But the more he works, the more vivid does the sense of their reality become. The plant physiologist has much to learn from the worker who confines himself to animals. Possibly, however, the process may be partly reversed—it may be that from the study of plant physiology we can learn something about the machinery of our own lives."

In a paper on the individuality of the animal body, Haeckel says that the actual organism (bion) is an unjointed bilateral person, without segments, with a few antimeres. In the *Arthropoda* (crustacea and insects) the mature physiological individual is jointed, two-sided or bilateral, with a few antimeres (limbs or appendages) and numerous segments. In these last there is an ideal psychic bond of a community of

interests replacing the bodily social or polyp-stock or worm-stock of the lower animals.

The subject of Fetichism in Animals is treated, by Mr. G. J. Romanes, in *Nature*, who believes that a sense of the mysterious exists in dogs, and that it is this sense which is the cause of the dread which many animals show of thunder. He relates a number of interesting anecdotes bearing on this subject.

Mr. Dall's Nomenclature in Zoology and Botany is a timely series of rules comprised in a report to the American Association for the Advancement of Science. It was the result of replies to a circular prepared by Mr. Dall, and sent to the leading systematists in this country. It may be considered as an authoritative code of rules, and should be followed as closely as circumstances and good judgment will dictate. With them should be read Professor Verrill's edition of the Rules of the British Association (*American Journal of Science*, July, 1869).

Treatises.

Among recent text-books on zoology, of value to the general student, is Schmarda's "Zoology," published in 1878, and beautifully illustrated with fresh wood-cuts. The introductory portion is especially valuable. Pagenstecher's "General Zoology" is not so well illustrated, but, as its name implies, is written from the side of general biology and comparative anatomy. It is incomplete; the third part is devoted wholly to the subject of respiration in animals. By far the most useful book, however, is the English translation of Gegenbaur's "Elements of Comparative Anatomy," the most authoritative German work. The style of treatment and the introduction of speculative questions into anatomical descriptions will be quite new to English-reading students.

There has appeared an American edition, revised for use in this country, of an excellent little treatise on the "Zoology of Vertebrates," by Professor Macallister, of Dublin.

Explorations.

Mr. Agassiz has, during the winter of 1877–78, explored the Yucatan Bank and other points, at great depths, with the dredge, aboard the United States Coast Survey steamer *Blake*. He discovered that the fauna of the Yucatan Bank is identical

with that of the Florida Bank, being characterized by the same species of echinoderms, mollusks, crustaceans, corals, and fishes already so well known from shallow water on the Florida side. He also examined the great Alacran Reef. It resembles an atoll in full activity, the eastern slope being nearly perpendicular, rising in a short distance from twenty fathoms to the surface. "The whole structure of this reef shows its identity of formation with that of the main Florida Reef, and with that of the reefs on the northern coast of Cuba, where the line of distinct and powerful elevation can be still plainly traced by old coral slopes, and by the ancient coral reefs in the hills surrounding Havana and extending to Matanzas." It is an atoll, Agassiz claims, apparently formed in areas of elevation, though, according to Darwin's theory of the formation of coral reefs, atolls could not be formed in areas of elevation. Many interesting deep-sea forms were dredged, and the Globigerina ooze, from 1323 fathoms upward, was found to be rich in animal life. In 968 fathoms, specimens of the eyeless macrouran (*Willemœsia*) were obtained, which were identical, as were most of the deep-water species dredged, with those brought up from great depths in the Atlantic by the *Challenger* expedition; a gigantic isopod, more than eleven inches long, closely allied to *Æga;* in 1568 fathoms, an *Umbellularia*, and a transparent, brilliantly striped holothurian were secured. From shallower water a number of fine specimens of the extinct genus *Conoclypus*, of a brilliant lemon color, were dredged.

Further dredgings were afterwards carried on by the same party in the Florida Channel during March and April last. Large numbers of Pentacrinus were obtained—twenty perfect specimens in all. The Marquesas Islands were found to have been formed in the same manner as the great Alacran Reef —*i. e.*, it is an atoll. It was found that the deep-water fauna on the western slope of the great Florida Bank corresponds with that of similar depths on the eastern slope of the Bank of Yucatan, and that this deep-water fauna extends over the bottom of the Gulf of Mexico, until the line running from the 100-fathom line in the latitude of Tampa Bay towards New Orleans strikes the Mississippi River slope. Here, owing to the presence of dark, rich mud, the former was very different; while the hauls in still deeper water off the Mis-

sissippi yielded no specimens of importance. Throughout the cruise, below 500 fathoms, forms characteristic of deep water in all the deeper basins of the ocean were obtained, while the species characterizing different local faunæ occurred at a lesser depth. It was found that the most striking characteristics of the Gulf of Mexico are the two great banks extending, the one to the west of the Florida Peninsula and northward of the Florida Reef, the other northward of the peninsula of Yucatan; the 100-fathom line in both cases running in a general way parallel to the shore-line, and forming the edge of the steep slopes of the deeper parts of the central portion of the Gulf of Mexico. The depth increases rapidly to the north of the Tortugas, and to the northward and westward of Alacran Reef, as shown by the proximity of the 100- and 1800-fathom curves, the eastern and southern edges of the central basin of the Gulf of Mexico having thus very steep sides, while the western and northern slopes are far more gradual. The north slope off Cuba is also quite abrupt, while the southern slope of the Florida Reef into the trough of the Gulf Stream is comparatively gentle. The soundings taken the past year developed a remarkable extension of the southeast end of the Yucatan Bank within the 1000-fathom curve, in the direction of the Tortugas, with a depth of 500 to 700 fathoms for over 100 miles. "The greatest depth of the Yucatan Channel is a little over 1100 fathoms, so that the temperature of all the water which finds its way into the Gulf of Mexico is necessarily at its deepest point (2119 fathoms) only the temperature of the bottom of the Straits of Yucatan (1127 fathoms)—namely, 39½° Fahr. The depth of the channel through which the water of the gulf finds its outlet is very much less—not more than 350 fathoms; and the Straits of Bemini are not half the width of the Straits of Yucatan, while the temperature of the water at the bottom is much higher, with a far greater velocity at the surface than that of the current flowing into the Gulf of Mexico through the Straits of Yucatan."

During his five months' exploration last year in Costa Rica, Mr. A. Boucard, a well-known ornithologist of Paris, collected about 1000 specimens of birds, representing 250 species; among them two new to science.

Dr. Streets's Contributions to the Natural History of the

Hawaiian and Fanning Islands and Lower California (*Bulletin*, No. 7, of the United States National Museum) contains notes on the habits and distribution of the birds, reptiles, fishes, crabs, etc., collected in the Pacific Ocean.

The researches of Professor G. Brown Goode, carried on for six months last winter in the Bermudas, are partly reported in a preliminary catalogue of the Reptiles, Fishes, and Leptocardians, in the *American Journal of Science and Arts* for October. Four species of fishes thought to be new to science are described.

Among the many interesting discoveries made during the past summer by the United States Fish Commission is the discovery of a new species of *Macrurus* (*M. bairdii*, Goode and Bean). It was trawled in 160 fathoms, 44 miles east of Cape Ann. Another interesting form, described by Messrs. Goode and Bean in the *American Journal of Science and Arts*, is a new species of *Lycodes* (*L. verrilli*), trawled in 90 fathoms, near Halifax, Nova Scotia.

Since the establishment of the famous zoological station, founded by Dr. Dohrn, at Naples, nearly a hundred zoologists have worked in this seaside laboratory. The results of their labors are in part to be published in octavo form under the title of "Mittheilungen aus der zoologischen Station zu Neapel," while the quarto series of more pretentious memoirs will be issued under the title of "Fauna und Flora des Golfes von Neapel," etc. In the first part of the "Mittheilungen," there is, says *Nature*, an account of the habits of a large number of the various animals living in the aquarium; also of the periodic appearances of pelagic animals in the Bay of Naples during the past two years; and the third is a list of the breeding-times of the marine forms inhabiting the Neapolitan seas. There is also a paper, by Dr. Eisig, on the Segmental Organs of Annelids; one by Dr. Meyer, on Some Points of Crustacean Anatomy; and two botanical papers. Dr. Dohrn gives the results of his studies on certain marine mite-like forms (*Pycnogonidæ*).

Besides its zoological laboratory in Vienna, the university of that city has founded a zoological station on the Adriatic Sea, at Trieste, the director of which is Professor Claus. Under the title of "Work done at the Zoological Institute of the Vienna University, and at the Zoological Station in Tri-

este," Professor Claus has edited the first part of a handsome volume containing memoirs on the minute structure of the *Siphonophores*, represented by the Portuguese man-of-war. A paper on the male reproductive organs of the crabs, and one on the origin of the vagus nerve in the sharks, with especial reference to the electrical batteries of the torpedo, also appear in the part issued.

Most excellent work was done in this country by Professor W. K. Brooks and others, of the Johns-Hopkins University, in a zoological laboratory established during the last summer at Old Point Comfort, Va. Unfortunately, the work done (regarding the development of *Lingula* and *Amphioxus*) remains unpublished for want of means on the part of the university, as few, if any, would be found to purchase the pamphlet or work containing the memoirs, owing to the great lack of advanced students in this country like those of Germany, who purchase such works at the expense of other luxuries.

The Zoological Station of the Zoological Society of the Netherlands has published its third report. The Station during the summer of 1878 was erected on the island of Terschelling, and in the course of two months it was visited by ten zoologists for the purpose of studying the animals of the Zuyder-Zee.

The Zoological Garden in Philadelphia has been specially favored. Its management has been in the hands of gentlemen of the highest character and position, and the exceptionally large receipts coming to it during the Centennial and preceding years have so assisted its rapid development that what is usually the growth of many years has been accomplished by the Philadelphia society in a few months. This garden was opened in July, 1874. Up to March 1, 1878, it had been visited by the large number of 1,508,501 persons, and its gate receipts amounted to $226,301.79. Its collection of animals is the finest in the country, and consists of 434 mammals, 453 birds, 58 batrachians, and 63 reptiles. The beauty of the grounds, the taste with which they have been laid out, the elegance of the buildings (perhaps too costly for their purposes), and the excellence of their collection combine to make the Philadelphia Gardens compare favorably with many of the long-established gardens of the

Old World. Already some of the dissections and observations of its inhabitants have made important contributions to science. The first complete dissection and structural description of the manatee (*Manatus americanus*) was made from its specimens, and some valuable contributions to comparative anatomy and physiology have resulted from their observation.

Geographical Distribution of Animals.

It is now known that numerous marine animals occur in inland lakes and rivers. Several species of *Blennius* are found in the fresh waters of Southern Europe, says Professor Duncan, in a *résumé* of this subject. *Gobius* is a fresh-water East Indian fish. *Palæmon jamaicensis* is a fresh-water shrimp; another small shrimp, allied to certain marine ones, occurs in the fresh waters of Italy, and another shrimp lives in the Mississippi as far north as Cairo, Ill. The blind fish of the Mammoth Cave are probably descendants of marine forms. The *Monolistra* of the Adelsberg caves is a fresh-water representative of a *Sphæroma* which lives in the Pontine Marshes. Again, several families which are marine in the Mediterranean Sea, such as the scomberoids, skates, and rays, are represented in the tropics by fresh-water forms. *Monocinus polyacanthus* (Haeckel) inhabits the Rio Negro. *Carcharias gangeticus* is found sixty leagues from the sea; *Pristis perroteti* lives in the Senegal. *Raia fluviatilis* has been taken near Rampur, nearly 1000 miles above tide reach; and Schomburgk found a *Trygon* in the river Magdalena. The land-crab of the West Indies is represented in fresh water by a *Telphusa*, though all the other crabs (*Brachyura*) are marine. Certain mollusks, usually marine in their habits, are known to live in streams or lakes. Among *Polyzoa*, *Hislopia* lives in fresh water, and the hydroid *Cordylophora* is a fresh-water form. In the lakes of Sweden, Switzerland, and North America are marine species which have survived the gradual change from salt to fresh water, while it may be regarded as a general rule that all terrestrial and fresh-water life has originated from marine forms, though this rule may have had its exceptions.

Among recent papers on the mammals in the *Proceedings* of the Zoological Society is an essay on the *Molossus* bats,

by G. E. Dobson; descriptions of new mammals collected by Professor Steere in the Philippine Islands; and descriptions of some new mammals from tropical America, by Dr. Günther, who also adverts to the presence of the genus *Atherura* (*A. africana*) on the west coast of Africa. He has before drawn attention to the occurrence on the coast of West Africa of fresh-water fishes previously considered to be exclusively typical of the Indian region. Thus the reappearance of the *Atherura* on the West African coast strongly confirms Mr. Wallace's view that there is present among the mammals and birds of West Africa a special Oriental or even Malayan element. "Instances of this kind," adds Dr. Günther, "appear to me to be of infinitely greater weight in solving the problem of the mode of dispersion of animals over the globe (or their genesis) than deductions drawn from lists of genera vaguely or artificially defined." He has also discovered African reptilian types in the Indian region.

Dr. Coues's Field Notes on Birds observed in Dakota and Montana along the Forty-ninth Parallel during the Seasons of 1873 and 1874 appear in Hayden's *Bulletin* of the United States Geological Survey. Dr. Coues found that the bird fauna of the Red River region is decidedly Eastern in character; but on crossing the Coteau into the Missouri region, or the great water-shed of the Upper Missouri and Milk rivers, the whole aspect of the country changes, and the assemblage of birds is different, and few, if any, distinctively Eastern birds extend across or even into this region. This extends to the very base of the Rocky Mountains, rising gradually to them. The Rocky Mountain region is strongly marked not only by "Western" species, but by Alpine forms, by exclusively arboreal species, and by the abrupt disappearance of the prairie birds.

The Hypothesis of Evolution.

In an interesting address on the Development of the Forms of Animal Life, delivered by Professor Allen Thomson, President of the Plymouth Meeting of the British Association for the Advancement of Science, he takes the most advanced ground held by embryologists, and endorses the conclusion that the phenomena of development in animals show that all pass through in their simple forms similar

stages of development; "that in the lower grades of animal and vegetable life they are so similar as to pass by insensible gradations into each other; and that in the higher forms, while they diverge most widely in some of their aspects in the bodies belonging to the two great kingdoms of organic nature, and in the larger groups distinguishable within each of them, yet it is still possible, from the fundamental similarity of the phenomena, to trace in the transitional forms of all their varieties one great general plan of organization." He adds that, "if we admit the progressive nature of the changes of development, their similarity in different groups, and their common characters in all animals—nay, even in some respects in both plants and animals—we can scarcely refuse to recognize the possibility of continuous derivation in the history of their origin; and however far we may be, by reason of the imperfection of our knowledge of paleontology, comparative anatomy, and embryology, from realizing the precise nature of the chain of connection by which the actual descent has taken place, still there can be little doubt remaining in the mind of any unprejudiced student of embryology that it is only by the employment of such a hypothesis as that of evolution that further investigation in these several departments will be promoted so as to bring us to a fuller comprehension of the most general law which regulates the adaptation of structure to function in the universe."

In a richly illustrated volume on the embryology and anatomy of the starfish, Mr. Alexander Agassiz takes exception to the prevailing Darwinian views in the following language: "While," he says, "the successive appearance of the great types of Echini in geological time—in other words, their paleontological development—is in the strictest harmony with what we know of their embryological development, we as certainly know nothing whatever of the causes which have brought about their sequence in time, in such striking agreement with the sequence in their phases of growth. The case of successive modifications of the ancestral horse, which has so often been brought forward as conclusive regarding the genealogy of the group, although more familiar, is far less complete and much more limited in time than the succession to be traced from the paleontological evidence of Echini. But, while natural selection gives a plausible explanation of

like problems among Vertebrates, it fails utterly when applied to the majority of the Invertebrates, and we have completely failed, thus far, to find any causes for their paleontological development differing from those acting upon their successive embryological stages at the present day, of which we know absolutely nothing."

In a paper on the Birds of Guadalupe Island, off the coast of Southern California, Mr. R. Ridgway discusses the subject with reference to the genesis of species. There are only eight species, and their affinities are almost entirely, as would be expected, with those of Western North America. Yet they are so far differentiated from them that they are recognized by Mr. Ridgway as specifically distinct. They all differ somewhat similarly from their nearest mainland allies in their principal features—namely, in (1) "increased size of the bill and feet, (2) shorter wings and tail, and (3) darker colors." These facts, adds the reviewer, point emphatically to the directly modifying influence of the peculiar conditions of environment to which they are subjected; and, taken with other now well-known facts, lead to the conclusion that the present differentiation of species and subspecies is mainly the result of the immediate action of climatic and other surrounding conditions.

Some remarkable observations of Schmankewitsch on the influence of external surroundings on the organization of animals have recently been published in Siebold and Kölliker's *Zeitschrift.* This refers to changes in *Artemia* and *Branchipus*, two allied genera of Crustacea. In a former article, published in 1875 in the Russian language, he discussed the differences between the fresh- and salt-water forms of *Cyclops* and allied forms, *Daphnia* and *Artemia* and *Branchipus*, and showed that several species are produced by difference in the density of the water and absence or presence of salt, with results of unusual interest and pertinence to discussions on the origin of species and genera.

From his studies of the nautilus and its fossil allies, Barrande infers that the type has undergone no modifications from the Silurian period to the present day, and that the facts elicited do not favor the evolution theory.

Dimorphism.

There are several cases of dimorphism known among grasshoppers—viz., two sets of individuals in the same species, which have been, or are liable to be, mistaken for different species. In the species allied to the common Rocky Mountain locust and the Eastern red-legged locust, Mr. Scudder states that there are ten or twelve species of these locusts, mostly occurring in the Mississippi valley, in which there are two sets of individuals—one with short and the other with long wings. In one instance three varieties occur, which are with little doubt to be referred to one species. The dimorphic forms of any one species are found at the same stations and cannot be considered racial.

Protection, Resemblance, and Coloration.

In an elaborate paper on the coloring matters of various marine animals, Mr. Moseley, late naturalist of the *Challenger* Exploring Expedition, calls attention to the coloring matters of deep-sea animals. Very little, if any, light, he says, can penetrate from the surface of the sea to depths such as 1000 or 2000 fathoms, and he believes that experiment has shown that little or no effect is produced on sensitized paper at the moderate depth of 60 fathoms. It is probably, as far as solar light is concerned, absolutely dark at depths of 1000 fathoms and upwards, and the fact that two blind decapod Crustacea occurred in from 450 to 490 fathoms seems to indicate a condition of extreme darkness at much less depths. Nevertheless, other animals living in very deep water have enormously enlarged eyes, and hence some light must exist. Professor Wyville Thomson and Dr. Carpenter have suggested that phosphorescent animals form the source of light in the deep sea. Mr. Moseley adopts this view, which seems to us, however, to be far-fetched, and adds that "the deep sea must be lighted here and there by greater or smaller patches of luminous *Alcyonarians*, with wide intervals, probably, of total darkness intervening. Very possibly the animals with eyes congregate around these sources of light." "No doubt," says Mr. Moseley, "in many cases the coloring of the deep-sea animals, as in the case of the purple *Holothurian*, is useless and only an example of persistence. The madder color-

ing of some of the soft parts of the corals may be in like case, but possibly useful for attraction of prey, being visible by the phosphorescent light. The same coloring matters exist in deep-sea animals which are found in shallow-water forms. Polyperythrin is found abundantly in surface-swimming *Rhizostomæ* and in deep-sea Corals and *Actiniæ*. Antedonin occurs in a shallow-water (9 fathoms) *Antedon* at Cape York, and in a *Holothurian* found in 1975 fathoms near the Antarctic Sea. No doubt in many instances in the case of deep-sea possessors of these substances, the pigments, from being in the dark, never exercise their peculiar complex action on light during the whole life of the animal, but remain in darkness, never showing their color, as does Hæmoglobin in so many animals.

An essay on the colors of Animals and Plants, by Mr. Alfred R. Wallace, gives a general account of the more recent discoveries in this field of study. He believes "that neither the general influence of solar light and heat nor the special action of variously tinted rays is adequate cause for the wonderful variety, intensity, and complexity of the colors that everywhere meet us in the animal and vegetable world." He groups them as follows:

Animals
- 1. Protective colors.
- 2. Warning colors.
  - *a.* Of creatures specially protected.
  - *b.* Of defenceless creatures, mimicking *a.*
- 3. Sexual colors.
- 4. Typical colors.

Plants ....5. Attractive colors.

In a recent essay on the colors of British Caterpillars, Sir John Lubbock confirms the statements of several European naturalists, who have indicated that, as a general rule, caterpillars which are dull-colored and have a smooth skin or are nocturnal in their habits are greedily eaten by birds. On the other hand, spiny and hairy caterpillars are spared, and are often brightly colored. Certain species—such as *Deilephila euphorbiæ*, *Abraxas grossulariata*, and *Zygæna filipendula*—are distasteful to birds; and in these cases brilliant coloring serves as a warning and, consequently, as a protection. Lastly, there are a few species—such as *Chærocampa elpenor* and *C. porcellus*—which appear to frighten birds by their resemblance to small reptiles—a resemblance singularly heightened by the curious eye-like spots on the thorax.

Lubbock has studied this matter from a statistical standpoint, and finds that out of eighty-eight spiny and hairy species tabulated, only one is green (*L. sybilla*), while a very great majority of the black and brown caterpillars, as well as those more or less marked with blue and red, are either hairy or spiny, or have some special protection. His results confirm, in a remarkable manner, he thinks, the conclusions previously arrived at by the naturalists he names.

An interesting case of natural selection is described by Mr. S. F. Clarke in the *American Naturalist.* The writer obtained a large number of eggs of a salamander (probably *Amblystoma opacum*). They were hatched in due season, and then began, for want of proper food, to develop cannibalistic tendencies and to eat off one another's gills. It was discovered that among the many there were a few which, though they came from the same parents and were subjected to the same conditions while in the egg, were yet gifted with greater vigor and energy than most of their brothers and sisters. These few stronger ones ate off the gills of many of the weaker ones, and, at the same time, were enabled to protect their own from mutilation or destruction. These favorable conditions—the large supply of food and the better aeration of the blood—soon began to show their influence upon the growth of the individuals thus favored. Within a week or ten days from the escape from the egg these favored few were fifty per cent. larger than their weaker comrades who were born upon the same day. "Their mouths had by this time increased so much in size that they were no longer satisfied with nibbling off the gills of their brethren, but now began to swallow them bodily. This great increase in the supply of food soon produced a marked effect upon those who were thus supplied; so that in ten days from the time that they began to feed in this way they were from ten to twelve times the length and bulk of those upon whom they were feeding. Developing at this rapid rate, they arrived at the stage when the gills are resorbed and the abranchiate form leaves the water for the marshy land or old, damp log, where it usually makes its home, and where it would find a supply of more natural food material. Here, then, was a very interesting case of natural selection by survival of the fittest: all the weaker individuals being

destroyed, and actually aiding the stronger ones by serving them as food until they could pass through their changes and escape to other regions where food was more abundant."

A case of mimetic coloring in tadpoles is recorded by Sarah P. Monks in the *American Naturalist* for October. She finds that the tails of the tadpoles resemble the submerged lower leaves of a plant, *Ludovidgia palustris*, in color, width, and shape. The resemblance in color was so striking that a friend, who was not on the lookout for analogies, mistook a leaf for a tadpole.

Mr. Darwin has referred to two species of *Orthoptera*, allied to *Pterochroza illustrata* and *P. ocellata*, remarkable for their perfect imitation of dead leaves, which was carried out in the venation of the wings, even to microscopic details, as compared with the ribs and veining of leaves.

A number of instances of protection resemblance are given by Mr. Meldola, in the *Annals and Magazine of Natural History*. Among others is the case of an Indian *Mantis*, which resembles a flower.

General Embryology.

Recent observers—such as Bütschli, E. Van Beneden, Fol, Hertwig, Strasburger, and Calberla—have thrown a great deal of light on the phenomena of the maturation and impregnation of the egg. Their conclusions have been summarized as follows by Mr. F. M. Balfour, the eminent English embryologist. In what may probably be regarded as a normal case, the following series of events accompanies the maturation and impregnation of an egg: (1) Transportation of the germinal vesicle to surface of the egg; (2) absorption of the membrane of the germinal vesicle and metamorphosis of the germinal spot; (3) assumption of a spindle character by the remains of the germinal vesicle, these remains being probably largely formed from the germinal spot; (4) entrance of one end of the spindle into a protoplasmic prominence at the surface of the egg; (5) division of the spindle into two halves, one remaining in the egg, the other in the prominence; the prominence becomes at the same time nearly constricted off from the egg as a polar cell; (6) formation of a second polar cell in the same manner as the first, part of the spindle still remaining in the egg; (7) conversion of the

part of the spindle remaining in the egg after the formation of the second polar cell into a nucleus—the female pronucleus; (8) transportation of the female pronucleus towards the centre of the egg; (9) entrance of one spermatozoon into the egg; (10) conversion of the head of the spermatozoon into a nucleus—the male pronucleus; (11) appearance of radial striæ round the male pronucleus, which gradually travels towards the female pronucleus; (12) fusion of male and female pronuclei to form the first segmentation nucleus.

It may be remembered that Dr. E. L. Sturtevant contributed to the *American Naturalist* for August a note on the development of unfertilized eggs in the body of the female pickerel. In the October number of the same journal Dr. W. K. Brooks gives the history of previously published cases of a similar nature, with the authorities. Dr. Burnett saw in eggs of the codfish before they were expelled from the ovaries, and therefore before impregnation, phenomena indicating that the segmentation of the yolk had already begun. Agassiz declared that eggs in various early stages of development may be found in the ovaries of the cod, whiting, and hake. Bischoff states that a few unfertilized eggs of the European frog were found to go through the early stages of development, and this has been confirmed by another French writer. Bischoff found eggs in various stages of segmentation in the ovaries of a virgin sow, and Hensen observed the same in the rabbit. Oellacher found that eggs laid by virgin hens undergo segmentation and form a blastoderm while in the oviduct, and he regards this as a normal process. Vogt says the unfertilized eggs of *Firola*, a mollusk, undergo segmentation, and Quatrefages records the same occurrence in *Unio*. Dr. Brooks concludes that "the egg has in itself the power to form a new individual, although this power is never perfectly, and usually not at all, shown until development is excited by the influence of the spermatic filaments of the male."

INVERTEBRATES.

Protozoa.

Professor Leidy's recent investigations have led him to suspect that the species of fresh-water Rhizopods are cos-

mopolite. He has found the greatest number of species and the greatest profusion near the sea-level, though they were abundant even at an altitude of 10,000 feet in the Rocky Mountains. The most prolific localities of the fresh-water Rhizopods are sphagnous swamps. Moist sphagnum often teems with multitudes of beautiful forms. A single drop of water squeezed from sphagnum has at times been found to contain hundreds of individuals of *Hyalosphæria*, *Nebela*, *Euglypha*, etc., of different species. While ponds and springs and ditches in sandstone, quartzite, argillaceous, and granitic districts have proved rich in Rhizopod life, ponds and ditches in limestone regions have been found to be exceedingly poor.

Regarding the nature of *Eozoön*, Haeckel expresses his positive opinion that it is a foraminiferous animal. He says that "the most experienced and competent students of the class of Rhizopods — at their head Professor Carpenter, of London, and the distinguished anatomist Max Schultze, of Bonn, deceased — are firmly convinced that the American *Eozoön* is a genuine Rhizopod—a *Polythalamium*, near akin to *Polytrema*. I have myself for several years made a special study of Rhizopods. I have minutely examined several fine preparations of *Eozoön* made by Carpenter and Schultze, and I have not the slightest doubt that it is a genuine *Polythalamium*, and not a mineral."

Believers in the animal nature of *Eozoön* have supported their views by reference to the Lower Silurian fossil *Stromatopora*, which is by different authors regarded as a foraminifer of gigantic proportions, or as a coral; while more recent observers, as Zittel, regard it as a sponge. In a recent discussion at a meeting of the Geological Society of London, Dr. Dawson explained his views as to the foraminiferal nature of the *Stromatoporidæ*, species of which occur from the Lower Silurian to the Devonian periods. In the discussion which ensued Professor Duncan remarked that different forms were called *Stromatopora*, and he doubted their foraminiferal nature. Dr. Murie thought that they represented sponges allied to the Hexactinellids. Mr. H. J. Carter, an excellent authority, believes, with Dr. Steinmann, that *Stromatopora* is allied to the Hydroids *Hydractinia* and *Millipora*, while Carter ridicules the idea that *Eozoön* is of animal nature.

A fourth part of Mr. Archer's valuable *résumé* of recent contributions to our knowledge of fresh-water Rhizopods refers to the one-chambered forms, such as the *Pelomyxa* and *Arachnula*, which are among the lowest Rhizopods allied to *Amœba*, and are of very peculiar interest.

Professor Leidy contributes to the *American Naturalist* a notice of the *Amœba*, and of the proper name that should be applied to our species, which is the same as the European, and is *Amœba proteus*.

Professor Haeckel claims that the observations as to the animal nature of *Bathybius* first made by Huxley and himself were correct, contrary to the opinion now held by Sir Wyville Thomson, Huxley, and others, that *Bathybius* is nothing but a gypsum precipitate. The original specimen of *Bathybius* was studied dead in alcohol. "This specimen," he says, "of *Bathybius* ooze, which had been very well preserved in strong alcohol, I examined as minutely as possible, employing the newest methods of research, and in particular the excellent method, not employed by Huxley in his investigation, of staining with carmine and iodine; my purpose being, above all, to determine more accurately the quantity and quality of the amorphous protoplasmic matter. This albuminous substance, which was reddened by carmine, was very evenly distributed through the ooze, and, in most of the specimens examined, constituted at least one tenth to one fifth of the whole volume. In many cases it was as much as one half. The same protoplasmic masses, which, on treatment with carmine, became of a more or less deep-red tint, took from iodine and pure nitric acid a yellow color; and with other chemical reagents they exhibited precisely the same properties as the protoplasm of animal and vegetable cells." Haeckel thinks that Huxley has prematurely recanted his earlier views concerning the organic nature of this *Bathybius* stuff. Dr. Bessels found a living substance in Smith Sound, which he called *Protobathybius*. It is figured and briefly described by Bessels in Packard's "Life-History of Animals." We had suspected that it was simply a *Bathybius*, without the coccoliths or foreign bodies found in the latter, and Haeckel takes the same view.

Dr. Leidy has recently discovered a new infusorian, belonging to a new genus and species, named *Trichonympha*

agilis. It is about $\frac{1}{300}$ of an inch long, and half as wide as long. It is fusiform, and clothed with cilia of extraordinary length, some of them extending from the head to a distance beyond the end of the body equal to a third of the entire length of the animal. Although actively and incessantly in motion, it remains attached to some object. Its chief movements consist in the frequent retraction or shortening and bending of the head end, with a narrowing and lengthening or shortening of the whole body, and a swelling outwardly and moving downwards or backwards of the long cilia, with a waving of the shorter ones at the summit of the head.

Dr. Leidy has found enormous quantities of infusoria and other parasites in the intestines of the white ant (*Termes flavipes*). The contents were mainly composed of decaying wood, which not only occupied the intestines of the ants, but in some cases is distributed as morsels of food occupying the interior of the parasites. In many instances the parasites are so numerous as to make up the greater portion of the bulk of the intestinal contents of the white ants, and may be estimated by millions. As the discovery was a recent one, he was not able yet to say to what extent these ants were generally infested with the parasites; but he had found that every individual which he had examined, collected from a single nest, contained them.

The *Noctiluca miliaris* is well known by descriptions and figures in the books, though we have never known of its being seen by more than one American, the late Mr. Edwin Bicknell, the well-known microscopist. Those he saw were collected in the harbor at Portland, Maine. They are round infusoria, with a large, long propelling lash. Under the name of *Leptodiscus medusoides* Hertwig describes an exceedingly interesting Noctiluca-like organism, which he had the good fortune to discover in the harbor of Messina during the winter of 1876–77. This new form is perfectly discoid in shape, with the flagellum characteristic of *Noctilucæ*. Its size varies, measured across the disk, from 0.6 mm. to 1.5 mm. The disk is thickest in the centre; somewhat raised or convex on the dorsal side, while the ventral is concave. Near the ventral surface and in the centre there is a bipartite, ovoid nucleus, the smaller half of which is homogeneous, the

larger granular. The numerous oil globules are imbedded just beneath the dorsal integument; but, with the exception of the whitish spot (granular area) in the centre of the disk, is clear and transparent, exhibiting slight iridescence of the convex side. As the name indicates, this organism is Medusa-like; but this likeness becomes still more strikingly manifest when the organism moves. As in *Medusæ*, change of place is effected by the powerful contraction and dilatation of the umbrella-shaped body, like the former, forcing the water suddenly from the cup-like cavity. In the energy and rapidity of the contractions, Dr. Hertwig says it is not behind any *Medusa*, provided the little creature is touched with a glass rod. Under these circumstances it darts, like a *Rhopalonema*, through the water as swiftly as an arrow, by the quickly succeeding pulsations or contractions of its umbrella-shaped body. The strongest contractions were produced by osmic acid. The creature, under the action of this reagent, becomes bell-shaped, about half as wide across the free border of the bell as it is high. As in *Medusæ*, the animal has the power of bending portions of the free border of the umbrella inwards; or sometimes the opposite halves of the disk become bent towards each other, like the opposite valves of a mollusk. Altogether, the discovery is a most interesting one, showing, as it does, the wide range of form and physiological differentiation which may be exhibited by a very restricted group of simple organisms.

A number of new species of Rhizopods, collected by the *Challenger* expedition, have been described by H. P. Brady.

An interesting essay, by V. Sterki, on the *Infusoria*, especially *Oxytricha* and its allies, will serve to keep up the interest in these organisms. A lengthy paper on the Flagellate *Infusoria*, by Bütschli, is translated in the *Quarterly Journal of Microscopical Science*. Flagellate *Infusoria*, contrary to the dictum of Pasteur, who claimed that neither microscopic organisms nor their germs are ever found in the blood of an animal in health, have been found by T. R. Lewis in the blood of healthy rats. The first volume of the third part of Stein's great work on the *Infusoria* has appeared. It contains an exhaustive history of the discoveries and writings of previous observers, from Ehrenberg to Carter, Busk, Williamson, Hicks, and James Clark. The author,

Ritter von Stein, regards this as probably the most interesting and important section of his great work. Siebold and Kölliker's *Zeitschrift* also contains the fifth paper on the Anatomy and Development of Sponges, by Professor F. E. Schulze, the present essay describing and figuring the metamorphosis of *Sycandra raphanus.*

A very interesting memoir on the Structure of the *Millipora* has been received from Mr. Moseley, of the *Challenger* expedition. The *Millipora* has always been considered a coral, until, in 1860, Professor Agassiz discovered that it was really the secretion from the bodies of minute hydroid polyps, in some respects like the common *Hydractinia* of our coast. This view was generally accepted in America and Germany, but not in England. Now, however, Mr. Moseley claims, and with a strong array of facts, that Agassiz's position was the correct one. He has also published an elaborate essay on the *Stylasteridæ*, a group of hydroid-like corals, which he proves to be allied to the *Millipora.*

Echinoderms.

Additional essays, by H. Ludwig, on the finer anatomy of the sand-stars and Brisinga—a deep-sea, many-armed starfish, found in deep water off the coast of Norway and in the abysses of the North Atlantic—will interest the special student.

Some points in the anatomy of recent Crinoids (*Pentacrinus* and *Rhizocrinus*), especially with reference to the blood system of these animals, are discussed by P. Herbert Carpenter in the *Journal of Anatomy and Physiology.* He has also published a morphological account of a new Crinoid from the Philippine Islands, named *Actinometra polymorpha.*

Mr. P. H. Carpenter's essay on the oral and apical systems of the Echinoderms appears in the *Quarterly Journal of Microscopical Science* for October. The Ophiurans of the English *Challenger* expedition have been described by Theodore Lyman, the larger part being new to science.

Worms.

The development of the parasitic worm *Ligula* has been studied by Duchamp, who made two pigeons swallow some *Ligulæ* from a tench. After four and five days respectively

they were killed, and each had in its intestine a living *Ligula*, with genital organs developed, and the matrices filled with eggs, just as with the duck.

A general account of the anatomy of the fluke-worm (*Distomum crassicolle*), by Dr. C. S. Minot, appears in the "Memoirs" of the Boston Society of Natural History. He calls attention to the close relationship of the flukes and tape-worms, and chronicles some new anatomical discoveries.

It has been found to be probable that the spread of various forms of elephantoid disease, perhaps even leprosy, is due to a very minute worm, closely allied to the large Guinea worm, the microscopic species being called *Filaria sanguinis hominis.* The eggs of this worm in India are swallowed in water drunk by men, and hatched out in the intestines. Hence it bores through the tissues into the blood-vessels, where it matures and carries on its work of obstruction. The process of reproduction, however, is carried on in another pest—*i. e.*, the mosquito. This much-abused insect acquires a fresh title to its noxious reputation in its supposed propagation of such a dreadful disease as leprosy. In India it has been found that the blood it sucks from leprous patients contains *Filariæ* with eggs, contained in the blood of its human victims. In the mosquito the worms remain until the eggs are ripe, when they are voided in the pools of water it frequents. The eggs are then drunk by human beings, and the cycle of life, with its ghastly results, begins anew.

At a late meeting of the French Academy, Messrs. Galeb and Pourquier remarked that they had found Filarian worms in the blood of the fœtus of a bitch, whose heart was teeming with them; the embryos, doubtless, passed through from mother to offspring. This explanation destroys the idea of verminous diathesis and of spontaneous generation, called in to explain the genesis of such *Hæmatozoa.* The authors also verify M. Davaine's view that the Nematoid worms circulating in the vessels of certain dogs are larvæ of the Hæmatic *Filariæ.*

That the blood of the earth-worm was free from corpuscles has been the generally received opinion; but it appears, from recent investigations of Professor Ray Lankester, that corpuscles exist in abundance in the larger, and even in the

finest, branches of the vascular system. They are flattened, fusiform bodies, mostly about $\frac{1}{3000}$ of an inch in length, and are colorless. Lankester thinks that they are the nuclei of the endothelial cells set free from the walls of the vessels, while the granule in their centre represents the nucleolus.

Leuckart discovered that a round worm (*Spiroptera obtusa*), encysted in the meal-worm or larva of *Tenebrio molitor*, completes its development in the digestive canal of the mouse. More recently, M. Galeb has found that a small round worm (*Filaria rhytipleurites*) inhabiting the fatty body of the common cockroach (*Periplaneta orientalis*) migrates into the alimentary canal of the rat, the latter devouring the cockroaches and setting free the immature *Filariæ* encysted in the insect.

A very full and philosophical account of the fresh-water worm *Nais*, with reference to its mode of budding and self-division, by Professor C. Semper, appears in a late number of his *Arbeiten*, etc.

A rotifer (*Notommata werneckii*) has been found by Balbiani to be at one period free, at another parasitic, in the tubes of *Vaucheria*, a fresh-water alga producing gall-like enlargements. In the free state this rotifer is elongated, vermiform, and divided externally into distinct segments; in the parasitic state it is, when mature, dilated, sac-like, very contractile, and without trace of segmentation, while the ovary is enormously developed. Like other *Rotifera*, this species lays two sorts of eggs, summer and winter ova. The latter are produced in the spring, but are not laid until later, the process of oviposition being delayed much longer than in that of the summer eggs. The young Notommatas form in the galls, and make their exit by openings which are made spontaneously at the summit of the adventive branches of the *Vaucheria*. Other species of *Notommata* are known to reside parasitically in *Volvox*.

Fritz Müller, author of "Für Darwin," some years ago announced that the *Polyzoa*, or corals, have a colonial nervous system, which connects all the individuals of one colony together. M. Joliet, who has just been investigating the subject, has come to the conclusion that Müller's nerves, ganglia, etc., are purely mythical, and that they are simply lines or branches running along the horny cells; and that the gan-

glia are the flattening out of the "central cords" of the adjacent polyps on opposite sides of the partition. He regards them as quite individual, and finds that they have to do with the formation of colorless blood corpuscles, like the spleen in *Vertebrata.*

A new locality for *Cordylophora lacustris* (Allman) is noted by S. F. Clark in the *American Naturalist.* This is an interesting fresh-water hydroid, allied to the marine *Clava*, and it is the first time that the species has been found in this country. This hydroid is interesting as being the only compound hydroid ever found in fresh water, and from the fact that it has a ramified spadix, and that the reproductive zooids are developed in a chitinous cup, while the nutritive zooids are not so developed or protected. A variety of this, described by Professor Leidy, was found by him in 1870 at Newport, while the specimens noticed by Mr. Clark occurred attached to a *Potamogeton* and a *Nitella*, as well as to the rocks in the creek.

Professor E. S. Morse's studies on the Brachiopod *Lingula*, made in Japan, have brought out some points of much interest, new to science. The discovery of auditory capsules in the class of Brachiopods is one of the most important. These organs he determined in a species of *Lingula*, and their position and general appearance recall the auditory capsules as figured by Claparède in certain tubiculous Annelids. He has also cleared up many of the obscure points in regard to the circulation, and is prepared to maintain the absence of anything like a pulsatory organ, the circulation being entirely due to ciliary action. Mr. Morse also described some of the habits of *Lingula.* While partially buried in the sand, the anterior border of the pallial membranes contract in such a way as to leave three large oval openings —one in the centre, and one on each side. The bristles, which are quite long in this region of the animal, arrange themselves in such a way as to continue these openings into funnels, and entangle the mucus which escapes from the animal. These funnels have firm walls. A continual current is seen passing down the side funnels, and escaping by the central ones. They bury themselves very quickly in the sand, and the peduncle agglutinates a sand-tube. They attach themselves by means of this tube to the bottom of dishes in which they are

confined. Morse brought living specimens of *Lingula* from Japan in a small glass jar. The water had been changed only twice in about four months, and yet no specimen had died. This illustrated the great vitality of *Lingula*.

The *Brachiopoda* dredged in the North Atlantic in 1868–70, on the expeditions of H.M.S. *Lightning* and *Porcupine*, have been fully described and figured by J. Gwyn Jeffreys, in the *Proceedings* of the Zoological Society of London. Particular attention is given to the vertical distribution and the geological range of these shelled worms, regarded still as mollusks by the author.

Mollusks.

Bobretsky, a professor in the University of Kiew and a student of the distinguished Kowalevsky, has just published, in the *Transactions* of the Society of Natural History, Anthropology, and Ethnography in the University of Moscow, an elaborate work on the development of the cuttle-fish, belonging to the genera *Loligo* and *Sepia*. The work is based on thin sections of the eggs, and has every appearance, from the quality of the drawings shown on the plates, of being a critical and exhaustive treatise on a difficult subject. Although the text is in Russian, an explanation of the plates is given in German.

A beautifully illustrated work on the dorsal eyes of a shell-less land snail (*Onchidium*) has been published by Professor Semper. He claims that these eyes, which are in the form of little black dots scattered over the back of the creature, are constructed on the vertebrate type. They are different in structure from the tentacular eyes of the *Onchidium* and other land snails, as the nerves arising from them are not thrown off from the cerebral ganglion, but from the visceral nerve centre. Semper describes the arrangement, size, and number of these peculiar dorsal eyes, their structure and developmental history, and then enters into a comparison of these eyes with those of the higher animals, and finally discusses the theoretical bearing of the facts he brings forward.

In a recent paper on the Nudibranch Mollusks of the Eastern seas, read before the Linnæan Society, Dr. Collinwood gives curious instances of specimens isolated in a dish of sea-

water spontaneously and neatly amputating the region of their own mouth.

In the *Atti della Reale dei Lincei*, at Rome, some interesting investigations are described, which were made by Messrs. A. and G. De Negri, at the Chemical Laboratory of the Genoa University, on the purple dyes of antiquity. The authors have thoroughly investigated the subject. After an elaborate account and an enumeration of the various historical data with regard to the mollusks from which the ancients obtained their purple colors, they enter into a discussion of the chemical and optical properties of these substances, the methods of dyeing with them, the adulterations found in them, and various other details concerning them. We must refer our readers to the original treatise for further particulars, as our space will not permit us to enter into them. The paper is accompanied by a number of plates, giving the spectra of the colors obtained from species of the genera *Aplysia* and *Murex*.

It is well known that there is a gigantic species of *Octopus* (*O. punctatus* Gabb) living on or about the Pacific coast, with arms five feet in length. The *Weekly Oregonian* of September, 1877, records the fact that "an Indian woman, while bathing, was pulled beneath the surface of the water by an Octopus and drowned. The body was discovered the following day in the bottom of the bay, in the embrace of the monster. Indians dived down, and with their knives severed the tentacles of the Octopus and rescued the body. This is the first recorded instance of death from such a cause in this locality; but there have been several narrow escapes."

In the supplement to the second edition of his "Acadian Geology," Principal Dawson speaks of the molluscan fauna of what he terms the great Acadian Bay, comprising the eastern portion of the Gulf of St. Lawrence, between Nova Scotia and the Bay of Chaleurs. "This Acadian Bay is a sort of gigantic warm-water aquarium, sheltered, except in a few isolated banks which have been pointed out by Mr. Whiteaves, from the cold waters of the Gulf, and which the bather feels quite warm in comparison with the frigid and often not very limpid liquid with which we are fain to be content in the Lower St. Lawrence. It also affords to the more delicate marine animals a more congenial habitat than they can find in the Bay

of Fundy, or even on the coast of Maine, unless in a few sheltered spots. . . . Hence the character of its fauna, which is indicated by the fact that many species of mollusks whose headquarters are south of Cape Cod flourish and abound in its waters. Among them are the common oyster, which is especially abundant on the coasts of Prince Edward Island and Northern New Brunswick; the quahog, or wampum shell; the *Petricola pholadiformis*, which, along with *Zirfea crispata*, burrows everywhere in the soft sandstones and shales; the beautiful *Modiola plicatula*, forming dense mussel banks in the sheltered coves and estuaries; *Callista convexa*, *Cochlodesma leana*, and *Cumingia tellinoides; Crepidala fornicata*, the slipper limpet, and its variety *unguiformis*, swarming especially in the oyster beds; *Nassa obsoleta* and *Buccinum cinereum*, with many others of similar southern distribution." He then adopts Verrill's hypothesis that this region was formerly connected with the Bay of Fundy, allowing the northward migration of the New England marine forms.

A paper on the anatomy of *Chiton*, by Dr. Von Jhering, in the *Morphologische Jahrbuch*, describes and figures certain points in the sexual apparatus, the kidneys, and the finer structure of the muscles.

The singular marine animal *Neomenia*, which was by Tullberg regarded as either a mollusk or worm—he was doubtful which, though he thought it might be more properly regarded as a worm—has been investigated by Von Jhering, who compares it with *Chiton*, and considers it as belonging, with *Chiton*, to his proposed order *Amphineura*.

Mr. W. W. Calkins announces in the *American Naturalist* that he has found *Ranella clathrata* on the west coast of Florida, at Cedar Keys. It occurred in shallow water, occupying dead shells of *Mercenaria mortoni;* also attached to the pretty coral *Oculina diffusa*. The specimens have been submitted to experts for identification, who find that it is a Pacific or West Coast shell, not heretofore known to exist on the eastern coast of North America, and adds another species to the list common to both oceans. There are a few crustacea and fishes known to be common to the two shores, indicating that in Tertiary times the Isthmus of Panama lay under the ocean, as its geological structure shows must have been the case.

Two paper-nautilus shells were found on the coast of Florida in the winter of 1877–8, and in the preceding winter one was found with the animal entire, besides another empty shell. Rev. S. Lockwood has noticed the occurrence of this animal on the New Jersey shore. This species, *Argonauta argo* Linn., inhabits the Mediterranean Sea, and is undoubtedly a waif from the eastern shores of the Middle Atlantic.

A writer in the *American Naturalist* calls attention to one mode of the distribution of fresh-water mussels. Mr. Darwin conjectured that the young of fresh-water mussels, by being attached to pond-weeds, may be transferred by birds from one place to another. Mr. R. E. Call has observed this, and states that it is a commonly observed fact that *Limnæa* and *Planorbes* do attach themselves to aquatic plants, and are carried about by birds. He quotes the case observed by Mr. Arthur F. Gray, of Danversport, Mass., who has in his collection the foot of a water-fowl to which is attached a bivalve shell, the bird having been caught and firmly held by the mollusk. A newspaper lately contained the statement that a bird was found held prisoner by a bivalve on the flats. Only by some such method as this are we able to account for certain facts in the dispersion of fresh-water shells.

Another writer notices the curious fact that at a point near White House Landing, Va., on the Pamunky River, where fresh-water mussels (*Unio*) abound, it has been found impossible to raise ducks, for the reason that at low water the ducklings were liable to be caught by the mussels and held until drowned by the rising tide. This story was afterwards confirmed by the Pamunky Indians, who live on an island below White House, and who, with every facility for raising large quantities of ducks, do not keep them.

Another *brochure* of Barrande's great work on the fossil Cephalopods of Bohemia has just been received. It is extracted from the forthcoming volume (II., text 5) of the quarto series of works entitled "Système Silurien du Centre de la Bohême," which has made the name of Joachim Barrande so distinguished as a paleontologist. In this *brochure*, chapter xvii. treats of the initial or embryonic part of the shell of fossil Cephalopods, with general observations; chapter xviii. discusses the vertical distribution of Cephalopods in all pa-

læozoic countries; and chapter xix. gives a general *résumé* of our knowledge of Cephalopods.

It has been found that the European oyster does not breed in parks made for fattening it, as the water is too fresh for it; but that if artificial tanks are to be self-supporting, the water must not be much less salt than on the natural banks from which they are stocked.

Crustaceans.

A number of sound-producing Crustacea have been observed by Hilgendorf and recorded in Von der Decken's "Reisen in Ost-Africa (Crustacea)," and more recently Mr. Wood-Mason observed a number of stridulating Crustacea at the Andaman Islands. The sound apparatus consists of two paired organs—*i.e.*, organs working independently of each other, situated on each side of the body. In certain forms they are seated partly on the carapace and partly on a pair of appendages. Of these some, as in *Matuta*, have a scraper in the carapace and a rasp on the appendages; while in others the rasp is placed on the body and the scraper on the appendages, as in *Macrophthalmus* and allies. In other forms the stridulating organs are situated entirely on the appendages, as in *Ocypode*, where the rasp is on one and the scraper on another part of the same appendage. In *Platyonychus bipustulosus* the rasps are on one and the scrapers on another pair of appendages.

Among the curious forms dredged at great depths by the *Challenger* expedition were certain blind Crustacea, called *Willemœsia*. The species of this and allied genera have been described by Mr. C. Spence Bate in the *Annals and Magazine of Natural History*. The eyes in all are rudimentary, the stalk being reduced to a minimum, forming a rigid part of the crust, and covered by the carapace. Now it appears that in the embryo stage the eyes are large and distinctly stalked. A parallel case is seen in the genus *Alpheus*, the *zoëa* or larva of which has eyes considerably larger and more like the permanent organ in other genera than the adult parent from which it springs. We may add that the eyes of the young blind craw-fish of Mammoth Cave are larger proportionately than in the adult. This alteration from the original type to a rudimentary condition is due, Bate rightly claims, to a

cause acting through the habits of the animal after it has passed through its *zoëa* stage. *Alpheus* is a parallel case, and as the result has been somewhat similar, it is highly probable that the conditions have been parallel. *Alpheus* is in the young stage a free-swimming animal with powerful organs of vision, but in its adult condition it burrows in sponges, etc., where the eye is of little use. *Willemœsia* also in its young stage has well-developed eyes, which it loses when it has arrived at its adult condition. This, the writer thinks, is attributable to a similar cause, viz., that it burrows in the soft mud of the deep-sea bottom. That the imperfect state of the eyes is not due to the loss of light from the great depth at which *Willemœsia* is taken is evident from the fact that *Thalascaris* (a new genus of *Crangonidæ*) is taken at depths equally great, and is remarkable for the large size of its eyes.

In a report on the present state of our knowledge of Crustacea, Mr. Spence Bate gives a *résumé* of what is known of the ears of these animals, especially the shrimps and crabs. From experiments made by Dr. Hensen, it appears that crabs and shrimps living in water did not notice sounds made in the air, and that they were only slightly affected by sounds made with a fife or bell in contact with a membrane connecting the same with the water. In experiments made with musical notes, he found that certain hairs vibrated to certain sounds. Under these conditions, Dr. Hensen found that a certain hair, which only vibrated under one note, will, under a different one, shake to the very base so powerfully that it cannot be distinctly observed, and that as soon as the sound ceases the movement also ceases. He has accordingly drawn up a scale of musical notes adapted to the various hairs which he thinks belong to this sense.

The structure of the eyes of worms and Crustacea has been carefully studied by J. Chatin, whose results appear in the *Ann. des Sc. Naturelles.* He concludes that the staff or filament of the optic nerve forms the most important part of the elements of the eye. Limited externally by the cornea, confined internally to the ganglion of the optic nerve, the staff consists of two parts quite distinct, differing notably in character and value; one being internal, and more or less slender, which should be called the staff or *batonnet* (literally

tip-cat); the other, external, short, swollen, but of variable form, is the *cone*. In its structure it is separated by transverse striæ into a certain number of disks, much as in the "staff" of the eye in vertebrates. He then alludes to the actual and heterogeneous series of worms, of which the *ensemble* constitutes a sort of *groupe de départ*, allied by direct parentage to other branches. This opinion seems to M. Chatin especially defensible when we examine the visual organs, which assume in them different forms, and which recall the eyes of mollusks or of vertebrates; while others are comparable, as regards their eyes, to certain lower animals. He finds that in some worms, as seen in *Protrula*, *Vermilia*, the staffs of the eyes are like those of Crustacea.

The stridulating apparatus of the spiny lobster (*Palinurus*) has been found, by Mr. T. J. Parker, to consist of a peculiar modification of the second joint of the antennæ working against the lateral surface of the antennulary sternum.

The development of the cray-fish has been freshly studied by Reichenbach, who supplements the works of Rathke, Lereboullet, and Bobretsky. He has found that many of the endodermal cells of the ordinary columnar form are lobed at the end towards the yolk, and give off more or less fine threads of protoplasm, which pass between, and in some cases surround, the yolk spheres. These cells evidently absorb the nutritive matter of the yolk, "not by a passive process of diffusion, but by an active process of ingestion, the food particles being immediately 'plunged into the living protoplasm of the cell,' and there digested." This active swallowing of particles of the yolk by embryonic cells was first observed by Lankester in the egg of the cuttle-fish.

Observations on the rate of growth of the barnacle have been made by Dr. Packard, who states that he has found that the common barnacle of our coast (*Balanus balanoides*) had attained its mature size between April 5 and November 17, or in one season. A number of similar observations are recorded by Darwin in his work on barnacles.

The Royal Society of Sciences of Upsala, founded in 1710, gives evidence of its vitality by the publication of an imposing *extra ordinem* quarto volume in connection with the fourth centennial celebration of the Royal University of Up-

sala. It contains a large number of papers by its members. Those on zoology comprise a note by H. Thiel on some Holothurians of the seas of Nova Zembla, illustrated by a plate. Tycho Tullberg, a descendant of Linnæus, contributes an illustrated paper on the byssus-gland of the edible mussel, its structure and relations. Professor Lilljeborg gives a systematic review of the Phyllopod Crustacea of Sweden. He regards the *Branchinecta grœnlandica* of Verrill as identical with the *B. paludosus* of Müller, which not only occurs in Greenland but also in Northern Norway, on the Dovre Fjeld in Lapland, in Nova Zembla, Vaigatch Island, and in Northern Siberia. A new species of *Lepidurus* (*L. macrurus*) is described from Archangel, in Northern Russia, which is nearly allied to *Lepidurus couesii* (Packard), from Montana. This is an interesting discovery, as showing the analogy of the Phyllopod fauna of the central region of North America—*i. e.*, the fauna of the great plains and Rocky Mountain plateau—to that of Northeastern Asia—a relation noticed by Packard in the insects of the Rocky Mountains. A good deal of uncertainty pervades the subject of the growth and breeding season of the Phyllopod Crustacea, all except *Artemia* inhabiting fresh water. The members of the family *Branchipodidæ* (*Branchipus* and *Artemia*) are found very early in the spring with ripe eggs, as soon as the snow melts. It now appears that *Eubranchipus vernalis* (Verrill) has been found near Salem, Mass., of adult age, with nearly ripe eggs, in December and January; so that this species attains its growth in the autumn. Whether it lays eggs then is not known, but it is not probable that the eggs are dropped before the early spring. The young may attain their growth in one season, and probably do. While in Utah last summer Dr. Packard ascertained that the *Artemia* of Great Salt Lake probably passes the winter months in the sexually mature state, as he was told that the adults occur abundantly in early spring, hence must get their full size in the previous autumn.

In a report on the insect and other animal forms of Caledonia Creek, New York, Mr. J. A. Lintner describes, for the New York State Commissioners of Fisheries, the various insects and crustaceans which abound in fresh-water streams and ponds, and serve as food for fishes. He confirms the

observations of Verrill and others, that nearly all the fishes which are most prized for richness and delicacy of flavor—the shad, the salmon, the trout, the white-fish, and the Otsego Lake bass—are those whose diet is to a great extent crustacean. Hence Mr. Lintner infers that the Crustacea are the best food upon which fishes can feed. He concludes that food for fish should be transplanted, and streams and ponds stocked with insects, Crustacea, etc.; for he infers, first, that in any stream having the same character of water, the addition of a similar fauna and flora should fit it for an equal abundance of trout; and, second, that streams, ponds, and lakes having a different character of water (as to current, temperature, substances in solution, etc.), by the addition of a similar fauna and flora, may be fitted for an equal abundance—perhaps greater—of some species of fish desirable for food. It is shown by the writer that insects and Crustacea can be readily transplanted, and made to multiply in profusion. In this connection he states that the craw-fish (*Astacus*), under liberal appropriations made by the government, is at the present time extensively cultivated in the rivers and brooks of France for table use.

Henry Woodward's catalogue of British fossil Crustacea, just published by the British Museum, contains a record of 197 genera and 1051 species and varieties, or more than three times as many as were known in 1854. Of these, more than 300 are of trilobites, the largest of them (the *Paradoxides Davidis*) being nearly two feet long. The *Ostracoda* are most numerous, amounting to more than 450. These are largely represented throughout the entire series of fossiliferous formations, and are equally well represented among living animals. Some important beds are chiefly composed of these accumulated valves.

The oldest short-tailed crab has recently been described by Dr. Woodward, under the name of *Brachypyge carbonis*. Before the discovery of this crab, the oldest one known was from the great *Oolite;* the present species is from the carboniferous formation of Belgium.

A fossil decapod crustacean (*Anthracopalæmon Hillianum*), represented by a carapace, is the first of this order found in the coal formation of Nova Scotia.

A fossil nebaliad crustacean and a species of *Termes*, or

white ant, have been described, from the carboniferous formation of Illinois, by Mr. Scudder.

A synopsis of the North American species of *Alpheus*, a genus of shrimps, by J. S. Kingsley, appears in the *Bulletin* of Hayden's United States Geological Survey. The common species on the coast of Florida—*Alpheus minus*—lives in great abundance in the larger openings (oscula) of sponges. This and another common Floridian form—*Alpheus heterochelis* (Say)—occur at Panama and at Realejo, West Nicaragua. These, with *Alpheus transverso-dactylus* (Kingsley), add three more to the small list of Crustacea common to the Atlantic and Pacific coasts of Central America.

In this connection it is interesting to notice the discovery of *Branchipus* (or *Chirocephalus*) in a fossil state, associated with *Archæoniscus*, and with numerous insect remains, in the eocene fresh-water limestone of the Isle of Wight, by Henry Woodward. Of the *Branchipus*, both sexes are beautifully preserved, the males showing their large clasping antennæ, and the females their egg-pouches, with large and very distinct disk-like bodies representing the compressed eggs. It is called *Branchipodites vectensis.*

Professor Pavesi contributes to the *Bulletin* of the Entomological Society of Italy an article on the pelagic fauna of the Italian lakes. The fauna consists chiefly of cladocerous Crustacea of the genera *Daphnia*, *Bythotrephes*, *Leptodora*, and *Heterocope.*

The *Nebaliadæ*, represented by the existing genus *Nebalia*, have generally been considered to form a family of Phyllopod Crustacea. Metschnikoff, who studied the embryology of *Nebalia*, considered it to be a "Phyllopodiform Decapod." Besides, however, the resemblance to the Decapods, there is also a combination of Copepod and Phyllopod characteristics. The type is an instance of a generalized one, and is of high antiquity, having been ushered in during the earliest Silurian period, when there were, if we regard the relative size of most Crustacea, and especially of living *Nebaliæ*, gigantic forms. Such was *Dithyrocaris*, which must have been over a foot long, the carapace being seven inches long. The modern *Nebalia* is small—about half an inch in length—with the body compressed, and the carapace bivalved, as in *Limnadia*, one of the genuine Phyllopods. There is a large ros-

trum overhanging the head, stalked eyes, and, besides two pair of antennæ and mouth-parts, eight pair of leaf-like, short respiratory feet, which are succeeded by swimming-feet. There is no metamorphosis, development being direct. Of the fossil forms, *Hymenocaris* was regarded by Salter as "the more generalized type." The genera *Peltocaris* and *Discinocaris* characterize the Lower Silurian period, *Ceratiocaris* the Upper; *Dictyocaris* the Upper Silurian and lowest Devonian strata, and *Dithyrocaris* and *Argus* the Carboniferous period. Our northeastern species is *Nebalia bipes* (Fabricius), which occurs from Maine to Greenland. The Nebaliads were the forerunners of the *Decapoda*, and form, according to A. S. Packard, Jun., the types of a distinct order of Crustacea, for which he proposes the name *Phyllocarida*.

Insects.

In an interesting article on insect sounds, by Dr. H. E. Tripp, published in the *Proceedings* of the Bristol Naturalists' Society, the author takes the ground that the sounds made by bees, flies, gnats, and the *Cicada* are vocal sounds, made by the air rushing from the spiracles or breathing-holes in the thorax, which constitute vocal organs, the tone produced being a reed-sound, the insect having, as it were, one or two pairs of mouths. Distinguishing insect sounds by the mode in which they are instrumentally produced, we may classify them as: 1. Stridulant tones, as of a rasp or file, the stridulation being produced by the rapid click of toothed processes. 2. Wing tones, as simple vibration of air. 3. Voice, as a reed-tone, essentially consisting of vibration of membranes. 4. Noises, or interrupted concussion-sounds, as when parts of the body are struck against each other or against foreign bodies; or, as in some rare cases, air-volumes expelled from the interior of the insect; or, again, as in the movements of the wings in certain *Acrydii* (grasshoppers).

The sounds made by most insects are undoubtedly sexual calls. Thus Hartman writes that in June, standing in a dense chestnut forest, he saw the voiceless females gather from all directions, while the males shrilled their love-calls. Landois, in an entertaining work on Animal Sounds, states that in many cases the object of insect-sound is the preservation of the individual, as many insects make no sound ex-

cept when attacked, alarmed, or irritated. Landois also believes that insect sounds serve as means of mutual communication and understanding upon subjects not immediately connected with sexual instincts. In Poggendorff's *Annalen*, vol. cl., Landois has published a long series of experiments, accompanied by phototypes from photographs of a number of sound-lines, produced by drawing a penknife over the surface of a highly polished plate of metal or glass. Now, the phenomena of friction sounds and tones in the *Articulata* are exactly analogous. In crabs, spiders, beetles, crickets, etc., the fine notches which are found on their various file- or rasp-like organs correspond with the marks on the sound-lines of the plates experimented upon; and over these file-notched organs some sharp edge, belonging to some other part of the body, is moved backwards and forwards. The tone produced bears exact relation to the fineness of the notches and the rapidity with which the moving part of the apparatus is driven. It is observed, for instance, that when the movements of the thighs of the grasshoppers begin rather slowly, the "srr" tone is deeper than when the motion is more rapid; and the finer the notches, or the more rapid the movements, so much more acute are the tones given out by the crickets, beetles, bugs, etc.

If the number of notches and the length of the file be known, and also the time occupied by the movement of the organs, the pitch of the tone produced by the insect can be easily reckoned. And, conversely, other known quantities may be found—as, *e. g.*, the number of notches on the file can be reckoned from the data of pitch of tone, length of file, and time of motion.

We can thus obtain some idea of the notes of insects whose fossil remains still show the length of the notched ridges and number of notches thereon, if we assume the movement of the parts to have the same rapidity as is observed in living species!

To determine the note of a free-flying insect requires a very musical ear, and also long practice in recognizing and distinguishing the note sounded by an insect flying rapidly by, as any one will find who tries. When the sexes of the same species differ much in size, so does the wing-tone.

A certain small bee gives the tone *h*, while the much larger

bee gives a tone more than an octave higher. This depends on the number of wing-vibrations in a given time. Marey has counted the number of vibrations of the insect wing, by help of a graphic method. Landois has prepared a table of musical notes and their corresponding vibrations, so that it becomes easy to determine the number of vibrations of the insect's wing, provided that the flight-tone be distinguished from the voice. He states that the female of a humblebee (*Bombus muscorum*) hums in flight the note *a*, which is equivalent to 220 strokes of the wing per second. The honey-bee sounds with its wing-motion the note *a'*, and therefore makes 440 per second, which is just double the number of vibrations made by the humblebee.

Fresh observations on the buzzing of insects have been made by J. Perez. He believes that the cause of buzzing certainly resides in the wings. In the *Hymenoptera* and *Diptera* the buzzing is due to two distinct causes — one, the vibration of which the articulation of the wing is the seat, and which constitutes true buzzing; the other, the friction of the wing, an effect which more or less modifies the former. In moths of strong flight, such as the sphinges, the soft and full buzzing which these animals produce is only due to the friction of the air by the wings. This sound, which is always grave, is alone produced. It is not accompanied by the basal beatings, owing to a peculiar organization, and especially to the presence of the scales. In the dragon-flies also, in which the base of the wing is furnished with soft fleshy parts, no true buzzing occurs; but a simple rustling, due to the friction of the organs of flight. M. Perez believes that the passage of air through the respiratory orifices has nothing to do with the production of sound, as when injured or closed the buzzing goes on. When the stigmata, or air-holes, are stopped hermetically, as was done by Burmeister, the buzzing is only weakened, as the insect itself is partially asphyxiated by the loss of fresh air. When—as Chabrier did—Perez stuck together the wings of a fly, the sound was still produced, as the base of the wing continued to vibrate, and the buzzing sound to be produced. But all buzzing was stopped if, by holding the wings pressed together, over as large an extent as possible, so as to exert a certain traction upon their bases, all movements of these organs are rendered impossible.

In whatever way the wings are confined, provided their immobility be incomplete, the buzzing absolutely ceases; contrary to Hunter's statement. M. Perez's observations can be readily repeated, if nice methods of procedure are followed, by observers in this country, and this vexed question be set at rest.

One of the walking-stick insects, or *Phasmidæ*, has been discovered by Mr. Wood-Mason to be a sound-producing insect. In *Pterinoxylus* he found that a stridulating noise was produced by a rasp on the hind wing, in connection with a resonant swelling on the wing-cover, and this appeared in the females. This apparatus is much like that of locusts (*Œdipoda*).

While the organs of sense are in vertebrate animals invariably attached to the head, in the lower animals ears and antennæ-like organs, and perhaps smelling organs, may be found in the abdomen, or elsewhere. That all those insects which produce sound must have the faculty of hearing it, seems a truism; still it is difficult to discover the seat of the organs of hearing. In locusts or grasshoppers the organs of hearing are situated at the base of the abdomen in two large sacs situated next to the stigmata in the basal segment. Mr. A. H. Swinton has now found that somewhat similar organs of hearing likewise exist at the base of the abdomen of some moths, as certain *Noctuidæ*, or owlet moths. If, says Mr. Swinton, after having killed an individual of a large *Noctua*, and denuded the abdomen of scales and hair, we examine its junction with the thorax, we observe a constriction of the segments that has occurred in the metamorphosis, whereby the first and second abdominal segments of the caterpillar are represented by dorsal arcs indicating a pedicel. In the *Noctuina* the organ of hearing is found between these contracted segments and the metathorax. The external ear is recognized in a rather large cavity that here penetrates the abdomen on each side, and is oval in section, with a posterior excavation, or couch. There is, besides, a tube, which is the counterpart of the Eustachian tube. In its general structure the moth's ear is like that of the grasshopper. Mr. Swinton has observed similar ears in moths of the silk-worm and geometrid families, and they may be traced in certain *Diptera*, as the crane-fly.

Curious organs of smell have been found by Fritz Müller, of Brazil, in the females of certain Heliconid butterflies, which he figures and describes in Siebold and Kölliker's *Zeitschrift*. He has also lately described certain pencils of hairs, felt spots, and similar structures on the wings of male butterflies.

In a paper on the biology of insects as determined by the emotions, Mr. A. H. Swinton discusses cases of simple muscular contractions and secretions.

The vessels attached to the end of the stomach of Myriopods, *Arachnidæ*, and insects, which, from being first discovered by the Italian anatomist Malpighi, were called Malpighian vessels, though at first regarded as corresponding to the liver of the higher animals, have of late years, by the best observers, especially Plateau, of Gand, Belgium, been thought without doubt to be excretory in their function, and to correspond to the kidney and ureters of the higher animals. In a paper just published in Siebold and Kölliker's *Zeitschrift*, Dr. E. Schindler reviews the whole subject, and, from a thorough examination of insects belonging to all the orders, concludes that the Malpighian tubes are specially urinary in their function, finding in their urinary concretions leucin, uric, and oxalic acids, and oxalate of lime.

While the whip-tail scorpion (*Thelyphonus giganteus*) of Mexico and adjoining parts of the United States has lately been shown to be poisonous, by a writer in the *American Naturalist*, Mr. E. Wilkinson, Jun., states that this animal is offensively odorous, apparently emitting the smell from its tail, which is long and filiform.

In a paper on the ornamental colors of the *Daphnidæ*, or water-fleas, Professor Weismann concludes that secondary sexual characters can in these animals become general specific characters, and illustrate the Darwinian view of the origin of the colors of butterflies.

A number of luminous beetles (fire-flies) and beetle grubs are known to exist, and a caterpillar is said to be phosphorescent. Baron Ostensacken has collected some statements made by various authors regarding luminous two-winged flies. Brischke has observed a light-giving gnat (*Chironomus tendens*), the same facts having previously been observed by Pallas. The head of the rare and remarkable fly *Thyreophora cynophila* is said to be phosphorescent. This

fly is metallic blue; its head comparatively large, swollen, and of a bright orange red. It lives in dark places, on offal, a sombre light issuing from its phosphorescent head. This statement of Macquart is probably taken originally from Robineau Desvoidy.

M. Jousset de Bellessure gives an extraordinary account of the mode in which *Libellula depressa* expands to its full size, and extends its wings after quitting the pupa skin. After describing the well-known process of the emergence of the insect, he inquires by what mechanism does the insect inflate itself and increase its volume to such an extent that after issuing from its little envelope it suddenly becomes double its former size. He states that at this time the function of respiration, which is very active in the adult dragon-fly, is not yet set up. There are no movements of inspiration and expiration; the abdomen is cylindrical, and the deep fold in the ventral surface of the abdomen, which he regards as essential to respiration, is not yet in existence. On dissection, the air-sacs of the body are found to be empty and flaccid. Nevertheless, the inflation of the dragon-fly is effected by air; and if the body is cut through with a pair of scissors, it collapses in a moment like a balloon. By taking suitable precautions, and dissecting the animal under water, it is found, he says, that the digestive tube here performs a most unusual physiological part. It is so much distended that it absolutely fills the whole interior of the body, pushing the other organs against the integuments. Under the influence of this energetic pressure the blood is pressed forcibly towards the periphery, distends the eyes, and gives the head its definite form; then passing into the wing, between the two membranes — which up to this time are separate, as M. Blanchard has described them — it accumulates in the wing, unfolds it, and circulates in it, depositing the pigment which is destined to color it. During this time the integuments, which are distended and bathed by the nutritive fluid, acquire their proper color and solidity. It is by swallowing the air, and storing it in its digestive tube, says the author, that the *Libellula* obtains the force necessary for the accomplishment of most of its transformations; and he thinks there is every reason to believe that the same thing occurs in many other insects.

An elaborate essay on the structure of the brain in insects, by J. H. L. Flögel, illustrated by photographs of microscopic sections, appears in Siebold and Kölliker's *Zeitschrift*. He finds that the central body of the brain, present in the adult insects of all orders, is wanting in caterpillars, but not in the larvæ of the *Hymenoptera*. He thinks this has something to do with the structure of the faceted eyes (absent in caterpillars).

Great consternation is occasioned among housekeepers by the ravages in carpets of a beetle allied to the museum pest (*Anthrenus*) so destructive to stuffed birds and insects. The carpet *Anthrenus* is a recent European importation, and is destined to be a terrible pest in this country. Mr. J. A. Lintner has given a full account of it, which appears in the *American Naturalist* for August. The insect originally appeared in Albany and neighboring cities, but has proved very destructive to carpets in Cambridge and Greenwood, Mass. It is very insidious in its attacks, and sets at defiance the usual remedies. The free use of benzine or of Persian insect-powder on the carpet seems the best antidote.

How the little ichneumon-fly (*Microgaster*) spins, when a larva, its white cylindrical cocoons, is fully shown by Professor Marshall. The larvæ of this insect, which have fed within the body of some grape-vine sphinx (*Philampelus*), bore through the skin of their host, and then spin a white cocoon. Sometimes a caterpillar will bear about 300 to 400 cocoons.

M. Charles Barrois contributes to the *Journal de l'Anatomie*, etc., an account of the development of a spider. He claims that at one period of its embryonic life it passes through a "Limulus stage;" but the resemblance of the embryo spider to the king-crab, so far as the drawing indicates, is so slight as to be scarcely worthy of mention.

Mr. Scudder continues, in the *Bulletin* of Hayden's United States Geological Survey of the Territories, his descriptions of Western fossil insects; the last paper treating of the Tertiary insects of the Green River shales, comprising ants, ichneumons, crane-flies, etc., beetles, bugs, grasshoppers, and dragon-flies, a spider, and a galley-worm (*Iulus*).

M. Maurice Girard has communicated to the Entomological

Society of France some new facts on the subject of living frogs attacked by flies (*Lucilia bufonivora*). M. Desquez has found a third subject, at Bondy, containing some maggots in its nose, so that it seems to leave no doubt but that the species exists around Paris. M. Fernand Lataste, well known for his studies on the herpetology of Gironde and the environs of Paris, has noted in his excursions a probably analogous fact, although it may be less certain, regarding the green frog (*Rana viridis* Linn.). An enormous subject of this species, caught at the bottom of a limpid stream not far from Bordeaux, had the lower jaw eaten by an ulcer, or by worms. Gratiolet has published a note on the dipterous larvæ living at the expense of the green lizard (*Lacerta viridissima*).

At a late meeting of the London Entomological Society, Mr. Rutherford exhibited a series of large brown irregular masses of strong web, from 4 to 7 inches in diameter, being the common envelopes of aggregations of cocoons of a species of silk-worm allied to *Anaphe panda* (Boisduval), sent from Mount Cameroons (5000 feet elevation). Each of these masses contained from 130 to 150 special cocoons, and to some of them were attached cases containing large larvæ (still living) of a parasite—either dipterous or hymenopterous, probably the latter.

"The Mound-making Ants of the Alleghanies" is an interesting pamphlet of about fifty pages, illustrated with six lithographic plates and a number of cuts, in which Rev. Henry C. McCook recounts his studies into the habits of some of our ants, with especial reference to the wood- or fallow-ant (*Formica rufa*), whose modes of building, general style of architecture of the nests and galleries leading therefrom, the repairing of the nests, engineering, addition of stories, age of hills, food, feeding-places, aphis-friends, sentinels, tree-paths, water supply, recognition of fellow-ants, amity and confederation, night-work, winter habits, guest-beetles, guest-caterpillars, natural enemies, means of attack and defence, are discussed with fulness and interest, the paper being the result of independent observations.

This ant is regarded by the author as the same as *Formica rufa* of Europe—an ant whose domestic life was studied by Huber, and more recently by Forel, though Mr. McCook's

observations were made independent of his Swiss contemporary.

Mr. McCook noticed, as confirming one of the most ancient records of the economy of ants (Prov. vi., 7), that in all their movements in column, and in all building and foraging and police operations, the ants exhibited an entire independence and individuality of behavior. Each emmet seemed to be a law unto herself, and turned freely and commonly unfailingly into the most helpful and necessary channels of duty, "having neither guide, overseer, nor ruler." While Huber records the fact that in Europe this ant does no night-work, the same species as observed by our author, "when observed (as they were by me) during nearly every hour of the night, from sunset to sunrise, were found to be pursuing the very same labors in the same way and in the same fields as during the day. The avenues, tree-paths, feeding-stations, feeding-grounds and hills were always thronged day and night." These ants perform some work even in the winter in Pennsylvania, in the interior of their nests.

"There are several inferences, more or less conclusive, concerning the winter economy of the fallow-ant which we may draw from the above facts. First, the ants dwell within their formicaries during winter, and make no attempt to modify the surface surroundings. Second, the vast majority of the community, together with the fertile queens, larvæ, and cocoons, occupy the underground galleries. This appears from the fact that but one young queen and comparatively few workers of the various classes were found in the hill galleries. Third, the composition of the mounds is such as to insure, in the central parts, a good degree of protection against ordinarily severe winters for the few ants that occupy them. Fourth, the vitality of the ants is sufficient to keep them active within the hills during all ordinary seasons. Fifth, it is yet more evident that the occupants of the underground galleries are not torpid during ordinary winters, if ever; but exist in a state of considerable activity. Finally, it would appear that the ants are able to spend the winter in the active state without regular and ordinary supplies of food.

"We do not advance this last opinion with any degree of confidence. The mystery of the underground galleries

still veils the facts that would solve the question completely."

The metamorphoses of the blister-beetles (*Macrobasis* and *Epicauta*) have been discovered by Mr. C. V. Riley, who publishes a full account of them in the *Transactions* of the St. Louis Academy of Sciences. He has found the larvæ of different ages within the egg-pods and devouring the eggs of *Caloptenus spretus.* From such larvæ Riley has reared three species of our common black blister-beetles, so destructive at times to the potato. These beetles then pass through three separate larval stages, in the second stage being coarctate and quiescent, taking no food. M. J. Lichtenstein has also, says Riley in his paper, just succeeded in proving that the European *Cantharis* has a similar "hypermetamorphosis," although its mode of life is unknown. Riley has also discovered and figured a singular beetle belonging to an undescribed genus and species, which he calls *Hornia minutipennis.* It is allied to the oil-beetle, *Meloë*, but has remarkably small wings. It lives in the cells of the mason-bee.

While many insects of different orders produce sounds in various ways, it is not commonly known that even the chrysalis of a butterfly (*Thecla*) "produces a slight, short chirp." Mr. F. G. Schild, of Germany, who discovered this fact, explains the noise by the hypothesis that the sound arises from air being pressed and drawn in through the tracheæ on the abdomen and above and behind the eyes. "It appears, however," state the editors of the *Entomologist's Monthly Magazine*, "that more than a century ago (1774) Herr Kleeman discovered a creaking noise proceeding from the chrysalis of a similar butterfly."

In the first part of his studies on the spiders of Malaysia, especially *Celebes*, comprised in a work of three hundred pages, Dr. Thorell describes a large number of species. The work is being published at Genoa.

The "Structure and Habits of Spiders," by J. H. Emerton, is an attractive little book, comprising almost wholly the observations of the author, with numerous illustrations from the pencil of this eminent artist. The book is new and fresh in its facts and drawings, and is a valuable contribution to biology.

Further contributions to the subject of dimorphism and

parthenogenesis in the *Hymenoptera* appear in the *Entomologist's Monthly Magazine.*

M. Lichtenstein has obtained galls of *Spathogaster baccarum* from eggs laid by *Neuroterus lenticularis.* Mr. Cameron now confirms similar observations by Adler, and has found that the female saw-fly, *Pœcilosoma pulveratum*, the male of which is unknown, laid eggs from which the embryo developed, but the larva did not hatch, owing to the withering of the leaf.

The minute *Demodex folliculorum*, a low mite-like animal found in the skin of the face of man, has been found by Mr. Walter Faxon to occur in the ox, injuring materially cowhides sent to market. His account appears in the *Bulletin* of the Museum of Comparative Zoology. In the parts about the neck and shoulders especially, the skins presented numerous slight swellings which, under pressure, emitted a quantity of soft, whitish matter. After being tanned and split, the leather appeared disfigured with pits from one to six millimeters in width, which in many cases penetrated nearly through the thickness of the leather. In many of the samples eight or ten pits occurred within the area of one square inch. There are three varieties of this *Demodex* which infest man, the cat, and dog, and either these or allied varieties or species occur in the skin of the fox, bat, ox, horse, and sheep.

In a synopsis of the boreal *Collembola*, or *Poduridæ*, Dr. Tullberg describes all the known Greenland forms of this group, of which there are five species known. Several are described from Nova Zembla, Siberia, and Spitzbergen, and our knowledge of the arctic species is greatly extended. *Orchesella cincta* is recorded from Newfoundland.

In the sixth edition of his "Guide to the Study of Insects," Dr. Packard, among other changes, proposes the name *Cinura* for those *Thysanura* belonging to the families *Lepismatidæ* and *Campodeæ*. The group is considered to be a sub-order, equivalent to the *Collembola* of Lubbock, while the *Thysanura* are regarded as constituting an order.

In studying the anatomy of the Rocky Mountain locust, described in the first annual report of the United States Entomological Commission, especially the male intromittent organ and accessory parts, Dr. Packard finds that the penis

is concealed from view by a movable piece or hood attached to the tenth urite, and which he calls the *velum penis*. He also distinguishes the *uro-patagia* (lateral inferior flaps developed from the supra-anal plate), and has studied the distribution of the sympathetic nerve and the terminal abdominal nerves, which are distributed to the female internal and external reproductive organs.

The sixth report of the State Entomologist of Illinois, Professor Cyrus Thomas, appears with much matter that will be useful to farmers and gardeners.

The transformations of the locust mite, the little red mite so annoying and sometimes destructive to the Rocky Mountain locust, have been discovered by Professor Riley, and published in the report of the United States Entomological Commission.

Further researches by Mr. Riley on the gall-producing plant-lice, allied to *Phylloxera*, the grape-vine pest, are of interest. Recently Dr. Kessler, of Cassel, by a series of ingenious experiments, has concluded that these insects hibernate on the trunk of the elm. In 1872, Mr. Riley, led by his previous investigations into the habits of the grape *Phylloxera*, discovered that some of our elm-feeding species of *Pemphiginæ* produce wingless and mouthless males and females, and that the female lays but one solitary impregnated egg. Continuing his researches the past summer, he has been able to trace the life history of those species producing galls on our own elms, and to show that they all agree in this respect, and that the impregnated egg produced by the female is consigned to the sheltered portions of the trunk of the tree, and there hibernates, the issue therefrom being the stem-mother which founds the gall-producing colony the ensuing spring. "Thus the analogy in the life history of the *Pemphiginæ* and the *Phylloxerinæ* is established, and the question as to what becomes of the winged insects after they leave the galls is no longer an open one. They instinctively seek the bark of the tree, and there give birth to the sexual individuals, either directly or (in one species) through intervening generations."

A swarm of locusts (*Acridium peregrinum*) is reported in *Psyche* to have boarded the ship *Harrisburg*, of Boston, on the passage from Bordeaux, bound to New Orleans, on the

2d day of November, 1865, in latitude 25° 28′ N., longitude 41° 33′ W., making the nearest point of land 1200 miles off. They came on board in a heavy rain-squall, the clouds and ship's sails being full of them for two days, as certified to by E. G. Wiswell, master of the vessel. This species appeared in Corfu, in Spain, and even in England. The Corfu swarm, adds Mr. Scudder, was composed of the variety with yellow-colored hind-wings, and therefore came from Northern Africa, where that form is found, while the Spanish and English swarms were of the rose-colored variety, and must have originated in Senegal. "But the most interesting point of all is the fact, first pointed out by Stol, that all the other species of that group of the genus to which this species belongs are American; whence it is highly probable that *A. peregrinum* also is indigenous to America, from whence it has been recorded. Its occurrence in mid-ocean in such numbers is a clear indication that it originally flew from one continent to the other in sufficient numbers to establish itself in a new home."

During a late trip to the Western Territories, Professor Leidy, while watching some cliff-swallows passing in and out of their mud-built nests, was told that these nests swarmed with bed-bugs, and that people would not usually allow the birds to build in such places, because they introduced bed-bugs into the houses. He collected a number of the bugs from the swallows' nests, as well as from the houses. The latter were found to be the true bed-bug; the former the *Cimex hirundinis.* The bugs infesting the bat and pigeon have likewise been recognized as a peculiar species, with the name of *C. pipistrelli* and *C. columbarius.* The habit of *C. hirundinis* was found to be similar to that of *C. lectularius*, the bed-bug, in the fact that the bugs during the day-time would secrete themselves in the crevices of the boards, away from the nests. After sunset he had observed the bugs leave their hiding-places, and make their way to the nests. From these observations it would appear as if the bugs peculiar to these animals (swallows and man) did not reciprocally infest their hosts.

VERTEBRATE ZOOLOGY.

By Professor THEODORE GILL,
Of Washington, D. C.

INTRODUCTORY.

The usual activity has been manifested during the past year by laborers in the different fields of Vertebrate Zoology. Memoirs have been published on the Morphology and Comparative Anatomy of different systems and parts, many articles have been devoted to Faunal Zoology, and numerous new species have been described, although of the latter fewer, perhaps, have been made known than on the average have been introduced during past years. The tendency to admit a wider range of variation, and to refuse specific rank to slight differences is becoming general, and this will operate in future to diminish the number of new species as well as to degrade many old ones. A notable example of the difference now—from the past—in the mode of treatment of variations has been recently furnished by memoirs of Messrs. J. A. Allen and E. R. Alston on the Squirrels of the Tropical Regions of America. According to Mr. Alston, no fewer than fifty-nine (59) specific names have been at one time or another proposed for forms occurring in the region in question; but these have now been reduced by Messrs. Alston and Allen, after independent examination of very rich material and of almost all the previously described types, to twelve species.

In the richness of the material at hand, it has not been easy to select that which might be regarded as of greatest value or interest from the mass of contributions to Vertebrate Zoology during the year. Abstracts have been chiefly made of those memoirs which are of special interest on account of the relations of the facts which they exhibit to problems of morphology, or from the light they throw on homologies; of those whose interest is inherent by reason of the popularity or well-known character of the animals in

question; and of those which relate especially to the American fauna, and thus concern every native naturalist.

Origin of Vertebrate Limbs.

Various views have been entertained respecting the genesis and development of the limbs of Vertebrates. That most prevalent twenty years ago, or more, was one especially maintained by Professor Owen, namely, that they were diverging appendages of special arches, the anterior or pectoral being the "ribs" or "pleurapophyses" of the occipital arch, and the posterior having corresponding relations with the pelvic arch. This, however, was long ago shown to be untenable. Recently several naturalists (*e. g.*, F. Balfour, J. K. Thacher, and St. George Mivart) have become satisfied that the limbs were originally developed from lateral fins of the same nature and parallel with the dorsal and anal, and that, in the words of Balfour, they are "remnants of continuous lateral fins." Balfour was led to this conclusion by the study of the embryonic development of Selachians, while Thacher and Mivart have reached the same result chiefly from the investigation of the grown forms of the same class, and the likeness and essential similarity of structure of the lateral and médian fins. There can be, in fact, very little doubt that the view of these naturalists named is the correct one, and, this being adopted, all the facts of development and modifications of the limbs harmonize. In the lowest of the Vertebrates — the Leptocardians, *i. e.*, *Amphioxus* and *Epigonichthys*—there are lateral folds, one on each side, of the same character as the dorsal and anal folds, designated as fins; and doubtless the nature of the limbed fins would have been recognized before had not the Marsipobranchiates intervened between the Leptocardians and the Selachians. All living Marsipobranchiates have eel-like forms and are destitute of lateral fins; and this negative character, which is probably simply the result of the elongated form and an atrophy or loss, has been insensibly taken as a principal feature of the class. In truth, however, the form is no more to be considered as a necessary element of the Marsipobranchiate type than is the eel-like form of the Teleost, and we must recognize in the living Marsipobranchiates simply modified and divergent derivatives of a type which doubt-

less was originally characterized by the development of lateral fins. The higher forms of Vertebrates manifest successive deviations from this primitive type.

In the Selachians, the lateral fins are low down on the sides or inferior, and the plane of their surfaces is nearly horizontal.

In the Ganoids, they evince more or less of a tendency to change the plane from horizontal to oblique—less in the Chondroganoids; most in the Amiids.

In the Teleosts, pectoral fins are advanced still higher up on the sides, becoming, on the whole, more and more elevated as the forms diverge from the Ganoids, and become specialized as thoracic and jugular Teleocephali.

The endoskeletal bases of the limbs are supposed to have originated from ingrowth of the pair-finned skeleton at definite areas, and the composite structures evidenced in the pectoral, and probably pelvic girdles, have apparently resulted from ingrowths at different stages. If, for example, we compare the shoulder girdle of the Selachians with that of the Ganoids and the Teleosts, we find that the first is quite simple, and it evidently represents only the inner elements of the girdle of the last two types. If the sturgeons are considered, it becomes plain that exostosis, or development of bone externally, has first supervened, and that this has subsequently penetrated inwards, and become closely identified with the inner or coracoid elements. (See Gill, "Arrangement of Families of Fishes," p. 9, 1872).

The process of differentiation between fins and the limbs of Terrestrial Vertebrates is best explicable by reference to the Polypterids. In those fishes, the pectoral fin is supported by two elongated bones connected with a basal cartilage. This basal cartilage apparently represents the humerus, and the succeeding bones the radius and ulna of the land Vertebrates; while in the specialized fishes, first the humeral rudiment disappears, and then the radial and ulnar, leaving, in most of the Teleosts, only the several parallel bones at the base of the fin, which are, apparently, homologous with the metacarpal, the carpal probably having been developed in the undifferentiated cartilage intervening in the Polypterids between the radial and ulnar elements.

Fishes, etc.

A goodly number of contributions have been made to the literature of Ichthyology in most of its branches. The Selachians have received special attention, and members of the class have been examined as to skeletal characters, by C. Hasse, A. Goette, W. K. Parker, and St. George Mivart; as to the nervous system, by E. Ehlers and J. V. Rohon; and for the embryology, by J. M. Balfour; while certain species have been elucidated by Garman, of Cambridge, Mass. The true fishes have also received a due share of attention from anatomists (although less proportionately than the Selachians), and the faunas of several regions have been especially studied, such as the fresh-water fishes of North America, by E. D. Cope and D. S. Jordan; the marine species, by G. B. Goode, T. Bean, and H. C. Yarrow; those of the Arctic regions, by C. Lütken; deep-sea forms, by A. Günther; Japanese types, by A. Günther and F. Hilgendorf; South American fresh-water forms, by F. Steindachner and C. Lütken; African fresh-water species, by C. Dombeck; Indo-Moluccan species, by P. von Bleeker; and Australian types, by T. Castelnau, Hector, and W. Macleay. Quite a large number of "new genera" have been proposed, but several of them are unquestionably the result of imperfect knowledge or erroneous ideas, and among such may be mentioned those named by Count Castelnau (1) *Brisbania* and (2) *Baridia* or *Beridia*. The former was proposed for a fish occurring in the Brisbane River (New South Wales), and is undoubtedly identical with *Megalops*, while the latter is the same as *Gnathanacanthus*, long before described by Bleeker. The embryology of different species has been investigated by A. Agassiz, Carlo Emery, C. Kupffer, and E. Van Beneden. Death has deprived ichthyology of the most active and one of the most useful laborers of the century, in the person of Dr. P. von Bleeker.

North American Fresh-water Fishes.

Professor Jordan during the past year continued his investigation of the fresh-water fishes of North America, and has given his latest views in a catalogue of all the recognizable forms. Six hundred and sixty-five species are admitted—many, however, with doubt; and these represent, ac-

cording to his views, 32 families and 157 genera. "The classification, as regards the families and higher groups, is throughout that of Professor Gill;" but "the order of the forms has been reversed, beginning with the most generalized forms," and ending with those "higher, or more specialized." The peculiarities of the North American fauna, from an ichthyological point of view, are so great and yet so little known, that a *résumé* of its characteristics must interest even the general reader. (1) No less than eight families are confined, so far as yet known, to North America, this side of Mexico; these are the Amiids, Hyodontids, Percopsids, Amblyopsids (including the blind fish of the Mammoth Cave), Aphredoderids, Elassomids, Centrarchids (sunfishes, black basses, etc.), and Etheostomids; the last two, and especially the Centrarchids, are very characteristic, and form one of the most prominent features of our fauna. Of the eight families, one (the Amiids) was formerly widely diffused in the northern hemisphere, and may possibly be still existent in temperate Eastern Asia. (2) In that part of Asia there are representatives of three other families, otherwise peculiar to North America, the Polyodontids (paddle-nose sturgeons), Lepidosteids (gar-pikes), and Catastomids (suckers); of these the Lepidosteids were formerly also existent in Europe during the Tertiary epoch. The peculiarities of the North American ichthyic fauna are thus partly autochthonic and partly due to the survival of ancient forms once widely diffused, but now extinct, or nearly so, save in America. (3) Another element for the southwestern fish-fauna is furnished by the families of Characinids and Cichlids, both of which send representatives into the adjoining United States; these families are especially interesting as being confined to Africa and America. (4) Eight families are characteristic of the northern hemisphere; three of these (Esocids, Umbrids, and Percids, typical perches and their allies) are special fresh-water types; the other five (Acipenserids, Salmonids, Labracids, Cottids, and Gasterosteids) are almost indifferently salt- or fresh-water forms—*i. e.*, they inhabit both, or are anadromous; but some species are limited to the fresh water, while closely related species may be marine or anadromous. (5) Eleven families are cosmopolitan or common to more than two regions; eight of these are really marine types, and the fresh-

water representatives are either exceptional or anadromous. There are about twenty-five species, the families being the Petromyzontids, Anguillids, Dorysomids, Clupeids, Microstomids, Atherinids, Sciænids, and Gadids; one family (the Cyprinodontids) is as much a salt-water as a fresh-water type; the remaining two are either, as in the case of the Cyprinids, purely fresh-water fishes, or, as in the case of the Silurids (catfishes), while certain groups of genera are marine, others exclusively affect the fresh water.

Still more remarkable than the number of families peculiar to the region in question is the number of genera. Accepting the idea of genus current among American ichthyologists, certainly over 110 are confined to this region. Even of the Cyprinids, which are more nearly equally diffused over the northern hemisphere than any other family, most of the genera are peculiar, and the only ones, apparently, common to Europe and America are *Telestes*, *Squalius*, *Phoxinus*, *Leucos*, and *Alburnus*. It is to be remarked that the genera shared in common are chiefly represented in America on the Pacific slope, and thus corroborate the closer relationships existing between that side of the continent and the Old World.

Vascular Dentine and Movable Teeth in Fishes.

Mr. C. S. Tomes, the well-known authority on the teeth of Vertebrates, has especially studied the structure and development of vascular dentine, and has announced, as the result of such studies, that there are four modifications, which are distinguished by him in the following terms:

(1) "Hard, unvascular dentine, the characters of which are sufficiently known.

(2) "Vaso-dentine, which is developed from odontoblasts after the manner of dentine, but contains an anastomosing net-work of canals modelled around and containing capillaries.

(3) "Plici-dentine, developed from odontoblasts, but from a complicated pulp, so that it is more or less divided up into distinct systems of dentinal tubes.

(4) "Osteo-dentine, developed from osteoblasts, like bone, and quite unlike dentine, permeated by a system of large canals, which do not contain, or have any special relation to, blood-vessels."

"The author lays no stress on the characters formerly given as distinctive of osteo-dentine—*i. e.*, (1) a laminated arrangement of the matrix is not unknown in vaso-dentine; (2) lacunæ are very frequently absent from bone in fishes, and very frequently from osteo-dentine, so that these characters, as those who have tried to apply them have found, are not useful in practice."

Mr. Tomes has also been struck by the peculiarity of the teeth of the hake (*Merlucius*) and some other fishes. "The attachment of the teeth of the hake is so peculiar as to merit a word of notice. The inner and longer of the two rows of teeth are set upon elastic hinges, which allow of their being bent inward towards the throat, but cause them at once to spring back into the upright position when pressure is taken off them. This arrangement, shared by the angler, was hardly to be expected in one of the Gadidæ; but the author has found in others of the family steps towards this highly specialized arrangement, the benefits of which, to a voracious predatory fish, such as the hake, are obvious.

"The common cod has teeth which admit of a small amount of motion only; but a comparison of them with those of the hake shows clearly that a further modification in the same direction would lead to an attachment similar to that of the latter fish.

"The haddock, which in this respect is a fair representative of the family, has teeth which admit of no motion at all."

This depressibility and mobility of the teeth is, however, by no means as uncommon as Mr. Tomes has evidently supposed. It seems to be characteristic of those fishes in which the teeth increase in size in the inward rows. It was long ago (in 1862) shown to be the case in the hake by Gill, and it also occurs not only in the Lophiids and Esocids, but in the Ceratiids, and many Serranids, Blenniids, Gobiids, and others. Even in the case of some fishes with obtuse armature, the teeth are movable; this is notably the case in *Pleuronectes*, one of the flatfishes, the teeth of which may almost be played upon like the keys of a piano, during the breeding season, though at other times quite fixed.

Various Physiological Adaptations of Fishes for Aerial Respiration.

M. Jobert, of Dijon, a French naturalist who has been travelling in Brazil, has recently published a memoir in which he has called attention to some interesting modifications of several diverse organs or regions for the same physiological purpose—that is, aerial respiration. It is probably generally known that although most fishes do not need any more air than that which is furnished through the medium of the water to the gills, there are some which have peculiar adaptations of certain parts for the direct respiration of air, and which actually need access to the air, and die if totally deprived of it. Such has long been known to be the case especially with certain Indian fishes. M. Jobert's studies have been on some characteristic South American types, and may be briefly summarized as follows:

It was long ago shown that the air-bladder in certain Characins of the genus *Erythrinus*, and in *Sudis* or *Arapaima* was, in part, cellular or lung-like, but M. Jobert has demonstrated that, not only morphologically, but physiologically, is the air-bladder a lung in two species of Erythrinines, as well as in *Arapaima*. In the Erythrinines, the posterior compartment of the bi-partite air-bladder is, at the anterior region, copiously provided with blood-vessels, which originate, not from the usual branch of the aorta, but from a special vein through which venous blood is conveyed from the intestine as well as the walls of the abdomen. "After circulating through the rich plexus of blood-vessels in the air-bladder, the blood is returned in a purified state directly to the *sinus venosus*, or hindmost division of the heart, instead of being taken into the portal vein, as is usually the case with the returning current from the swim-bladder." In *Arapaima gigas*, it is the upper surface of the air-bladder that is endowed with the proper amount of vascularity, and this has, according to M. Jobert, the appearance of the lung of a bird.

In other fishes, it is a portion of the intestinal tract that is specialized for purposes of aeration, and observations have been made by Jobert on representatives of several groups of the order of Nematognathi—an order typified by the

common catfishes of the northern hemisphere. All these come to the surface to breathe and take in a fresh supply of air. Three modifications are noticed.

(1) In *Hypostomus*, it is that portion of the intestinal canal *immediately behind the stomach* that is specialized. "Here the mucous membrane entirely loses its ordinary character, being devoid both of villosities and of glands, and, therefore, no longer suited for absorption or secretion. The walls of this portion contain a rich plexus of blood-vessels, supplied partly from the aorta, but partly also by a vein bearing blood from the remainder of the intestine. After circulating through the plexus, and undergoing aeration, the blood is returned, as usual, into the portal vein."

(2) In *Doras*, the respiratory portion of the intestinal canal is provided with villosities and not with glands.

(3) In *Callichthys*, it is the *posterior extremity* of the intestinal canal that is modified for respiratory purposes, and in this genus the impure air is expelled through the anus, and not through the mouth, as in the other forms.

In still other types than those studied by M. Jobert, the modification for aerial respiration is manifested in the development of peculiar diverticula or offshoots from the pharynx, as in *Ophiocephalus*, *Saccobranchus*, and *Amphipnous*.

The special interest attached to these facts arises from the manifold ways in which the same physiological function may be exercised, and the susceptibility of so many different parts to the assumption of the same office. The lungs themselves, be it remembered, are merely a development of the air-bladder, and this, doubtless, originated as a simple diverticulum of the intestinal canal. In this connection, too, it is interesting to recall that some years ago Fritz Müller demonstrated in the land-crabs of Brazil analogous variations in the modifications for aerial respiration — that is, each form was shown to be adapted for life on land by diverse modifications of homologous parts, or by a peculiar modification of a certain part.

It may be well to add that some portions of M. Jobert's work should be revised, as in the case of the Erythrinines. It was long ago shown that in the typical *Erythrini*, the anterior part of the hinder compartment of the air-bladder was

cellular, and that in *Macrodon* there was no cellular portion. M. Jobert's investigations purport to have been based on three species—*E. tæniatus* and *E. brasiliensis*, in which the air-bladder was found to have a cellular area; and *E. trahira*, in which there was none. The *E. tæniatus* is doubtless the *E. unitæniatus*, but the *E. brasiliensis* of Spix is apparently the same as *E. trahira* (*Macrodon*), which has no cellular air-bladder, and consequently M. Jobert must have made an erroneous identification. Nothing could better attest the close relationship of these forms, so different physiologically, than such a mistake.

Egg-laying Sharks and Rays.

A number of communications have been published in popular periodicals, and otherwise, during the past year, respecting viviparous and egg-laying sharks and rays, which show the advisability of a brief statement of facts. Contrary to the popular impression, viviparity is the rule, and oviparity the exception, among the Selachians. Of the ten families of sharks represented along the eastern coast of the United States, nine are viviparous, and only one oviparous; that one being the *Ginglymostomidæ*, of which a single species occurs, mostly confined to Florida. Of the six families of rays, five are characterized by viviparity; and the only egg-laying forms are the species of skates, or ordinary rays. But while the family of *Raiidæ* is the only one of the order of *Raiæ* in which oviparity is manifested, there are several of the order of *Squali*, the chief of which is that of *Scylliidæ*. M. Vaillant has lately (in the *Comptes Rendus* of the French Academy of Sciences, vol. lxxxvi., pp. 1279–1281) given a lengthy description of the eggs of *Stegostoma* (one of the *Scylliidæ*), which had been previously unknown.

Deep-Sea Fishes.

The past has been a fruitful year for the knowledge of the fish inhabitants of the deep seas. Above all are the gleanings of the *Challenger*, which have been submitted to Dr. Günther; but besides these are the results of waifs from the deep-sea fishing-grounds of the Gloucester fishermen, as well as estrays described by Dr. Lütken, from Greenland, and by Mr. T. E. Clarke, from New Zealand.

The species described as new by Dr. Günther from the collections of the *Challenger* number sixty-one, and among them are the representatives of sixteen perfectly new generic types, whose affinities even, in most cases, are quite remote from any of the forms previously known. Several species were secured from casts made in water 2750 fathoms deep. We can here only give the relationships as indicated by Dr. Günther, reserving for another *Annual* more explicit information. The families most numerously represented are the *Gadidæ*, *Brotulidæ*, *Macruridæ*, and *Scopelidæ*, of which the first three divide twenty-six species among themselves, while the Scopelids number seventeen species, all belonging to types quite distinct from those found in shallow waters. Of the others, one belongs to the family of Scorpænids; one to the Cottids; four to the Stomiatids; two to the Salmonids (belonging to the new genus *Bathylagus*, and probably representing a "new" family); five to the Alepocephalids; two to the Halosaurids; one to the Nemichthyids; and one to a new family of Apodals allied to the Nemichthyids. These have all been described in the *Annals and Magazine of Natural History*, for July, August, and September, 1878.

The fish-fauna of the depths is thus assuming notable proportions; and it is already in season to reconsider the advisability of enumerating its representatives in the faunal works of the countries to which they are nearest, as has been the custom. Such species cannot be considered as integral constituents of the littoral fauna of any one country any more than can the fishes of Great Britain, for example, of the United States. In fact, there is a greater difference between the shallow-water fishes of the United States and the deep-sea species than there is between the former and the littoral fishes of Great Britain. The ichthyography of the depths of the ocean is yet in its infancy; enough is known, however, to indicate that certain (generic) types have an almost universal range in the bathmic and isothermal zone they affect, and their distribution is perhaps, in many cases, coincident with the temperature and conditions suitable for them, while those that are especially limited to small areas are probably in the minority. In future ichthyologies, therefore, this element will doubtless be considered as an inde-

pendent one; the subdivisions can only be determined when more material has been accumulated.

"Annual" Fishes.

There is a family of fishes—the Gobiids—very rich in species, most of which live near the bottom, and many of which are eminently adapted for such stations, for their ventrals are modified in an infundibuliform manner for adhesion to rocks, etc. There are, however, a few representatives of the family whose compressed body and lateral eyes proclaim them to be free swimmers in midwater. Among the most interesting of these are a couple of fishes inhabiting the European seas. They are the *Boreogobius pellucidus* and *Crystallogobius Nilssonii.* These have been especially investigated lately by Professor Robert Collett, of Christiania, Norway (see *Proceedings* of the Zoological Society, London, 1878, pp. 318–339). Both species are quite abundant at certain seasons in the Christiania Fjord, but while the latter has only been found in the Norwegian and Swedish waters, the former extends round the European coast-line to the Adriatic and Black seas.

As just noted, they are much compressed, their eyes are lateral, and, moreover, when living, they are quite transparent, so much so that their presence in the water is chiefly manifested by their dark-colored eyes. The *Boreogobius* has some large readily-deciduous scales, but the *Crystallogobius* is entirely naked. They not only swim freely in the water, but associate together in large numbers. The *Boreogobius* is by far the most abundant, and occurs in enormous numbers; it is caught in nets drawn at depths of from one to fifteen fathoms. The *Crystallogobius* appears to be less common and to dwell at greater depths. Both spawn, in the North, chiefly about the end of June and the early part of July. As the spawning season approaches, and in its height, the males develop large canine teeth, and become otherwise differentiated. After the spawning season the adults suddenly disappear, and where hosts were a short time before, none can be found except the young. It is, therefore, supposed by Professor Collett that the adults die after spawning, and that the species are, in fact, "annual vertebrates," performing the entire cycle of their life-history in a year, and succeeded

wholly by a new generation. It will be in order for American ichthyologists to search for the species, for it is probable that in proper stations they or kindred forms will be found in the Western Atlantic.

Fresh-water Suckers.

We are again indebted to Professor Jordan for the much-needed revision and characterization of another group of fresh-water fishes—this time the Suckers, or Catastomids. The family value of this group is recognized, and the three subfamilies defined by Gill in 1861 are retained. Thirteen genera are adopted, 8 of which belong to the subfamily of *Catastominæ*, 1 to the *Cycleptinæ*, and 4 to the *Bubalichthynæ*. These genera are definable chiefly by the modifications of the mouth, the single or double constriction of the air-bladder, resulting in two or three chambers, and the differences in the pharyngeal bones and their teeth. All the known species save two are peculiar to America, the only exceptions being the *Catastomus rostratus* of Eastern Siberia, and the *Myxocyprinus asiaticus* of China; of the others, 52 inhabit the streams and lakes of the United States and British America, and a single species (*Bubalichthys meridionalis*) has been discovered in a river (Rio Usumacinta) of Guatemala. The predominant genera are *Myxostoma* (*Ptychostomus* of Agassiz) and *Catastomus;* of the former, 17 species being recognized by Professor Jordan, and of the latter 14. The "Buffalo fishes," or "Carps," of the Mississippi and Great Lake basins appear to be quite satisfactorily determined; the bulk of the species (7 in number) belong to the genus *Carpiodes*, while *Bubalichthys* has 2, and all the forms of *Ichthyobus* are reduced to a single species.

The North American Trout and Salmon.

Prominent as are the typical Salmonids as game fishes, their species have been by no means well determined, and there has existed great difference of opinion as to the value of characters manifested in the American as well as foreign representatives of the family. Dr. George Suckley, in his monograph on the "North American Species of Salmon and Trout," recognized 43 species, and since his time several have been added, which he would doubtless have admitted as valid

forms. The student who will critically examine that monograph, however, will be dissatisfied on account of the insufficiency of characters, or the vagueness of others alleged to differentiate the several forms, and the scepticism evoked thereby would appear to be well justified by the examination of the fish themselves. Messrs. Gill and Jordan have lately investigated the subject, and have come to the conclusion that the species had been unduly multiplied, and that the 43 species acknowledged by Suckley should be reduced to 18. The total number of recognizable species of Salmones now known from all the waters of North America is apparently not more than 24. These 24 represent several well-marked genera, which are primarily distinguished by osteological characters and the dentition of the vomer, but with such characters are co-ordinated physiological and color peculiarities which enable them to be recognized independently, and even render them convenient in practical use. The importance of the group, and the universal favor with which the species are regarded, justify a somewhat detailed enumeration here.

Physiologically, the *Salmones* may be divided into two categories: (1) those that pass all their lives in fresh water; and (2) those whose lives are chiefly spent in the sea, but which ascend fresh-water streams to multiply their race. The former may indeed occasionally descend to the sea and even flourish there, as in the case of the common trout of the Eastern States, but their natural home is the fresh water, and there they feed and increase; the latter, of course, pass the early portion of their lives in the fresh waters where they were hatched, but at an early age descend into the sea, and there remain and grow until the sexual instinct impels them to ascend the streams. The fresh-water species undergo comparatively little change during the breeding season; but in the anadromous representatives of the group, the males develop more or less hooked jaws, assume hectic colors, and die after their sexual duties have been performed. It seems most probable that the salmon type was originally a fresh-water form, and that the proneness to take to the salt water has been a subsequently developed tendency. But, although the anadromous habit and persistence in fresh water has been found to be co-ordinated with structural characters, such is

the case only in a limited degree, and the group cannot be divided into natural morphological sections distinguished by the habits in question. Two genera may be said to be anadromous—*i. e.*, *Salmo* and *Oncorhynchus;* three normally fresh-water—*i. e.*, *Salar*, *Salvelinus*, and *Cristivomer;* and one doubtful—*i. e.*, *Hypsifario.*

1. The genus *Salmo* is now restricted to a single species, the common salmon, *Salmo salar.* Although normally an anadromous type, and refusing to eat even when it ascends fresh-water streams during the breeding season, it nevertheless is liable to be landlocked; and when thus excluded, *from infancy*, from access to the sea, it may accommodate itself to the fresh water, and therein increase and multiply, but under such circumstances it never attains the size its anadromous relatives do.

2. The genus *Salar* is represented by the common trout of Europe (*Salar fario*) and a number of related species in the United States. All the American species are confined to the western portions of the continent, and may be recognized by the black dots liberally sprinkled over the back and sides as well as fins. The teeth on the vomer extend quite far backwards. They are characteristic fresh-water fishes. Six species are recognizable—*i. e.*, *S. irideus* (the common Californian trout), *S. tsuppitch*, *S. spilurus*, *S. stomias*, *S. henshawi*, and *S. clarkii.*

3. The genus *Salvelinus* is typified by the chars of Europe, and in this country is manifested in the common trout of the Eastern States and related species found elsewhere. All the American species have red or vermilion spots; the chief character, however, is the restriction of vomerine teeth to the front of the bone and the immersion of the shaft below the surface. The common Eastern species is widely diffused, and its proper name is *Salvelinus fontinalis.* A second Eastern species is the blue-back of certain Maine lakes, to which it seems to be confined, and from one of which it derives its name *Salvelinus oquassa;* this is a very strongly marked form. Much nearer to the *S. fontinalis* are the *S. spectabilis*, and especially the *S. bairdii* of the Pacific slope, and the *S. stagnalis*, *S. rossi*, *S. hoodi*, *S. lordi*, *S. arcturus*, *S. naresii*, and *S. tudes* of the higher north.

4. The genus *Cristivomer* is peculiar to North America,

and embraces the Great Lake trouts. The species are at once recognized superficially by their pale gray spots, but the chief distinctive characters are osteological, and especially the development of the vomer and the crest-like expansion of the anterior tooth-bearing portion, or "dentiger." The species have been unduly multiplied. It is pretty certain that the so-called *S. namaycush*, *S. confinis*, *S. symmetrica*, *S. toma*, and *S. adirondacus*, which have been quite frequently admitted, are forms of one and the same species—*Cristivomer namaycush.* A well-defined second species exists, however, in the *Cristivomer siscowet* of Lake Superior.

5. In the Northern Pacific is found a type distinguished by comparatively numerous (14–17) anal rays. They are strictly anadromous species, and the males, in the fresh water, soon develop attenuated hooked jaws, the upper hooking over the lower, and to this character the generic name bestowed on the group—*Oncorhynchus*—alludes. At least four species ascend the rivers of the Pacific slope. The chief is *O. quinnat*, the common California salmon; the other species are *O. gorbuscha*, *O. keta*, and *O. nerka.*

6. A type closely allied to *Oncorhynchus* is represented by the red salmon or red trout of the Chiloweyuck and other rivers. It is characterized by its high and much compressed body, and has been distinguished as *Hypsifario kennerlii.*

It will be thus seen that although the American Salmonids have been much reduced in the number of species, several well-marked types of higher value exist. Three are not represented in Europe, while, on the other hand, only one (*Hucho*) is found in Europe which is not represented likewise in America. It is noteworthy that the single species of *Hucho* spawns in the spring (April), while all the other salmones, so far as known, breed in the fall and early winter.

Deep-sea Angler-fishes.

Among the most characteristic of the types peculiar to the great depths of the ocean is the family of Ceratiids. This was first proposed in 1863 for the *Ceratias holbollii*, of which several specimens have been secured along the Greenland coast; and that species was the only one then accurately known, although another form (*Himantolophus grœnlandicus*) had been previously indicated from the cephalic spine

and other remains not preserved. The family has, within the last few years, been considerably enlarged, and three species, representing as many previously unknown genera, have been made known in 1878. The Ceratiids may be said to be *non-pediculate Pediculates, deprived of ventral fins.* For although they are true Pediculates in all the essential features of their organization, the actinosts, or bones that directly support the pectorals, are not much more elongated than in many other fishes, and there is no geniculation so characteristic of the other representatives of the order. The deep sea of Greenland, compelled by the storms, had thrown up almost all of the species heretofore known; but now there are certainly besides, (1) the *Melanocetus* found off Madeira; (2) a form (*Mancalias uranoscopus*) found at the depth of 2400 fathoms, between the Canary and Cape Verde islands; and (3) a new generic type (*Ægeonichthys appelli*) very much like a Greenland one, obtained at New Zealand. The open Atlantic and Indian oceans, as well as the Gulf of Mexico, are also known to have yielded other species, although they have not yet been determined. There are several noteworthy peculiarities to these fishes. The eyes are very small; the cephalic spine is dilated into a bulbiform expansion, and this is in most cases surmounted by, or gives rise to, a number of tentacles; and, more than all, the bulb is grayish or whitish at its terminal portion. The universal coincidence in the latter respect leads to the conjecture that the peculiarity is more than one of coloration, and it is quite possible, if not probable, that the whitish portion is histologically modified and capable of phosphorescence. The complicated terminal appendages of the cephalic spine are evidently for the purpose of attracting the prey of their possessors. It is well known that such is the purpose of homologous parts in the allied Lophiids (anglers) and Antennariids (toad-fishes) of the shallow seas, and the appendages of the Ceratiids are still more elaborate and better adapted for the purpose. We can then well believe that their angling ability is still further enhanced by the capacity to attract the doomed prey by their delusive light from a distance. That their ability to flourish in the struggle for existence, notwithstanding their clumsy shape, is great, is manifested by their development under so many forms.

There are indications that while the grown fishes inhabit the great depths of the ocean, development may take place near the surface. The very young of forms evidently nearly allied to the *Himantolophinæ* of Greenland have been obtained in surface water in the open Atlantic; and it is quite probable that the ova deposited in the depths may find their way upwards, like those of the cod and mackerel, and be there hatched.

Amphibians and Reptiles.

The amphibians and reptiles furnish an example, as do also the classes known under the collective name of fishes, of groups very diverse in structure, but generally studied together in common by the same persons. Of those who have devoted most attention to both classes, or to special groups of one or the other, during the past year, are, among anatomists, W. K. Parker, L. C. Miall, and Rabl-Rückhard; among physiologists, J. Priestley, H. N. Martin, W. von Wittich, J. B. Sanderson, and F. J. M. Page; and among embryologists, F. B. Balfour, C. Kupffer, and B. Benecke. Some of the most conspicuous students of special faunas have been, for North America, E. D. Cope, H. C. Yarrow, W. Henshaw, and E. Coues; for South America, E. D. Cope and F. Müller; for Europe, F. K. Knauer, M. Lessona, and V. Collin de Plancy; for Asia, W. Peters and R. H. Beddome; for Africa, W. Peters; and for Australia, W. A. Forbes. The chief investigators of the fossil types have been E. D. Cope, O. C. Marsh, A. Gaudry, H. Seeley, R. Owen, R. Wiedersheim, and A. Portis.

The most interesting contributions to the knowledge of the Amphibians are those respecting the physiology of generation and early life. Two of these have been recorded in the *Nineteenth Century*, and from the accounts therein we partly extract the following details:

Differences in Development of New-born Salamanders.

In the popular estimation, great importance is attached to the occurrence of viviparity or oviparity, and to adaptation for breathing air directly or through the medium of the water in animals, and it is generally supposed that such characters are of primary systematic value. Rarely, in fact, at least among vertebrates, do we find animals very closely allied

differing in those respects; but, nevertheless, among Amphibians, there are several marked cases of deviation from the rule. One of the most interesting concerns the life-history of two species of Salamanders. These are inhabitants of Europe, one a common and widely distributed species—the *Salamandra maculosa*, and the other an Alpine species—the *Salamandra atra*. Both are viviparous, and in each oviduct there are between 40 and 60 eggs; but there is, normally, a great difference between the offspring of the two species when first excluded by the mother. In the *Salamandra maculosa*, almost all the eggs are fertilized and equally developed, and about 40 or 50 young are born, which retain the embryonic gills, and are very small and soft-skinned. In the *Salamandra alpina*, however, only the eggs nearest the oviduct are fructified, and generally not more than two young become fully developed, and these remain within the body of the mother, feeding on the neighboring embryos or eggs, until they attain a length of about two inches. At birth they have lost their gills, are vigorous and well developed, and the skin is provided with the glands which secrete a nauseous defensive fluid characteristic of the adult. Such are the normal conditions.

But lately an enthusiastic and talented lady naturalist, Miss von Chauvin, has shown that there is no radical physiological difference between the two species, and that the young of the *Salamandra alpina* will survive, if exposed at the same stage of development that the Spotted Salamander exhibits at birth. That lady took from the uterus 23 larvæ provided with gills, and put them in water. Most of them soon died; but two lived, one of which exhibited all the larval characteristics, while the other resembled the mother, but retained the gills. Both these and the ones that died appeared to be perfectly "at home" in the water, and swam freely about. In the survivors, however, the long-training embryonic gills became withered, and these seemed then to inconvenience the animals, and were soon thereafter rubbed off. The larvæ then rested quiescent in the darkest part of the vessel in which they were confined for several days; after, "on each side of the head, just in the position of the old gills, three little processes appeared, and soon increased till they took on the form of small bladders, provided with a close

net-work of capillary blood-vessels. Eventually each vesicle, increasing in size, gave off at its free end three or four short, blunt branchlets; but, even when fully developed, these secondary gills did not equal in length the diameter of the animal's head, so that, although agreeing in number with the primary feather-like gills, they differed from them in every other particular. When they had attained a certain size, the larva resumed its active habits, to which the small outstanding gills offered no hindrance."

There was, however, a great difference between the two survivors in the length of time taken to develop the adult characters. The less-advanced larva did not begin to cast its skin or lose the (secondary) swimming membrane of its tail till the fourteenth week of its aquatic life, and not until the sixteenth week were the gills lost; while in the more matured larva, at the end of the second week of its extra-uterine existence the gills had been dropped, and the animal left the water to lead a terrestrial life.

It is noticeable that, notwithstanding the great disparity in the number of young born to the two species of Salamanders, the adults are about equally numerous in the regions in which they respectively occur, and we have thus a striking exemplification of the perils which the unprotected and immature young, and still more the eggs of animals, are subjected to. But even those animals in which the young are born immaturely have a great advantage over the oviparous species, and in the last, consequently, eggs are developed in vast numbers to insure the perpetuation of the species; as witness, for example, the codfish, which develops eight to ten millions of eggs in its ovary. Nature rarely fails to adjust the conditions to the surroundings.

For further details and speculations as to how the differences between the two species of Salamanders originated, we must refer to the original article in the *Zeitschrift für wissenschaftliche Zoologie*, vol. xxix., and the *Nineteenth Century* for March, 1878.

Natural Selection Exhibited in the Development of Amblystoma Larvæ.

Collateral with the experiments of Miss von Chauvin may be placed the observations of Mr. Samuel F. Clarke, a fellow

of Johns-Hopkins University, on the differences manifested in the larvæ of *Amblystoma*. This genus is especially interesting by reason of the great variation as to the time of casting the gills, and the assumption of the adult characters in the different species, long ago pointed out by Cope; and also because in one species of the genus, found in Mexico—the famous *Axolotl*—the animal seems to be normally arrested, in its native place, in its development, and rarely, if ever, to pass beyond the larval stage. The observations of Mr. Clarke relate to the individuals of one and the same brood; the species was supposed to be *Amblystoma opacum*. In the early part of spring the eggs are laid in masses of from 5 to 200, attached to water plants or overhanging blades of grass. Some of these, being transferred to glass jars, were found to rapidly develop, and the rate of growth seemed to be largely determined by the purity as well as temperature of the water. Nevertheless, there were, almost from the first, considerable individual differences, and "among the many there were a few who, although they came from the same parents, and were subjected to the same conditions while in the egg, were yet gifted with greater vigor and energy than most of their brothers and sisters or cousins." These vigorous fellows nibbled at the gills of their weaker kindred, and the consequence was that the growth of the latter was retarded by the diminished aeration of the blood caused thereby, and the reduced power to obtain food supply, while the former flourished in inverse ratio. The discrepancy between the two thus rapidly increased; and "within a week or ten days from the escape from the egg, these favored few were fifty per cent. larger than their weaker comrades who were born upon the same day." Their mouths had then become sufficiently large to enable them to ingest some of the weaker ones, and this they did not hesitate to do. "This great increase in the supply of food soon produced a marked effect upon those who were thus supplied, so that in ten days from the time that they began to feed in this way they were from ten to twelve times the length and bulk of those upon whom they were feeding." All the weaker individuals were thus eliminated, and actually aided "the stronger ones by serving them as food until they could pass through their changes and escape to other regions where food was more abundant."

Oral Gestation in Amphibians.

It has long been known that certain fishes carry their eggs in their mouth, and thus protect them; but no example of such mode of gestation had been observed among Amphibians, remarkable as they are for many peculiarities in gestation, or, in fact, among any other vertebrates. Recently, however, a Spanish naturalist, Mr. Espada, has found that an analogous habit prevails in a peculiar Chilian toad known as the *Rhinoderma darwinii.* This species has been claimed to be viviparous on account of the discovery, in what was supposed to be the abdomen, of living young, and thus to be exceptional among the anurous Amphibians; but this idea is now seen to be the result of an error of observation. What is perhaps most curious is that it is the organs of voice that are modified for gestation. The male Anurans, as is generally known, have a pair of vocal sacs or bladder-like structures opening near the angles of the mouth; and when they croak, they inflate the sacs with air, and thus increase the loudness of the voice. It is these organs that are subordinated to protection of the brood in *Rhinoderma*, and for this purpose they are greatly enlarged, commencing, as usual, at the angles of the mouth, but extending forwards to the chin, "and backwards over the abdomen, reaching high up on the flanks, and meeting one another in the middle of the body." In each of these sacs are harbored some five to fifteen young, the smallest at the bottom and the largest near the apertures; none of these have been observed with gills, and in the oldest, which had attained a third of the length of the adult, the intestines were well developed. Co-ordinate with the hypertrophy of the vocal sacs and their new functions are the abbreviation of the tongue and a peculiar form of the shoulder bones.

Reptiles Nearest to Mammals.

By most naturalists, so far as is known, it has been supposed that the Dinosaurians were, of all known reptiles, those most nearly related to mammals as well as to birds. Professor Cope, however, has lately adopted a new view, and finds in the *Anomodontia* the forms most resembling mammals, and he regards those reptiles "as probably the ancestral group from which the latter were derived." The relationship, he

thinks, is manifested in the scapular arch and humerus, in which they most approach the Monotremes, and in the pelvic arch, which, as Owen had already shown, resembled that of the mammals. The tarsus, too, is "more mammalian than in any other division of reptiles." Closely related to the *Anomodontia* are certain reptiles whose remains have lately been found, and which, according to Cope, constitute a group designated *Pelycosauria*, and deemed to be co-ordinate with the *Anomodontia;* the two groups, in fact, are combined together to form an order of which they are suborders. The order is named *Theromorpha* (mammal-formed), and the principal distinctive characters are the composition of the scapular arch, in which an *epicoracoid*, as well as coracoid, and scapula are developed; the union of the three pelvic elements throughout, those *closing the obturator foramen;* and the absence of a quadrato-jugal arch. The nearest living relatives are the curious lizard-like *Sphenodontidæ* (*Hatteriidæ* of some) of New Zealand.

Birds.

Ornithology has had, as usual, a larger number of devotees than any other branch of vertebrate zoology, and it is gratifying to find that much more attention is being paid to morphology and embryology than was formerly done. One of the most active laborers on the anatomy of the class has been A. H. Garrod. Among the most active in the line of osteology have been St. George Mivart and W. Kitchen Parker. The feathers have been especially studied by Th. Studer. The embryology of different species has been investigated by Cadiat, G. Colasanti, C. Dareste, E. Gasser, A. M. Marshall, and, from an osteological point of view, by W. K. Parker.

Of the groups to which attention has been directed, the most noteworthy are the *Laridæ*, studied by H. Saunders; the Herodiones, systematically revised by R. Ridgway; and the Humming-birds, of which some genera have been revised by D. G. Elliott. The genus *Mesites*, a form of previously doubtful character, has been elucidated by A. Milne-Edwards.

The laborers in the faunas of specific regions have been numerous.

The North American fauna has been zealously investigat-

ed by E. Coues, R. Ridgway, H. W. Henshaw, T. M. Brewer, C. H. Merriam, W. Brewster, C. Bendire, G. B. Sennett, and J. C. Merrill. A large number of species—between fifteen and twenty—have been added to the United States fauna. The northern regions receive five species, all well-known European birds, among which are *Parus cinctus* and *Cyanecula suecica;* the southwestern territory (Texas) the remainder, all of which, save one, were previously known as Mexican forms; the exception is a species of *Parula* described, under the name of *P. nigrilora*, by Coues. "Descriptions of the First Plumage in Various Species of North American Birds" has been published by William Brewster, and forms a valuable supplement to descriptive ornithology. The most important work is by Elliott Coues, on the "Birds of the Colorado Valley," which, on the title-page, purports (and quite correctly) to be a "repository of scientific and popular information concerning North American ornithology." Only the first volume was published in 1878, and that is restricted to the families of Passeres from the *Turdidæ* to the *Laniidæ*, inclusive, of the current system. A noteworthy feature of this volume is the bibliographical appendix, extending from p. 576 to p. 784, and devoted exclusively to a "list of faunal publications relating to North American ornithology." This is an instalment of a general bibliography of ornithology, and the extent of the proposed work may be imagined from the example given.

The fauna of Central America has had its chief students in P. L. Sclater and O. Salvin, as well as A. Boucard; while the birds of several previously almost (ornithologically) unknown West Indian islands have been enumerated by J. Lawrence. The investigations of Mr. Lawrence were based on collections made by Mr. F. A. Ober, who visited the West Indian islands of Granada, Dominica, St. Vincent, Guadeloupe, Martinique, Antigua, and Barbuda, for the special purpose of unveiling the peculiarities of their avifaunæ.

The birds of South America have received attention from H. Durnford, A. von Penzeln, P. L. Sclater, and O. Salvin.

The species of Southern Asia and the Moluccan Archipelago have been examined especially by T. Salvadori, R. B. Sharpe, and the Marquis of Tweeddale. The fauna of New Guinea has received the most noteworthy additions.

Different islands of the Polynesian group have had their avifaunæ elucidated by O. Finsch, E. L. Layard, and R. B. Sharpe.

The Pubic Bones of Birds.

It has been generally assumed by anatomists that the pubic bones are represented as a whole, in birds, by the elongated backward-extending bones parallel with the sacrum, and that they are homologous with the pubic bones of reptiles, *e. g.*, but retroverted or bent backwards. It would now seem, however, that this view is not exactly correct. Even in the Dinosaurs of the most generalized structure, the pubic bones, at their bases, are expanded or extend behind the *ant-obturator foramina* (for the transmission of the *obturator internus* muscles) backwards and downwards beneath the ischiac bones, with which they articulate by simple suture, while in the most bird-like types of the same order they extend into elongated processes parallel with the ischiac bones, but only connected by suture below the acetabula. In both types, however, the pubic bones extend downwards and forwards as is the wont. But while in the generalized forms the posterior or post-acetabular expansions are very short or rudimentary, in the ornithoid forms they have become longer than the anterior portions. On a renewed comparison, then, with birds, it becomes obvious that the pubic bones of the avian type are not, as a whole, homologous with the principal or anterior portions of the reptilian pubes, but that they must be considered as composed of two parts—viz., (1) the anterior or ant-acetabular processes, which are more or less atrophied; and (2) the posterior or post-acetabular processes, which are excessively hypertrophied. It thus appears that, so far as regards the pubic bones, birds are distinguished by the reversed development of their respective parts. For the basis of this generalization, we are indebted to articles on the Dinosaurian Reptiles, by Dr. J. W. Hulke (*Journal of the Geological Society of London*, vol. xxxii., pp. 364–366) and Professor O. C. Marsh (*American Journal of Science and Arts*, vol. xvi., pp. 415, 416, pl. 10).

The Moulting of Parts of the Corneous Covering of Bills in Birds.

Some years ago (in 1874), Mr. Robert Ridgway announced the important discovery that the conspicuous median crest-

like excrescence at the base of the upper mandible of the pelican was characteristic of the breeding season, and that when that season had passed, the bird cast the excrescence, and appeared without it till the approach of the next nuptials. The fact of the deciduous nature and periodical recurrence of corneous elements in the bills of birds does not appear previously to have been recorded in scientific literature, and the announcement thus signalized was of unusual interest.

A moult of corneous elements of the bill, analogous to that in the pelican, but much more comprehensive, was shown last year, by M. Bureau, to take place in the common puffin (*Fratercula arctica*) of Europe. Differences in the bill had long before been noticed in this type, but had been attributed to age or specific differentiation. M. Bureau's scepticism as to the verity of these views was excited by observations on the puffins inhabiting islands of the French province of Brittany; and finally he was led to the knowledge that the differences signalized were the result of a regular seasonal moult of constituents of the bill; and that the brilliantly colored one was characteristic of the season of love, while the plainer was the feature of the season of rest from amorous labor. As the discovery is of more than usual interest, a somewhat detailed notice is in place.

The bill of the puffin may be distinguished into two parts, an anterior and a posterior, which, on the upper mandible, are nearly equal, and narrow towards the forehead; while on the lower mandible they correspond at the commissure, but differ in relative proportions. The anterior of these has a single persistent sheath, and it is only on the posterior that the deciduous elements are developed.

In the upper mandible are six pieces—viz.:

(1) A high *supranasal saddle* extending from side to side (1).

(2) A longitudinal *subnasal lamella* on each side (2, 3).

(3) An oblique tæniform *prenasal lamella* on each side (4, 5); and

(4) An oblique *basal lamella* extending from side to side, and distinguished by its punctulate surface (6).

On the lower mandible there are three pieces—viz.:

(1) An *inverted saddle*, corresponding to the supranasal one (7); and

(2) A *mental lamella* on each side at the base (8, 9).

Besides these, on each side of the head are developed—

(1) A *supraocular lamella* (10, 11); and

(2) A *subocular lamella* (12, 13).

All these multiple pieces (not less than 13 in number) are distinctly differentiated at the period of moulting, and finally "fall apart like the pieces of a coat of mail," although when in high season the corneous covering is apparently homogeneous. These parts are assumed at maturity and in the breeding season, and their development is coincident with the assumption of the colors of the nuptial season. The full breeding dress is thus marked, according to M. Bureau, by (1) hypertrophy, (2) corneous outgrowths, and (3) peculiar coloration, and its loss is conversely manifested by (1) atrophy, (2) deciduous corneous elements, and (3) plainer coloration.

Although, as has been stated, the remarkable features thus enumerated are new to science, it has been suggested that they may have been observed by the inhabitants of the regions in which they abound; and the German name attributed to the species in one instance, by Brehm (*Larventauscher*), may involve a reminiscence of the knowledge of such changes, the name implying a "mask-changer." The common form of the German name, however, is *Larventaucher*, which means simply a "diver with a mask." It is probable that the latter is the proper form, as it is not likely that the common people had observed as closely as the contrary supposition implies. The coincidence is, nevertheless, noteworthy.

The Genus Mesites.

A striking illustration of the slight value and evanescent nature of the differences observable in birds, and which have been used to characterize even "subclasses" and "orders," is exemplified by the genus *Mesites*—a form peculiar to Madagascar. This type was originally placed, provisionally at least, by Is. Geoffroy St.-Hilaire, G. R. Gray (at first), and Bonaparte, among or near the Gallinaceous or Columbine forms; later, by G. R. Gray, Sundevall, and Hartlaub, among the Passerines in or near the *Eupetidæ*, or the *Motacillidæ*; and, later still, by Bartlett, near the *Eurypygidæ*. In other words, it has been referred to four different "orders" of ornithologists, and yet these orders were based chiefly on ex-

ternal characters. A recent examination of the anatomy of the genus has convinced M. Alphonse Milne-Edwards that the genus is a grallatorial form, and the type of a very distinct family allied to that of the Rails and to that of the Herons. Those two families, it is also to be remarked, are placed in widely different groups by Professor Huxley; the former belonging to the *Schizognathæ*, and the latter to the *Desmognathæ*, two of the four primary groups in which all birds (except the ostrich group) are divided. The osseous roof of the mouth resembles that of the Rails (that is, the bird is schizognathous), but in other respects it more nearly approximates the Herons.

A False Under-tail in Storks.

In birds generally the tail is well defined, and not to be confounded with or overpassed by contiguous feathers. In a number of species, however, the upper tail-coverts are increased in size, and assume diverse forms; but perhaps the most curious development is that exhibited by certain members of the family of Storks, or Ciconiids. It is but recently that the facts in the case have been made known, and renewed attention has been lately called to them by Mr. Ridgway and others. The birds in question are, in most respects, closely allied to the common stork of Europe, but the true tail is very short and deeply forked, while the *lower tail-coverts* are *much elongated*, extend far beyond the tail itself, and are quite stiff, thus simulating the rectrices, and deceiving the observer into the belief that they form the true tail. "Indeed," says Mr. Ridgway, "all authors whom I have been able to consult in the matter describe the black, stiff feathers as the upper coverts, and the longer, softer, but still firm feathers beneath them, with a rounded posterior outline, as the tail; in fact, it was only after the most careful examination that I determined the former to be true rectrices." Mr. Ridgway's observations were based on the South American *Ciconia maguari*, for which he has established the genus *Euxenura*. It appears, however, that the same characteristics are exhibited by the *Ciconia episcopus* of Africa and India, which had previously been distinguished as the type of the genus *Dissura*. These are the only two forms known which are characterized by such a peculiarity of the tail and its coverts.

Mammals.

The chief part of the work done on mammals during 1878 has been in the line of anatomical investigation, general or specific; but, at the same time, some important systematic treatises have been published. Only a few of the contributions can be alluded to. In general osteology, E. von Ebner and G. M. Humphreys may be mentioned. In the anatomy or physiology of the nervous system, A. Adamkiewicz, M. Duval, S. Stricker, and A. Vulpian have done considerable work. The lungs have been especially investigated by L. Stieda. The placentation has been studied for the aï (*Bradypus tridactylus*) by N. Joly; for the apes, by W. Turner; and for the dugong, by P. Harting. The last contribution is noteworthy, inasmuch as the placental characteristics of the Sirenians (of which the dugong is a representative) were previously unknown. J. A. Allen has published an elaborate memoir on the geographical distribution of the class. Special groups and species have been investigated, but chiefly from an anatomical standpoint. The Monotremes have been illustrated in a handsome monograph by P. Gervais. A much-needed systematic revision of all the known bats is due to G. Dobson. P. Van Beneden and P. Gervais's great work on the Cetaceans has been continued. W. H. Flower has elucidated the family of Ziphiids, and especially the genus *Mesoplodon*. Several numbers of a monograph of the *Felidæ*, superbly illustrated by Wolf, were published by D. G. Elliott. The anatomy of the binturong (*Arctictis*) was examined by A. H. Garrod; that of the anteater by G. Valentin; and that of the Armadillos by A. H. Garrod and M. Watson. The history of the urus (*Bos primigenius*), as well as the European bison, has been investigated by Aug. Wrzesniowski. A new specific name for a gorilla-like ape has been introduced by E. Alix and A. Bouvier. Fossil forms have been described by E. D. Cope, O. C. Marsh, A. Gaudry, P. Gervais, W. B. Dawkins, R. Hoerness, C. Capellini, and W. H. Flower, and postgraduates of the College of New Jersey (H. F. Osborn, W. B. Scott, and F. Speir, Jun.).

The Primary Zoogeographical Regions of the Earth as determined by the Mammals.

The interest for some years felt in the geographical distribution of animal life has been again stimulated, at least in the United States, through the publication of an important and elaborate memoir, by Mr. J. A. Allen, on the "Geographical Distribution of the Mammalia, considered in Relation to the Principal Ontological Regions of the Earth, and the Laws that Govern the Distribution of Animal Life." The data have been collected and co-ordinated with the conscientious thoroughness that is characteristic of Mr. Allen's work. The author finds no reason to change his views, formerly expressed and held in common with Humboldt, Wagner, Dana, Agassiz, De Candolle, and others, "that life is distributed in circumpolar zones, which conform with the climatic zones, though not always with the parallels of the geographer. . . . These are directly antagonistic to the scheme of division of the earth's surface into the life-regions proposed by Dr. Sclater in 1857," and recently adopted by Mr. Wallace in his famous work. Mr. Allen has, however, modified the scheme formerly (in 1871) promulgated by himself, and now submits the following division of the earth's surface.

The primary terrestrial regions of the globe are designated as (1) "realms;" the secondary as (2) "regions;" and the regions themselves are subdivided into (3) "provinces;" thus—

I. Arctic realm, undivided.
II. North Temperate realm, with 2 regions—viz.:
  1. American region, with 4 provinces—viz.:
    a. Boreal.
    b. Eastern.
    c. Middle.
    d. Western.
  2. Europæo-Asiatic region, also with 4 provinces —viz.:
    a. European.
    b. Siberian.
    c. Mediterranean.
    d. Manchurian.
III. American Tropical realm, with 3 regions—viz.:

1. Antillean.
2. Central American.
3. Brazilian.

IV. Indo-African realm, with 2 regions—viz.:
1. African region, with 3 provinces—viz.:
a. Eastern.
b. Western.
c. Southern.
2. Indian region, with 2 provinces—viz.:
a. Continental.
b. Insular.

V. South American Temperate realm, with 2 provinces —viz.:
a. Andean.
b. Pampean.

VI. Australian realm, with 3 regions—viz.:
1. Australian, with 2 provinces—viz.:
a. Australian.
b. Papuan.
2. Polynesian.
3. New Zealand.

VII. Lemurian realm, undivided.

VIII. Antarctic or South Circumpolar, undivided.

It would be unadvisable to let this appear without some cautionary remarks.

Unquestionably temperature exerts a very great influence over the distribution of life; and a naturalist who first approached the subject of zoological geography from a consideration of marine animals might very well have an exaggerated idea of its importance. There is, or has been, within recent geological times, such a free circulation of the sea that no great obstacles intervened to the diffusion of many forms, wherever the conditions were favorable. Temperature, indeed, was one of those conditions, and the distribution of marine animals is essentially coincident with thermometric zones. But a divergence of continental areas has prevailed from a distant geological epoch, and, as a matter of fact, the animal associations of the several great isolated continental areas are, on the whole, very distinct, and their differentiation, it may be assumed, has advanced *pari passu* with that of

the areas they inhabited. This has apparently progressed to such an extent that various types have been able to accommodate themselves to, or have been modified for, the various climates, and thus, to a large extent, isothermal distribution has been subordinated to land distribution.

As to the (1) Arctic and (2) North Temperate realms, we may well hesitate to admit that there is any such distinction between them as to compel us to contradistinguish the latter, as a whole, against the former. Indeed, the former seems to be almost only definable by negative characters, and to be now neutral ground, from which, by the rigor of the climate, most forms of animal life have been excluded; while the "regions" of the latter have each their own peculiarities, which entitle them to recognition as independent "realms" far more than do the characteristics of the Arctic a like rank.

With respect to the (3) Indo-European realm, another set of considerations come up for notice. Mr. Allen distributes the 49 families of mammals represented in the "realm" under four categories: (1) "12 common to both regions, and also of wide extralimital range;" (2) "18 common to both regions;" (3) "10 peculiar to the African region;" and (4) "9 occurring in the Indian region, but not in the African." Mr. Allen has evidently been especially influenced by the figures of the second category, but has apparently not considered one circumstance of vital importance. While it is quite true that *most* of the 18 families enumerated are *now* in great part confined to the two "regions" in question, in the Tertiary epoch almost all ranged far to the northward in Europe, and several into America, and the present restriction is due partly to the change of climate and partly to the encroachments of the human race. Indeed, the first and second categories may well be combined in this consideration; and then the distinctive peculiarities of the Indian and African regions will be seen to be quite decided. These distinctive peculiarities are reinforced to such an extent by the peculiarities of other classes—especially the fishes—that instead of combining the two, we should rather be disposed to contrast the African against the Indian in connection with the "Europæo-Asiatic region."

Passing over other open questions, it need only be added that there are almost as good, if not even better, reasons for

combining the Lemurian and African regions as for separating them, and that it is premature to recognize an "Antarctic realm" until there is evidence that there are some land animals in it. Mr. Allen's entire memoir, however, deserves a careful study, and will well repay such an examination.

The Species of Bats.

On the whole, of all the orders of mammals, the Bats have been, until lately, least studied and understood. Recently, however, Mr. George Edward Dobson has capped his labors on that order by a complete monographic account of all the representatives of the group, under the title of "A Catalogue of the Chiroptera in the Collection of the British Museum." "The total number of species described in the following pages is 400." Of these 71 belong to the suborder of *Frugivora*, or fruit-eating bats (designated, by Dobson, on account of the large size of most of the species, *Megachiroptera*), and the rest constitute the suborder of *Animalivora* (named, by Dobson, in contrast with the former, *Microchiroptera*). The frugivorous bats all belong to one family (the *Pteropodidæ*); but the animalivorous forms are manifested under several modifications of family value. The number and relationships of such families, however, can by no means be said to be satisfactorily established by Mr. Dobson, although better approximated than by his predecessors. Mr. Dobson has considered, or at least analytically applied, (1) as of the first importance, the total inclusion in, or partial extension from, the interfemoral membrane of the tail; (2) then the number of the phalanges of the middle finger; (3) next the development or non-development of the cutaneous foliaceous appendages around the nostrils; (4) the presence or absence of tragi to the ears; and (5) lastly, the development of the intermaxillary bones. Distinguished by the varying combinations of modifications of those parts, five families are recognized among the animalivorous forms. These are: (1) *Rhinolophidæ*, with subfamilies *Rhinolophinæ* and *Phyllorhininæ*; (2) *Mycteridæ*, with subfamilies *Megaderminæ* and *Mycterinæ*; (3) *Vespertilionidæ*, homogeneous; (4) *Emballonuridæ*, with subfamilies *Emballonurinæ* and *Molossinæ*; and (5) *Phyllostomidæ*, with subfamilies *Phyllostominæ* and *Lobostominæ*. These five families are segregated among two

"alliances," distinguished by differences in the parts already mentioned, as well as by the structure of the hair. The alliances are designated *Vespertilionine* and *Emballonurine;* the former comprising the first three families, and the latter the remaining two. The *Vespertilionine* forms have "hair-scales imbricated, the tips of the scales in an oblique line, not terminating in acute projections;" while the *Emballonurine* types have "hair-scales in a transverse series, the tips of the scales in a straight [zonary] line, at right angles to the longitudinal axis of the hair, nearly always terminating in acute projections." Several types that have by many naturalists been regarded as of family value are suppressed or placed lower in rank. Thus, the *Molossidæ* are reduced to a subfamily of *Emballonuridæ;* the *Mormopidæ* to similar rank (with the name *Lobostominæ*) under *Phyllostomidæ;* and the *Desmodidæ* are even degraded to the station of a simple "group" under the same family. The author thus differs markedly from Huxley, who had considered the last as representative of a primary subdivision of the bats, co-ordinate with the combination of all the others. No convincing reasons are given for dissent from this view; nor is it apparent why the very decided modifications of dentition and splanchnology of the type in question, co-ordinate as they are with other characteristics, are not of as much taxonomic value as the characters employed to differentiate the families of *Microchiroptera.* Nevertheless, whatever may be the ultimate decision on such points, the groups, as well as the species, are, on the whole, so well analyzed and diagnosed that the work must be considered as embodying a most decided advance, and marking an epoch in chiropterology.

The species, as already indicated, are primarily segregated among two suborders, distinguished, among other characters, by their general adaptation for vegetable or animal food. The coincidence between diet and structure is, however, by no means exact. The *Pteropodidæ*, indeed, are almost exclusively frugivorous; but some of the *Animalivora* (*Stenodermata*) are said to be equally so, while the others differ in the character of the animal food most affected by them. Most of them are entitled, by right of regimen, to the name *Insectivora*, generally conferred on them; but some prey upon other animals, such as smaller representatives of their own order,

as well as small mammals, birds, amphibians, and even fishes, as in the case of some *Megadermidæ*, while others are specialized blood-suckers, or vampires. The fame of the blood-sucking vampire-bats of South America has been greater than has the knowledge of what they really are been exact. The older naturalists, in fact, were misled, and attributed the sanguinivorous habits to innocent insect- or fruit-eating species; and the significant name of *Vampirus* was conferred on forms that no more sucked blood than their kindred. The attribute, however, does really pertain to a couple of species of tropical America—the *Desmodus rufus* and *Diphylla ecaudata*. "It fell to the lot of Mr. Charles Darwin to determine one of the species, at least; and the following is his account of the circumstances under which the discovery of the sanguinivorous habits of this species was made: 'The vampire-bat is often the cause of much trouble, by biting the horses on their withers. The injury is generally not so much owing to the loss of blood, as to the inflammation which the pressure of the saddle afterwards produces. The whole circumstance has lately been doubted in England. I was therefore fortunate in being present when one (*Desmodus d'orbignyi* Nat.) was actually caught on a horse's back. We were bivouacking late one evening near Coquimbo, in Chili, when my servant, noticing that one of the horses was very restive, went to see what was the matter, and, fancying he could detect something, very suddenly put his hand on the beast's withers, and secured the vampire'" ("Naturalist's Voyage Round the World," 1838, p. 22). The species are adapted for this blood-regimen by much enlarged convergent and acutely pointed upper incisor teeth for piercing the skin, and a stomach peculiar by the great cæcal elongation of the cardiac extremity for digestion of the blood.

Of course, the North American species are included with the others. The number is reduced from the 20 recognized by Harrison Allen to 16, and the common European *Vesperugo serotinus* is considered to be specifically identical with the *Scotophilus fuscus* and *Scotophilus carolinensis* of American authors. For the benefit of those interested, and to whom Dobson's work may not be available, the following names adopted by that author are compared with the species recognized by Harrison Allen:

SUBORDER—MICROCHIROPTERA.

Family—Vespertilionidæ.

Group 1.—Plecoti.

Antrozous pallidus (p. 171) = Antrozous pallidus, Allen.

Plecotus (Corinorhinus) macrotis (p. 180) = Synotus macrotis and Synotus townsendii, Allen.

Vesperugo (Vesperus) serotinus, var. B. (p. 192) = Scotophilus carolinensis and Scotophilus fuscus, Allen.

Vesperugo (Vesperugo) hesperus (p. 228) = Scotophilus hesperus, Allen (doubtful species).

Vesperugo (Vesperugo) georgianus (p. 235) = Scotophilus georgianus, Allen.

Vesperugo (Lasionycteris) noctivagans (p. 238) = Scotophilus noctivagans, Allen.

Nycticejus crepuscularis (p. 266) = Nycticejus crepuscularis, Allen.

Atalapha (Atalapha) noveboracensis (p. 269) = Lasiurus noveboracensis, Allen.

Atalapha (Atalapha) cinerea (p. 272) = Lasiurus cinereus, Allen.

Atalapha (Dasypterus) intermedia (p. 274) = Lasiurus intermedius, Allen.

Vespertilio (Vespertilio) nitidus (p. 318) = Vespertilio nitidus, Allen.

Vespertilio (Vespertilio) evotis (p. 324) = Vespertilio evotis, Allen.

Vespertilio (Vespertilio) subulatus (p. 324) = Vespertilio subulatus, Allen.

Vespertilio (Vespertilio) lucifugus (p. 328) = Vespertilio affinis, V. lucifugus, and V. yumanensis, Allen.

Family—Emballonuridæ.

Nyctinomus brasiliensis (p. 437) = Nyctinomus nasutus, Allen.

Family—Phyllostomidæ.

Phyllostoma waterhousii (p. 464) = ? Macrotus californicus, Allen.

Whales of the Ziphiid Family.

Believers in the existence of a "sea-serpent" have felt themselves much supported in their belief by the discovery, from time to time, of some gigantic species of cetacean previously unknown. The group of the order of Cetaceans which has received the greatest number of additions is the family of Ziphiids. Previous to the present century not a single representative of the form had been recorded in scientific literature. The typical genus was based, by Cuvier, on an imperfect skull found in 1804 near Fos, Bouches-du-Rhone, on the Mediterranean coast. By Cuvier the remains were supposed to belong to an extinct type, for which he revived a mediæval name of uncertain application—*Ziphius.* A short time before, however (in 1804), Sowerby had described a living example of the same family under the name of *Physeter bidens.* Within the last ten years, the family has received most notable additions, not only from the present seas, but from tertiary strata. Professor Flower, who has done most to elucidate the family, has lately published "A Further Contribution to the Knowledge of the Existing Ziphioid Whales," and has increased the number of species of the genus *Mesoplodon* to eight, two new species being added, based on skeletons obtained from New Zealand. The Pacific, in the neighborhood of New Zealand, seems, indeed, to be the favorite abode of the recent Ziphiids. There they have been found, not infrequently, in considerable "schools," while the individuals found in other parts of the world have been solitary, and specimens have been obtained generally at long intervals. Too much importance must not, however, be put on this apparent difference, as it may be the result of accident. It is quite possible, nevertheless, that the family is dying out in the Atlantic, and that the conditions for its existence, whatever they may be, are most developed in the Australasian waters. In tertiary times, representatives of the family were numerous in species as well as individuals in Europe, and co-existed with forms which are now almost or wholly extinct in the European seas, but which still flourish in the Australian.

Apropos to the question of the reality of sea-serpents, too much weight should not be attached to the discovery of new

species of gigantic cetaceans, or other known types, as indicative of the probability of the existence of such animals. After all, the type, in the case of the cetaceans, had long been known, and the species would naturally be confounded under it, and, in fact, could only be properly discriminated after careful comparison and study. In the case of a sea-serpent, however, we should have to account for the non-discovery of any remains of a type not correlatable with those of one already known, either in the present or past epochs. As to the continued survival of representatives of Plesiosauroid or Mosasauroid types, in view of our knowledge of their structure and their geological range, we must consider the supposition as having no foundation in fact or probability.

Size of the Tiger.

Exaggerated statements of the size of the tiger, or certain individuals killed by hunters, are not infrequent. Few men have had as much acquaintance with the species as Sir Joseph Fayrer, the author of a special monograph on the "Royal Tiger of Bengal," published in 1875, and therefore his statements have exceptional weight. In an article in *Nature* for November 7, 1878, he has given the results of his inquiries and own measurements; and has announced the belief that "the full-grown male Indian tiger may be said to be from 9 to 12 feet, or 12 feet 2 inches, the tigress from 8 to 10 feet, or, *perhaps in very rare instances*, 11 feet, in length, the height being from 3 to 3½ feet, or, rarely, 4 feet, at the shoulder." The animal "should be measured from the nose along the spine to the tip of the tail, as he lies dead where he fell, before the skin is removed. One that is 10 feet by this measurement is large, and the full-grown male does not often exceed this." The average length of the male is about 9 to 9½ feet, and of the female somewhat less.

"The mere length of a tiger is not necessarily an indication of its real size. The tail is included in the measurement —so tiger-hunters have ruled that it shall be—but the tail is a somewhat variable element; in some it is long, in others short, and it is quite possible that a 9-foot 6-inch tiger with a short tail may be heavier, stronger, and larger than a 10-foot tiger with a long tail. No doubt anything over 10 feet is very large, and those of 11 or 12 feet are rare and ex-

ceptional, even though part of their great length may be assigned to an immensely long tail." The tail in the adult varies between somewhat less than 3 feet and a little more than 4 feet. The heaviest tiger, a male, recorded by Col. Macdonald, "weighed 448 lbs.; the lightest, a tigress, 242 lbs."

In conclusion, a review of the testimony adduced leads to the belief that, in spite of the positive testimony, tigers 12 feet long at present must be almost as rare as men 7 to 8 feet high.

The Alleged Hermaphrodism of the Hyena.

Those who are conversant with the ancient literature of natural history will remember that the Hyena was formerly generally believed to be hermaphrodite, and even in the present day, inhabitants of regions where the *Crocuta* is found believe it to be so. Aristotle, however, must be noted as an exception. We need not be surprised at the currency of the belief, in view of the great similarity of the sexual parts of the male and female. Dr. M. Watson has recently published a couple of well-illustrated articles (*Proceedings* of the Zoological Society, London, 1877, pp. 369–379; 1878, pp. 416–428) on the Generative Organs of the *Hyæna crocuta*, and has remarked that the anal and perineal regions of the female and male are so very similar "that without a very accurate examination it is impossible to distinguish between the sexes. In both there is a well-developed glandular pouch above the anus; in both there are cutaneous elevations corresponding in appearance to that of the scrotum in the males of allied species; and in both there is an elongated, pendulous, penis-like body, surrounded by a prepuce, and perforated at its extremity by a single aperture of small size." But it is only in the *Crocuta* that this similarity prevails. The male organs in the several species of the family are essentially similar; but while the female organs are like them in the *Crocuta*, in the other species they are quite different. For the details we must be content to refer to Dr. Watson's papers. What is noticed here is chiefly for the purpose of drawing attention to the homologies of the parts in the different sexes, as well as to certain taxonomic deductions resulting from the facts. In the words of Dr. Watson, "Nowhere in the group of mammals is the truth of the con-

clusions at which embryologists have arrived respecting the homologies of the various parts of the sexual apparatus in the two sexes so beautifully shown as in the animal under consideration. Did any doubt remain regarding the similarity of plan upon which these are built up, it would be at once dispelled by an inspection of the sexual organs of *Hyæna crocuta*." The taxonomic deduction may be surmised. Since there is so great a difference between the *Hyæna crocuta* and the other species of the family, it would seem that in the interests of an expressive system, the fact that there are such differences should be represented in the nomenclature by distinct generic designations for the forms so differing; and it will be advisable to retain the modified genus *Crocuta* proposed by the late Dr. Gray for the *Hyæna crocuta*, while the other species can be preserved in the restricted genus *Hyæna*.

The Placental Characteristics of the Sirenians.

It is probably generally known to our readers that great importance has been attached to the mode and extent of development of the placenta and contiguous parts in mammals, and that the systematic arrangement of the class has been based on the modifications of these parts by several eminent naturalists. The gaps in our knowledge of the placentation of the class have interfered with the completeness of the taxonomy, but these have been gradually filled, and during the past year the most serious hiatus has been obliterated by the elucidation of the characteristics of the placenta and embryo of the Sirenians. The Dutch University of Utrecht lately procured the fœtus of a dugong with its adjacent membranes, and this has been studied by Dr. Paul Harting, and elaborately described in the *Tijdschrift voor Nederlandsche Dierkundige Vereeniging*. The following is a summary of the results of his observations:

1. The egg of the common dugong is an elongated oval sack, of which the greater portion was situated in one of the cornua of the uterus, but a small part of which in the neighborhood of the anterior pole penetrated into the other cornu.

2. With the exception of the two poles and the adjoining area, the entire chorion is covered with very dense but short and little ramified villosities.

3. There exists no trace of a deciduous membrane.

4. The allantois with its vessels extends over the entire internal surface of the chorion, to which it is intimately connected.

5. The umbilical cord has a very short trunk, from which diverge four much longer branches, each composed of an artery and a vein, which extend and ramify on the inner surface of the placenta.

6. The amnion invests the trunk as well as branches of the umbilical cord, and binds the latter by membranous lamellæ. Its surface is entirely smooth.

7. The internal surface of the placenta carries a large number of appendages which are diverticula of vessels as well as veins. In the interior of these diverticula is found an areolar tissue.

8. The umbilical vesicle has disappeared, or, at least, there exists only a rudiment in the trunk of the umbilical cord.

In brief, the Sirenians present a *diffuse placenta without a decidua*, and in this respect resemble the Cetaceans as well as Ungulates, but, on a more detailed comparison, in the opinion of Dr. Harting, they agree more nearly with the Ungulates than with the Cetaceans. For the full exposition of the resemblances and differences, as well as reasoning on the facts, we must refer to Dr. Harting's memoir.

A Supposed New Gorilla.

It may be of interest to many of our readers to learn that a skeleton and skin of an adult female gorilla have lately been sent from Landana, Congo, which exhibit considerable differences from specimens previously obtained, and which have, therefore, been discriminated under the new specific name *Gorilla mayema*, by MM. Allix and Bouvier, of Paris. The supposed new species is said to be of considerably smaller size than the common species. In the skull, differences are observable in the depth of the temporal fossæ, the narrowness of the cranium behind the orbital arches, the narrowness of the interorbital space, and a greater prominence of the keel which rises in the middle of this space, the length and flattening of the zygomatic arches, and also a very noticeable diminution of the height of the spinous apophyses of the first cervical vertebræ. Furthermore, "the back is thickly cov-

ered with long hair, contrary to what is seen in the other gorillas, in which the skin of this region is denuded and simply covered with short and worn hairs." The hairiness of the back is supposed to indicate a difference of habits, and that the new form does not repose, like the common gorilla, against its back, but is more arboricolar, like the chimpanzee. Although such differences as those recorded are interesting, the species cannot be considered to be well established, and, like the considerable number of others of the gorilla and chimpanzee types that have been proposed from time to time, must be considered as at least doubtful, till a very critical examination of much more material than is yet available can be made. At present, it seems best to admit only two species of African apes—*Mimetes troglodytes* (the chimpanzee) and *Gorilla savagei* (the gorilla). Whether the differences observable in specimens of those generic types are of specific, varietal, or only individual value, remains yet to be ascertained.

Chronological Paleontology of the Vertebrates.

Much activity has been manifested in investigations of the Vertebrates of the different geological horizons; the most active in this country during last year, as in those preceding, having been E. D. Cope and O. C. Marsh. Abstracts of several memoirs and communications of special interest are given; but, perhaps, quite as important as these are the researches of the gentlemen just referred to, on the reptiles of the Permian epoch; a memoir, by Cope, on some Fishes of the "No. 3" Cretaceous beds of Dakota; and articles, by Messrs. Cope and Marsh, on gigantic Saurians of the Dakota Rocks of Colorado. A "Paleontological Report of the Princeton Scientific Expedition of 1877," by Henry J. Osborn, Wm. B. Scott, and Francis Speir, Jr., may be also specifically mentioned, on account of the discoveries therein recorded, as also for the reason that it contains a full systematic catalogue of the Eocene Vertebrates of Wyoming.

The Dipnoous a Predominant Type of the Palæozoic Age.

It will be remembered that the order of *Protopteri* is represented, in the present epoch, by only three fresh-water genera, (1) *Protopterus*, of Africa; (2) *Lepidosiren*, of South Amer-

ica; and (3) the not-long-ago discovered *Neoceratodus*, of Australia. The type is quite exceptional now, and stands out thoroughly isolated from the fishes of the present, and, in fact, cenozoic ages, and is, to some extent, intermediate between the typical fishes and amphibians. It is, however, yearly becoming more and more evident that in the early mesozoic, as well as later palæozoic times, it was a predominant type of fishes, and that this type was widely distributed in the sea as well as in fresh water, and was manifested under numerous and diverse forms representing a number of distinct families and higher groups. During the past year our knowledge of the order has been extended by the investigations of Professor Traquair, of Edinburgh, and Professor Newberry, of New York. The former has especially elucidated the affinities of the common Devonian genus *Dipterus*, and the problematical forms indicated under the names *Palædaphus*, *Holodus*, *Heliodus*, *Conchodus*, and *Cheirodus*. The main facts brought out are: (1) that *Dipterus* agrees with *Ceratodus* in being "autostylic" and not "hyostylic," as has been suggested; (2) that *Palædaphus*, *Holodus*, and *Heliodus*, were based on remains of the same genus, and that that genus was a gigantic Dipnooan; and (3) that *Cheirodus* of McCoy, was intended for the Platysomid genus named *Amphicentrum*, in 1836, by Young, but that *Cheirodus* of Pander is probably identical with *Conchodus*, and belongs to the Dipnoi. The huge *Dinichthys* of the Ohio carboniferous has also been referred to the Dipnoi by Newberry. The reference of these forms to the Dipnoi involves that of a number of others. Some of these had, indeed, already been approximated to the type in question, but the want of definite knowledge regarding some essential points of structure rendered such approximations provisional; the position of the genera referred to may now be regarded as tolerably assured.

Ceratodus in the American Jurassic.

The family of Ceratodontids, so interesting from several points of view, and to which attention has been called in previous volumes of this *Annual*, has now been found to have flourished in the American waters of the Jurassic age. A left lower dental plate has been discovered with other vertebrate remains in the Jurassic of Colorado, and on it has been

based the *Ceratodus Guentheri* of Professor Marsh. On the assumption that the plate belonged to an adult, the species must have been little, if any, larger than the existing *Neoceratodus* of Australia (see *American Journal of Science and Arts* (3), vol. xv., p. 76).

An American Ichthyosauroid Form.

No remains of reptiles of the family of Ichthyosaurids, or of any related type, had been found in any American formation until the past year. In the last month of that year, however, Professor Marsh announced the discovery of portions of the skeleton of a species which agreed in all essential respects with the corresponding parts of Ichthyosaurids. The skull, "in many features," showed a strong resemblance, and "its general form" was the same; "the great development of the premaxillaries, the reduced maxillaries, and the huge orbit defended by a ring of bony plates, are all present" in the one as in the other. As to other portions of the skeleton, the vertebræ and ribs "cannot be distinguished from the corresponding parts of *Ichthyosaurus*." One notable difference, nevertheless, exists between the American reptile and the Ichthyosaurids of the Old World. The jaws "appear entirely edentulous, and destitute even of a dentary groove." On account of this want of teeth, notwithstanding the agreement in other respects, Professor Marsh believes that the American form should be differentiated, even to an *ordinal* extent, from the *Ichthyosauria*, and he proposes to call such order *Sauranodonta*, and names the family *Sauranodontidæ*, the single species being designated as *Sauranodon natans*. The skull of the discovered specimen was about 2 feet long; "one trunk vertebra measures 85 mm. in width, 38 mm. in length on the floor of the neural canal, and 21 mm. between the centres of the two rib articular faces of the same side." The length of the entire animal is supposed to have been about 8 or 9 feet. The remains were found in association with shells of Ammonites and Belemnites, in beds referred to the Jurassic age, and immediately below what has been called, by Marsh, the "*Atlantosaurus* beds;" and the enclosing strata are proposed to be called the "*Sauranodon* beds."

The discovery thus signalized is of great interest; but we

cannot refrain from expressing our doubts whether Professor Marsh will be justified in proposing to distinguish the newly found type as an order distinct from the *Ichthyopterygia.* The mere presence or absence of teeth in the jaws is generally, and apparently very properly, regarded as of no very great systematic value, and unless other characters are associated with the negative or positive character in question, groups so differentiated may be very closely related. Doubtless, however, the character in this instance, at least, is of family importance; and we may therefore hail, in the *Sauranodontidæ*, a type especially interesting in its morphological as well as its geological relations.

An American Jurassic Mammal.

As is well known, mammals older than of tertiary age are among the rarest of fossils, and the discovery of a species in this country of Jurassic age is therefore noteworthy. The greater part of the right lower jaw (deprived, however, of all the teeth except the penultimate molar) of a small animal about the size of a weasel was obtained in the beds designated, by Professor Marsh, as the "Atlantosaurus beds of the Upper Jurassic." This fragment has served for the foundation, by Marsh, of the *Dryolestes priscus*, representative of a new genus as well as species. The tooth preserved, it is said, "has the same general form as the corresponding molar of *Chironectes variegatus*, Illiger," the water-opossum of South America. Although doubtless a Marsupial, nothing positive can be predicated from the known remains. It may be remarked as a singular fact that of the now quite numerous species of Triassic and Jurassic mammals known, almost nothing but the lower jaws have been found, and, as has been indicated, the *Dryolestes* is not an exception to the rule.

The Miocene Mammalian Fauna of Oregon.

Through the labors of Messrs. Leidy, Marsh, and Bettany, a considerable number of species of mammals of the order of Ungulates have been made known as representatives of the Miocene fauna of Oregon, but of the other types of the class almost nothing was known. Towards the end of last year, however, Professor Cope contributed a memoir "on some of the Characters of the Miocene Fauna of Oregon," which has,

to a considerable degree, supplemented the data already acquired; and types of the orders of Rodents and Carnivores have been added. During the epoch in question, the Ungulates were conspicuous on account of their number and variety; and members of the existing families of Rhinocerids and Dicotylids (Peccaries) flourished, in company with several species of the horse-like Anchitheriids, and with representatives of the generalized types of Elotheriids and Oreodontids. The family of Chalicotheriids, or Brontotheriids, was also apparently manifested under a huge form, which has been distinguished by Cope as a new generic type (*Dæodon shoshonensis*). This is considered by its describer to be "the largest of the North American *Perissodactyla*, with the possible exception of the *Menodus Proutii*." Among the Carnivores contemporary with these were several *Canidæ*, either related to the wolves and foxes of the present epoch, or generically distinct, and a sabre-toothed Felid of the genus *Machærodus*. Rodents of the families of *Castoridæ* (Beavers), *Saccomyidæ*, and *Sciuridæ* (Squirrels) are also among the novelties added by Professor Cope.

BOTANY.

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During the year 1878 there has been great activity in all the departments of botany, but, contrary to what was the case in 1877, the more important publications have related to phanerogams rather than cryptogams. As usual, the work done in America has been almost entirely descriptive, but it has been of a high order; and we record with pleasure an unusual number of American books, especially relating to phanerogams and ferns, which have not been surpassed by any corresponding European publications. With the exception of Great Britain, the activity of European botanists has been directed rather to minute researches on the structure of the vegetable cell, to the development of the lowest forms of vegetable life, and to vegetable physiology, than to descriptive works, although there has been by no means a dearth of the latter. In giving an account of the progress of botany we have, for the convenience of the reader, separated the part relating to America from that relating to foreign countries, beginning with the publications of this country.

PROGRESS IN AMERICA.

Phanerogams.

During the present year there have appeared several of the most valuable contributions ever made to a knowledge of American phanerogams. First in importance must be mentioned Part I. of the "Flora of North America," by Professor Asa Gray. This work is in reality a continuation of the "Flora of North America," by Torrey and Gray, in two volumes, which ended with the *Compositæ*. The new "Flora" begins with the *Goodeniaceæ*, and Part I. ends with the *Plantaginaceæ*. It covers nearly 400 pages, and the descriptions include 1560 native species belonging to 298 genera, and 96 species of introduced plants belonging to 26

genera. In the *American Naturalist* for October, Mr. Sereno Watson gives a critical review of the "Flora," and states that, comparing the last-named work with Gray's *Manual*, the probable total number of species of phænogamous plants in North America is between nine and ten thousand. The following statistics, by Mr. Watson, are of general interest: "As regards the distribution of this (North American) flora, it appears, from a very cursory examination, that it divides readily into an eastern, a central, and a western section. The first may be considered as covered essentially by Gray's *Manual* and Chapman's *Flora*, and the last in good degree by the *Botany of California*. Taking these as guides, and making to each the additions indicated by the present 'Flora,' it is found that the eastern division includes 610 native species, of which 130 are peculiar to the *Manual*, 205 to Chapman's *Flora*, and 275 common to both. The *Botany of California* includes 567 species, of which 58 belong also to the Atlantic States. Of the remaining 450 species, 48 are high northern and do not enter the United States; 8 are Mexican and not yet found within our limits; 290 are mainly southern, belonging to the warmer and dryer interior; and 103 are found only in the Rocky Mountains or the cooler region westward to Oregon. Had Greenland been included in the limits adopted by Dr. Gray, only two other species (*Veronica fruticulosa* and *Gentiana nivalis*) would have been added, and of these the latter is reported from Labrador."

Second only to the work of Professor Gray in its importance to the student of the North American flora is the "Index to American Botany," by Mr. Sereno Watson, of which Part I. has appeared, and includes the *Polypetalæ*. It covers about 450 pages and forms one of the Smithsonian miscellaneous collections. The preparation of the "Index" must have required very great labor, and the work has been most carefully and accurately performed by Mr. Watson.

Besides the two works already mentioned, there are several articles to be noticed in which new American species have been described. In the *Proceedings* of the American Academy of Arts and Sciences of January 9, Professor Gray has a paper on the American species of *Elatine*, of which he recognizes four; and a second paper on Two New Genera of *Acanthaceæ: Carlowrightia*, in honor of Mr. Charles Wright,

and *Gatesia*, in honor of Dr. Hezekiah Gates. A third paper contains a description of 17 new species of *Astragalus*, most of which were collected in Arizona by Dr. E. Palmer. Finally, several miscellaneous species, principally *Compositæ*, are described. In the *American Journal of Science* for February is an article by Mr. Sereno Watson on the Poplars of North America. In the same journal is a paper by Professor Gray on Forest Geography and Archæology, in which are considered the causes which have produced a forest in California which is rich only in coniferous trees, while the forest of the Atlantic States is, with one exception, the richest in species of any in temperate regions. Four diagrams are given showing the comparative richness in species of the Atlantic-American, the Pacific-American, the Japan-Manchurian, and the European forests, and also the relative proportion of coniferous trees in the same regions. The *Transactions* of the Academy of Science of St. Louis include a Synopsis of the American Firs (*Abies*), by Dr. George Engelmann. He recognizes nine American species. He is of the opinion that the microscopic character of the leaf has been too much regarded, to the neglect of the characters furnished by the reproductive organs. The subdivision of the genus, he thinks, can, with much greater certainty, be based on the differences of the leaf-structure than on the length of the bracts, as was formerly done. In the *Torrey Bulletin*, the same writer has some notes on the somewhat confused American species of *Vitis*. The *Botanical Gazette* contains a paper by Dr. A. W. Chapman on Plants from the Semi-tropical Regions of Florida, in which a number of new species are described.

A monograph of the genus *Lechea*, by Mr. W. H. Leggett, appeared in the *Torrey Bulletin*, accompanied by an elaborate revision of Rafinesque's paper on the same genus. A considerable number of lists of flowering plants have appeared, among which we may particularize a "Catalogue of the Phænogamous and Cryptogamous Plants of the Dominion of Canada," by T. Macoun; two lists of plants found in the Indian Territory, one by Mr. A. Wood and the other by Mr. G. D. Butler; and a paper on the Distribution of Certain Plants in Missouri, by G. C. Broadhead. Mr. T. S. Brandegee has a paper on the *Coniferæ* of the Crestones in the *Botanical Gazette*.

Among the notices of rare plants should be recorded the re-discovery of *Shortia galacifolia* in North Carolina. Only one specimen of the plant was known to exist—that in the Michaux Herbarium at Paris. The common European heath *Calluna vulgaris* has been observed near Egg Harbor City, N. J.; but Mr. Thomas Meehan, who has visited the locality, thinks that it must have been recently planted by some emigrant. Two lists of introduced plants have been published, one by Mr. Addison Brown, in the *Torrey Bulletin*, who reports 63 species near Jersey City, 24 of which are not in Gray's *Manual;* the other by Mr. Mohr, of Mobile, who reports 64 introduced species from different points in the Gulf States.

The "Wild Flowers of North America," of which the second fascicle was noticed in last year's *Record*, has not been continued during the present year, but the announcement is made that it will hereafter be published at the Naturalists' Agency, Salem. On the other hand, the "Native Flowers and Ferns of the United States," by Professor Thomas Meehan, has successfully completed its first volume of 48 plates, and it is understood that a second volume is in progress. An excellent set of dried plants from Florida has been offered for sale by Mr. A. H. Curtiss.

Higher Cryptogams.

The present year has been especially prolific in books relating to American ferns, and most of them have been of high character. First in importance is the admirable "Ferns of North America," by Professor D. C. Eaton, with plates by J. H. Emerton. This work is a decided credit to the botany of this country, and will be the authority for native species. Eleven parts have appeared during the year, so that the work is now half completed. The text and plates have not fallen off from their original excellence. A second book, "Ferns in Their Homes and Ours," by John Robinson, is an excellent guide, not only to the culture, but also to the structure and classification of ferns. A third book, "Ferns of Kentucky," by John Williamson, is also a decided acquisition to our fern books, and should be favorably mentioned. Besides the above-named works, a large number of pamphlets and articles have appeared in the different journals. Mr. G. E. Davenport has published an elaborate memoir, entitled

"Notes on *Botrychium simplex*;" and the same writer has a paper in the *Torrey Bulletin* for January on Vernation in *Botrychia*. Both papers are illustrated. In a third paper by Mr. Davenport, in the *Naturalist* for November, he gives an account of *Aspidium spinulosum* and its varieties, and makes a new species, *A. Americanum*, of *A. spinulosum*, var. *intermedium*, Eaton. Four interesting ferns, new to the United States, *Ceratopteris thalictroides*, *Cheilanthes microphylla*, *Asplenium firmum*, and *Asplenium cicutarium*, are reported by Professor Eaton in the *Torrey Bulletin* as having been found in Florida. Professor Eaton has determined a collection of ferns collected in Trinidad by Mr. August Fendler, and sets of them have been distributed from the herbarium at Cambridge. The popularity of the study of ferns is shown by the fact that scarcely a number of the *Torrey Bulletin* or *Botanical Gazette* has appeared during the year which has not contained notes, often of considerable length, about our native species. The *Botanical Gazette* for January contains a paper on the species of *Isoetes* of the Indian Territory, by Dr. George Engelmann. Besides a description of the new species, *Isoetes Butleri*, there are some remarks on *Isoetes melanopoda*, which is peculiar to a belt of prairie country extending from northeast to southwest, from Illinois to Iowa, the Indian Territory, and Texas.

In the department of bryology the literature is rather scanty. Mr. C. F. Austin has two articles in the *Botanical Gazette*, in one of which he describes five new mosses; the other is a note on *Polytrichum tenue* and *P. brachyphyllum*. In the *Torrey Bulletin*, Professor Eaton has a note on *Conomitrium Julianum*, which he found in abundance at Hamden, Conn. When spread out in water, the capsules detach themselves in large numbers. Supplement No. 1 of the *Musci Appalachiani*, containing one hundred species of mosses collected mostly in the eastern part of North America, is announced as ready for distribution by Mr. C. F. Austin.

THALLOGENS.

Lichens.

In discussing the progress of botany in America, while speaking of the higher plants, it was only necessary to men-

tion the writings of native botanists, since very little, if any, work having special reference to the American flora is undertaken in Europe. When we come to thallogens, however, at least half, and perhaps more, of the descriptive work is done in Europe. In the way of lichens we have to mention a list of lichens of Southern Illinois, collected by Mr. J. Wolf, and described by Mr. Henry Willey, the list including sixty-one species. The same writer, in an article in the *Torrey Bulletin* entitled North American Lichenography, completes the bibliography of North American lichens, previously treated by him in a paper in the *Proceedings* of the Essex Institute.

Algæ.

Dr. Wittrock, in the *Botaniska Notiser*, a Swedish journal, has an article on the American Species of *Œdogonium* and *Bulbochæte*. Most of the species mentioned, however, are from South America. At the end of the article is a critical note on certain species described in the "History of the Fresh-water Algæ of North America," by Professor H. C. Wood, with whom Dr. Wittrock does not entirely agree, but refers several of the species of Professor Wood to previously described forms. The second fascicle of the "Algæ Am. Bor. Exsiccatæ," by Farlow, Anderson, and Eaton, contains fifty species, several of which are new.

The articles on American fungi are, as usual, very numerous, and scattered through several different journals, both European and American. The thirtieth report of the New York State Botanist, Mr. C. H. Peck, contains the description of a large number of new fungi, and is illustrated by two plates. At the end of the report, Mr. Peck gives his views with regard to several species of *Lenzites*, which he does not consider distinct from *L. confragosa*. A number of new species, belonging principally to the genus *Æcidium*, collected in Colorado by Mr. Brandegee, are described in the April number of the *Botanical Gazette*, by Mr. Peck. The *Torrey Bulletin* contains a note by Mr. J. B. Ellis on the re-discovery of *Sphæria barbirostris*, Duf., near Vineland, N. J. The second volume of the Bussey *Bulletin* contains a list of the fungi found in the vicinity of Boston, being a continuation of a previous article. It is followed by critical notes of some of the species, particularly those belonging to the *Chytri-*

dineæ, *Peronosporeæ*, and *Uredineæ*. The *Erysiphei* of the United States have been treated in an article, by Professor C. E. Bessey, in the seventh biennial report of the Iowa Agricultural College; and the *Bulletin* of the Minnesota Academy of Natural Sciences contains a notice of the Mycological Flora of Minnesota, by Dr. A. E. Johnson. An addition to a paper, by Mr. M. C. Cooke, on the *Valsei* of the United States, is to be found in the *Proceedings* of the Academy of Natural Sciences of Philadelphia, in a paper by Mr. W. C. Stevenson, who gives measurements of spores of some of the species of the Schweinitz collection. A synopsis of the *Myxomycetes* of the United States, by M. C. Cooke, arranged from Rostafinsky's monograph of the *Myxomycetes*, has been reprinted from the *Annals* of the Lyceum of Natural History of New York.

New American fungi are described by Von Thümen in the *Torrey Bulletin*, *Flora*, and the *Naturaliste Canadien*. Lists and descriptions of new Californian species, collected principally by Dr. Harkness and Mr. Moore, have appeared in *Grevillea*, in articles by Cooke, Plowright, and Philips. In the same journal is a continuation of the descriptions of New Jersey fungi, by Cooke and Ellis, with illustrations of some of the species, and diagnoses, by Mr. Cooke, of the fungi issued in the first two fasciculi of "Fungi Americani."

During the year two series of dried specimens of American fungi have been presented to the public. The first, of which two fascicles have already been issued, is entitled "Fungi Americani," and includes two hundred specimens collected in Florida and South Carolina by Mr. H. W. Ravenel, and published by him in connection with Mr. M. C. Cooke. The series will probably be completed in two more fascicles. The second set of fungi is prepared by Mr. J. B. Ellis, under the title of "North American Fungi." One century has already been issued. The work is to include one thousand species from the temperate parts of North America, and Mr. Ellis will be aided by several of the mycologists of the United States.

Vegetable Anatomy and Physiology.

The *Naturalist* contains several articles by Professor W. J. Beal. One, entitled How Thistles Spin, has several figures of the hairs of *Cirsium altissimum*. In a second article

he shows the means by which insect fertilization is accomplished in *Utricularia* and *Pyxidanthera*. A third article, on Hairs and Glandular Hairs of Plants, is accompanied by a number of cuts illustrating the structure of the hairs of plants belonging to several different orders. Professor Beal, in conclusion, asks, "Why may not these glands also draw nourishment from the particles of dust which fall on them from the air, or from the particles of soil which, in many cases, accumulate to such an extent as to completely cover some portions of the plant? As root-hairs are active in absorbing materials from the soil, including something from solid substances, why should not the active glands absorb materials from the dust and fragments of soil?" The cleistogamous condition of the flowers of *Danthonia spicata* is noted by Mr. C. G. Pringle in the *Naturalist* for April. He thinks that the seeds borne at the top of the culm of this grass fall in midsummer and germinate on the spot; whereas the seeds concealed in the culm are only set free by the breaking of the culm in a high wind, and are consequently likely to be blown to a considerable distance, thus aiding in the diffusion of the species. Mr. Martindale, in the June number of the same journal, confirms what Mr. Pringle states with regard to *Danthonia spicata*, but does not find a similar state of things in *D. sericea*. The *Naturalist* also contains an essay on the Transpiration of Plants, by Dr. J. M. Anders, to which the George B. Wood prize was awarded. We must also mention an excellent paper, by Professor Todd, on the Distribution of Timber in Southwestern Iowa, with Inferences concerning the Origin of Prairies, also in the *Naturalist*. The conclusion is as follows: "While acknowledging that prairie fires, the amount and distribution of rainfall, the nature of the soil, the temperature and inclination of surface, that all may have more or less importance in explaining the origin of forests and prairies, we may nevertheless be convinced that the fundamental condition of forest growth is a constant medium humidity of air and soil. Let us, therefore, while not neglecting our pluviometers, look more carefully to our hygrometers in the study of this subject." The *Torrey Bulletin* contains two articles by Mr. N. L. Britton, one entitled, When the Leaves Fall; the other, When the Leaves Appear. Two tables of dates accompany the arti-

cles. Mr. Britton states that in diœcious plants the female appears to hold its foliage longer than the male. The leaves of *Darlingtonia Californica* and their secretions form the subject of a letter addressed by Mrs. R. M. Austin, of Prattsville, Plumas County, Cal., to Professor Gray, and communicated by him to the *Botanical Gazette.* She finds that the sweet secretion is confined to the inner and rough portion of the hoods on both sides of the "fish-tails," and extending down the wing to where it makes the outward bend. In the *Gazette* is a letter, by Mr. J. G. Lemmon, on the Big Trees of California, in which he gives some interesting measurements. The famous tree called the Father of the Forest, he says, has been shamefully overrated every way. Instead of being 40 feet in diameter and 450 feet high, it is only 18 feet in diameter at a distance of six feet from the roots, and the length is only about 300 feet. The probable age of the tree is, according to Mr. Lemmon, only about 1500 years! Another tree, called the Livery Stable, which has received twenty-two horses at a time into its hollowed base, is 84 feet in circuit. In the second volume of the *Bulletin* of the Bussey Institution is a paper, by Mr. Francis Parkman, on the Hybridization of Lilies. Mr. Parkman gives an account of his crossing *Lilium speciosum* with *L. auratum*, which resulted in the beautiful hybrid named in his honor. He concludes that lilies, when hybridized, produce offspring which show the features of the male parent very slightly, or only in exceptional cases. A critical review of Mr. Parkman's paper is given by Professor Gray in the *American Journal of Science.*

The *Proceedings* of the Academy of Natural Sciences of Philadelphia contain a number of important papers, among which may be mentioned a communication of Mr. Thomas Meehan on "The Law Governing Sex." Dr. J. Gibbons Hunt gives some observations on *Stapelia asterias*, in which he describes the manner in which flies are attracted to the flower and remove the pollen masses.

Miscellaneous.

No special botanical work has been undertaken by the different surveys of the West during the present year. The well-known botanist Dr. C. C. Parry, accompanied by Dr. E. Palmer, has made an extended trip through the northern

central parts of Mexico. By the will of Mr. Stephen T. Olney, of Providence, the well-known collector, a large sum of money was left to be spent in providing instruction in botany in the State of Rhode Island, under the direction of Professor Gray and Mr. W. N. Canby. The Court has, however, set aside the will on the ground of insanity; and, as it is, Brown University, of Providence, one of the legatees under a previous will, will receive a certain sum to be spent for botanical purposes.

GENERAL.

Phanerogams.

The classic "Prodromus" of De Candolle, which was brought formally to a close with the dicotyledons, has been, in a sense, revived under the title of "Monographiæ Phanerogamarum," of which one volume has appeared under the direction of MM. Alphonse and Casimir De Candolle. The volume contains a monograph of the *Smilaceæ*, by A. De Candolle; one on the *Restiaceæ*, by Dr. Masters; and a revision of the *Meliaceæ*, by C. De Candolle. The "Flora of British India," by Sir J. D. Hooker, has advanced as far as Part V., being the second part of the second volume. The *Rosaceæ* are elaborated by the editor, the *Leguminosæ* by J. G. Baker, the orders from *Saxifragaceæ* to *Haloragеæ* by C. B. Clarke, the *Rhizophoreæ* by Rev. G. Henslow, and the *Myrtaceæ* by J. F. Duthie. The "Flora Australiensis" ends with the seventh volume, by George Bentham. The "Flora of Mauritius and the Seychelles," by J. G. Baker, and the third volume of the "Flora of Tropical Africa," by Professor Oliver, bear testimony to the great activity of the botanists at Kew, who, under the lead of Sir J. D. Hooker, have undertaken to describe the plants of the British dependencies. The plants collected by Dr. Hooker in his journey to Morocco have been described by the *Journal of Botany*, British and Foreign, which contains a number of articles, of which we may specify Spicilegia Floræ Sinensis, a record of hitherto unrecorded Chinese plants, by H. F. Hance; three papers, by J. G. Baker, on Two New Genera of *Amaryllidaceæ* from Cape Colony, New *Compositæ* from Monte Video, and a Classification of the Species of *Hippeastrum*; the *Dipterocarpeæ* of New Guinea, by Professor Thiselton Dyer; Notes on *Rubi*, by C.

C. Babington; *Conspectus Polygalarum Europæarum*, by A. W. Bennett, etc., etc. The "Forest Flora of British Burmah," in two volumes, is by S. Kurz, Curator of the Herbarium of the Botanic Garden, Calcutta, whose lamented death occurred soon after the publication of this work. Four parts of a superb "Monograph of the Genus *Lilium*" have been published by H. J. Elwes, with illustrations by W. H. Fitch.

In Germany there have been but few publications relating to phanerogams. In *Linnea*, Count Solms-Laubach has a synopsis of the *Pandanaceæ*. The "Flora Brasiliensis" has been increased by several volumes, including the *Lemnaceæ* by Hegelmaier, *Araceæ* by Engler, *Oxalidaceæ*, *Geraniaceæ*, and *Vivianaceæ* by Progel, *Rafflesiaceæ* by Solms-Laubach, *Meliaceæ* by C. De Candolle, and *Cucurbitaceæ* by Cogniaux. Dr. Maximowicx, of St. Petersburg, has described new plants from China and Mongolia belonging to the genus *Corydalis*, besides revisions of other genera. In Italy we have to notice a continuation of the Dalmatian *Flora*, by the late lamented Professor Visiani; and the second fasciculus of Beccari's *Malesia*, principally devoted to a description of the *Icacineæ* and *Menispermaceæ* of the Indo-Malayan and Papuan Archipelago. Reichenbach has published a third volume of the *Xenia Orchidacea*, and he has a paper entitled *Orchideæ Kalbreyerianæ*, in *Flora*. Two papers on the *Olineæ* have appeared from Decaisne and Baillon, in which decidedly antagonistic views are expressed.

In the way of hand-books and manuals, we may mention a new edition of Hooker's "Student's Flora of the British Islands," and McNab's "Morphology and Physiology and Classification of Plants" (*London Science Class-books*). In German we have Seubert's "Excursionsflora für Süddeutschland" and "Flora von Deutschland" by Dr. August Garcke, as well as several others. Hallier's "Taschenbuch der deutschen und schweizer Flora" seems to have called forth criticisms which are very far from favorable. A series of class-room diagrams called "Anatomisch-physiologischer Atlas der Botanik," by Dr. A. Dodel-Port, has been recommended by several well-known botanists.

Anatomy and Morphology.

The second part of Eichler's "Blüthendiagramme" is the

most important work on the morphology of higher plants which has appeared during the year. It is very elaborate, and as yet no good synopsis of its contents has appeared in any of the journals. It has been very favorably reviewed by Celakovsky in *Flora*. The "Mechanische Theorie der Blattstellung," by Schwendener, is a very solid, but rather dry work, and difficult to read. "La Morfologia Vegetale," by Professor Caruel, embodies the author's lectures in the University of Pisa. The subject of general morphology is treated in an interesting and satisfactory manner, although the book is a text-book rather than an elaborate treatise. An important paper by Professor Warming, of Copenhagen, on the Ovule, giving a detailed account of his studies in relation to its development, was published in the *Annales des Sciences*. Hanstein has published the observations made by the late Alexander Braun and himself, with relation to *Cœlebogyne ilicifolia*. The experiments were made at Berlin upon a female plant shut up in an enclosure, so that there was no possibility of fertilization by pollen from outside. Nevertheless, seed was ripened in this diœcious species, and the fact of parthenogenesis seems to Braun and Hanstein to be proved in this case. A second paper by Kamienski on the Development of the *Utriculariæ* has appeared in the *Botanische Zeitung*. Professor Dickson, of Glasgow, communicated to the *Journal of Botany* an abstract of his paper read at the meeting of the British Association in 1877, on the Structure of the Pitcher of *Cephalotus follicularis*. The Anatomy of the Stem of Monocotyledons, and the Terminal Growth of the Root in Phanerogams, are treated at considerable length in the *Annales des Sciences*, the former by A. Gillard, the latter by Ch. Flahault.

Higher Cryptogams.

The development of ferns and mosses has been studied by several botanists of note, and a number of interesting papers on the subject have appeared. One of the most interesting is an article by De Bary on Non-sexual Reproduction in Ferns, in the *Botanische Zeitung*. The paper was originally read at the meeting of German Naturalists at Munich, in the autumn of 1877. The object of De Bary's researches was to ascertain whether the abnormal growths arising

from a suppression of the archegonium in *Pteris cretica* were to be found in other ferns. He found that the same condition also existed in *Aspidium Filix mas*, var. *cristatum*, and *Aspidium falcatum*. In the three species mentioned the prothalli usually contained normal antheridia, but archegonia were extremely rare, and, as far as could be ascertained, were always abortive. The non-sexual or budding process, in all three species, consists in the formation of a protuberance on the under surface of the prothallus, from which grow a first leaf, root, and stem-bud, as in the normal embryo formation, although their relative position and date of development vary. De Bary gives the name of apogamy to the substitution of some other form of reproduction in cases where the power of sexual reproduction has been lost. Apogamy is of three kinds: apogeny, where the function of both male and female organs is destroyed; apogyny, loss of reproductive power in the female; apandry, in the male organ. De Bary's paper ends with some valuable remarks on parthenogenesis in the vegetable kingdom. The germination of the *Schizeaceæ* has been investigated by Dr. Hermann Bauke, who studied three species of *Aneimia*, and one *Mohria*. The development of this suborder is, with the exception that the archegonial thickening is on one side rather than at the sinus of the prothallus, very much the same as in the suborder *Polypodiaceæ*. The same writer has also published a preliminary notice of the sexual reproduction in *Platycerium*, *Lygodium*, and *Gymnogramme*. A paper by H. F. Jonkmann on the Development of the Prothallus of the *Marattiaceæ* is to be found in the *Botanische Zeitung*, but is left in an unfinished condition by the author. The Development of the Embryo, or rather the Central Cell, of the Archegonium of the *Equisetaceæ*, is the subject of a paper in Pringsheim's *Jahrbuch*, by Dr. Sadebeck, who finds that the embryo, as in ferns, divides into four parts—a stem-bud, first leaf, primary root, and the so-called foot. There have been but very few articles relating exclusively to descriptions of ferns, but we may mention a list of Bulansa's Ferns of Paraguay; Notes on some Japanese Ferns, by J. G. Baker; and a list of Venezuela Ferns, by Dr. Ernst.

The most important paper relating to the development of mosses is that of Kienitz-Gerloff in the *Botanische Zeitung*.

The species especially studied were *Phascum cuspidatum*, *Ceratodon purpureum*, and *Funaria hygrometrica;* and the article, which abounds in minute details, is made comprehensible by drawings. We would also mention the *Monographia Metzgeriæ* and *Bryinæ acrocarpæ*, by S. O. Lindberg; a Description of Twelve Mosses from India, by C. Müller, in the *Flora;* and *Musci Frondosi* from Central Brazil, collected by Dr. Warming, and described by Ernst Hampe. A dried collection called *Musci Austro-Africani* has been offered for sale by Dr. A. Rehmann.

The *Characeæ* have been treated of in several articles, the principal aim of the writers being to explain the position of the order in respect to mosses, and to Sachs's order of *Carposporeæ*. The July number of the *Journal of Botany*, British and Foreign, contains an article by A. W. Bennett on the Structure and Affinities of *Characeæ;* and the September number, a paper by Professor T. Caruel on the Place of *Characeæ* in the Natural System. The December number contains an elaborate essay on the Pro-Embryo of *Chara*, by Sydney H. Vines. The general opinion seems to be that the *Characeæ* form a distinct group by themselves. Celakovsky, in *Flora*, discusses the Morphological Signification of the Spores of the *Characeæ*. He thinks that the female organ of *Chara* should be considered an oogonium, and not a "Sporenknöspchen," as the term is applied by Alexander Braun. A fifth fascicle of Braun, Rabenhorst, and Stizenberger's *Characeæ* has just made its appearance.

Thallogens.

A very important paper on the development of lichens, by Dr. E. Stahl, is entitled "Ueber die Bedeutung der Hymenialgonidien." It is the second part of a work mentioned in the *Record* of 1877. The present paper treats of the significance of the hymenial gonidia. The species whose development has been especially studied by Stahl are *Endocarpon pusillum*, *Thelidium minutulum*, and *Polyblastia rugulosa*. Stahl considers that the hymenial gonidia are derived from the thalline gonidia, and that their peculiar appearance is owing only to their place of growth. When the spores are discharged, a number of hymenial gonidia are also discharged with them. Stahl cultivated the spores of the

species above named, and was able to watch their development and the effect produced by the growth of the hyphæ upon the free gonidia. In *Endocarpon* and *Thelidium* he was able to follow the whole course of the development from the germination of the spores until the ripening of new spores. The most important result of Stahl's work was the following: He took the spores of *Thelidium minutulum* and the gonidia of *Endocarpon pusillum*, and found that the former grew as well upon the gonidia of the latter as upon its own gonidia, and he was able to produce new asci and spores of *Thelidium* when growing upon the foreign gonidia. This is the first successful attempt at reproducing a perfect lichen by sowing the spores, and strengthens, in a forcible manner, the theory of Schwendener that lichens are fungi parasitic upon certain algæ. Dr. Minks, in a paper in *Flora*, "Das Microgonidium," gives a statement of his views of the origin of gonidia in lichens, which are opposed to those of Stahl. He thinks that if Stahl had made use of higher powers of the microscope, he would have seen the same structures as Dr. Minks himself. Exactly what those structures were it is rather difficult to understand from Dr. Minks's paper, and no figures are given; so that botanists will hardly conclude that he has satisfactorily answered Stahl's paper until the appearance of the memoir, of which he states that the present paper is only a prodromus. Borzi, in a careful paper which appeared in the Italian *Journal of Botany*, in which he gives the result of his investigations on the sexuality of the *Ascomycetes*, confirms the views of Stahl with regard to the reproduction in lichens. *Flora* contains a number of descriptive papers on lichens; by Krempelhuber, on Species Collected in the Argentine Republic; and Notes, by Nylander, on some European Lichens, and on Lichens from the Desert of Sahara and from Corsica. The Austrian *Botanical Journal* has a paper by Arnold on Lichenological Excursions in the Tyrol; and in the *Journal* of the Linnæan Society is a Description of some British Lichens, by Leighton.

Of the numerous contributions to our knowledge of algæ may be mentioned, in the first place, the superb work of Thuret and Bornet entitled "Études Phycologiques." This is probably the most elaborate and beautifully illustrated

work which has ever been published in relation to the structure and development of algæ. It includes 51 folio steel engravings from drawings by Riocreux and Bornet. The text is principally by Bornet, as Thuret died before the work was finished. The illustrations and account of the development of the *Phæosporeæ* and *Fucaceæ* are very complete. The Development of *Botrydium granulatum*, by Woronin and Rostafinski, shows that species pass through several different phases, which had been considered by preceding botanists as distinct species. There are several different modes in which the zoöspores are produced, and some are furnished with one and others with two cilia. The latter unite in twos or some larger number, and may be said to conjugate, forming what Rostafinski calls an isospore. The second paper, on the Development of *Acetabularia mediterranea*, is by Professors De Bary and Strasburger. The growth of the plant until the formation of the spores had previously been studied by Woronin at Antibes. In the present paper the spores are shown to contain zoöspores, and so should rather be called zoösporangia. There is also described a peculiar basal process. Dr. Goebel, who studied for a time at the zoological station at Naples, gives the result of his observations on *Ectocarpus pusillus* and *Giraudia sphacelarioides*. He found that the zoöspores conjugated very much in the same manner as in some of the green *Zoösporæ*. Conjugation has also been observed by Reinke in *Monostroma bullosum* and *Tetraspora lubrica*. The effect of the action of light on the motions of zoöspores has been studied independently by Stahl and Strasburger. In the *Record* for 1877, we referred to an article by Sachs, in which he described the figures formed by small particles floating in liquids, and suggested that the figures assumed by zoöspores were of a similar nature, and due to currents. Stahl and Strasburger, however, agree in thinking that there is a direct influence of light on the motions of zoöspores, and that they are not caused wholly, at least, by currents. Strasburger divides zoöspores into two classes: aphotometric, those not influenced by variations in the intensity of the light; and photometric, which are so influenced.

Dr. Wittrock, in the *Proceedings* of the Royal Swedish Academy, furnishes an account of the spores in the *Mesocar-*

peæ, with special reference to the new genus *Gonatonema*, in which the spores may be said to be parthenospores.

A lengthy article on *Phycochromaceæ*, by Borzi, is to be found in the Italian *Journal of Botany*. Professor Cohn notes the occurrence of a new *Rivularia*, in which there is no gelatinous envelope, in the River Leba; and Dr. Gobi has noticed the same species near St. Petersburg. A very curious parasite growing on *Laurencia obtusa* is described by Count Solms-Laubach, on which he founds a new genus, *Janczewskia*. Dr. Kjellmann describes with great minuteness the algæ found on the shores of the Skager-Rack. The article is accompanied by a chart of dredgings and soundings. In the Austrian *Journal of Botany*, Hauck continues his account of the algæ of the Adriatic. Dr. Gobi, in the *Memoirs* of the St. Petersburg Academy, has an account of the algæ of the White Sea. Nordstedt has three papers: on some *Desmids* collected in Italy and the Tyrol; on some fresh-water algæ from Brazil; and on some algæ from the Sandwich Islands. Professor E. Percival Wright, of Dublin, has made some interesting studies on the development of tetraspores in *Polysiphonia*. He finds that they are outgrowths from the so-called central siphon. Professor Wright has also distributed two papers on some parasites—one belonging to the genus *Chlorochytrium*, the other to *Rhizophydium*. One of the longest and most elaborate works on algæ which have appeared the present year is the second volume of the "Cryptogamic Flora of Silesia." The algæ have been worked up by Dr. Kirchner, a student of Professor Cohn, who has himself contributed material. The work is prefaced by a notice of the works of different algologists who have studied the flora of Silesia. Some Papuan algæ are described by Zanardini in the Italian *Journal of Botany;* Arctic algæ have been described by Professor Dickie; and algæ from the Auckland Islands, by Rabenhorst. Munier-Chalmas has made the interesting discovery that a number of fossils, which were presumed to be *Foraminifera*, are, in reality, algæ belonging to the order *Siphonaceæ*, and nearly related to *Dasycladus;* and, strange to say, one of the fossil species of the China Sea is found to be still living near the island of Cuba. In the way of published exsiccata, there have been issued several fasciculi of Rabenhorst's

"Algen Europas;" two fasciculi of Nordstedt and Wittrock's "Algæ Scandinavicæ;" and a fine set of New Zealand algæ by Dr. Berggren.

The number of articles on fungi is enormous, and it is only possible to refer to a few of the more important works. On *Hymenomycetes* we must notice a Clavis Synoptica Hymenomycetum Europæorum, by Cooke and Quelet. The Fungi of the Arctic Expedition have been described by Berkeley; and a list of fungi from Queensland, comprising 120 species, has been published by Berkeley and Broome.

M. C. Cooke gives in the Italian *Journal of Botany* a prodromus of a Monograph of the *Hendersoniæ*. In Italy there has been great activity in matters relating to fungi. Professor Saccardo has lengthy articles in the two numbers of *Michelia* which have appeared this year on Italian fungi, and also an Enumeratio Pyrenomycetum *Hypocreaceorum*. Spegazzini has an article on some coprophilous fungi in the same journal. The Fungi Italici Autographice Delineati of Saccardo has been extended from Parts V. to VII. Pirotta, in Italy, and Niessl, in Germany, have published monographs of the genus *Sporormia*. The *Ustilagineæ* have been further treated by Professor Fischer von Waldheim, in a Russian monograph; and by Schröter, in two articles in the "Beiträge zur Biologie," in which he shows the identity of some species thought to be distinct. At the end of the paper are some remarks on the genus *Entyloma*. Van Tieghem has published a third paper on the *Mucorini*, in which he describes several new species, and gives an arrangement of the tribes of the group. Pasteur mentions in the *Comptes Rendus* that he has ascertained that two of the species of *Mucorini*, recently described by Van Tieghem, are capable of producing alcoholic fermentation, and a rather spirited discussion has taken place between Pasteur and Trecul on this subject. The *Bulletin de la Société Botanique* contains a number of notices of fungi. Some new species are described and figured by Baudier, and Prilleux has some remarks on wood discolored green by fungi. The columns of the *Botanische Zeitung* contain communications from Rees and Gramitz with relation to *Oidium albicans*, the "Soorpilz." The latter believes the species to be identical with *Mycoderma Vini*, the wine fungus, but the former strongly denies

it. In the way of exsiccata there have appeared during the year continuations of Rabenhorst's, Oudeman's, and Von Thümen's series, and of Saccardo's Mycotheca Veneta; and a new series, Fungi Gallici, is announced by Roumeguere.

Diseases of Plants.

The full and final account of Woronin's investigations on the cause of the disease known as "club-foot" in turnips has been published, with most excellent illustrations, in Pringsheim's *Jahrbücher*. He thinks that the disease is caused by a minute fungus related to the *Myxomycetes*, to which he gives the name of *Plasmodiophora brassicæ*. A dispute has arisen between Cornu and Millardet as to the cause of the swelling of the roots of vines attacked by the *Phylloxera*. Millardet had advanced the opinion that the swelling was caused by the mycelium of some unknown fungus rather than by the *Phylloxera*. Cornu, on the other hand, denies the existence of any mycelium which could cause the trouble. Cornu reports a new disease of the vine in the district of Narbonne. It forms blackish spots on the leaves, stems, and grapes, and Cornu thinks the fungus is what was described by Cesati as *Cladosporium viticolum*. In the *Comptes Rendus* are two notes by Cornu, on the Spots on Maple Leaves caused by *Rhytisma acerinum*, and on the Lettuce Mould. From the experimental station at Klosterneuberg, near Vienna, have been issued a number of papers. The most important is a Description of the Species of Fungi which Attack the Vine, by Von Thümen. Two hundred and twenty species are mentioned, but they are not all peculiar to the grape. A second paper by Von Thümen treats of Two New Diseases of Grapes caused by *Apiosporium citri* and *Sphærella gibelliana*. Another account of Fungi which Attack the Vine is given by Pirotta, who enumerates 104 species. "The Phenomena of Decay in the Wood of *Coniferæ* and Oaks" is the title of a book, illustrated with twenty-one plates, by R. Hartig, who gives the details of the changes produced by certain species of fungi in the trees above named. Dr. Ernst, of Venezuela, has a paper in Spanish on the Diseases of the Coffee-tree, including those of insect as well as of fungus origin. A curious fungus from Samoa, called *Limamea* by the natives, was exhibited at a meeting of the Linnean Society, by

Rev. Thomas Powell. It destroys the bread-fruit trees and the so-called chestnut. The natives believe that an antidote to its ravages exists in the liliaceous plant *Crinum asiaticum*, which they plant between the trees liable to be affected. A Dr. W. Zopf, of Berlin, advertises a series of models to illustrate ergot, the rust in grain, the potato-rot, and the vine mildew. They are of a size to be used in lecture demonstrations.

Bacteria.

The work by Naegeli, entitled "Die niedrigen Pilze," published late in 1877, but not widely distributed until 1878, is important in a sanitary point of view. Although no new facts are brought forward with regard to the development of particular species of bacteria, yet the subject is well treated from a theoretical standpoint. He divides the lower fungi into *Sprosspilze*, *Schimmelpilze*, and *Spaltpilze*. The former group, including yeast, produce fermentation, as the alcoholic fermentation, but do not cause disease in animals—at least not malarial or contagious diseases. The *Schimmelpilze* act slowly and produce mouldiness, but do not cause disease in animals. All malarial and contagious diseases, if produced by any living organisms, which Naegeli strongly maintains is the case, must be caused by the *Spaltpilze* or *Schizomycetes*. He does not, however, believe that enough is known by scientific men to warrant the assertion that certain diseases are produced by definitely known and named species of bacteria. He does not agree with Cohn in this respect, and he maintains that in the classification of *Schizomycetes* proposed by the latter are included forms not at all nearly related to bacteria, but which belong to plants of a much higher order. In fact, Naegeli, as opposed to Cohn, is inclined to regard many of the so-called species of *Schizomycetes* as merely different conditions of the same species differently affected by external forces. It must be observed, however, that Naegeli's objections are supported rather on theoretical and speculative grounds than on any published observations which he has made; while, on the other hand, Cohn and his co-worker, Dr. Koch, have given to the public detailed accounts of their observations, which tend to show that organisms which produce certain contagious diseases can be specifically defined. The work of Naegeli is mainly occupied with considerations

of the methods of avoiding contagion. He starts with the hypothesis that *Schizomycetes*, or bacterial organisms, grow in places where there is a certain amount of water; but that they are not so easily disseminated when in water as when in the form of a powder or crust, left after the water has for any reason evaporated. Hence, as regards malarial diseases, the most dangerous districts are not those where standing water abounds during the whole year, but those where, at some seasons, the water dries up, leaving the organisms in the form of powder or dust, which is easily carried about and dispersed by the wind. Naegeli argues strongly against the prevailing belief that contagious diseases are generally propagated by the drinking-water, but believes, on the other hand, that contagion is generally spread by means of the air. He is also sceptical as to the value of antiseptics and prophylactics in general, believing that they frequently do harm by leading to a false sense of security.

Dr. Koch, whose Observations on the Development of *Bacillus anthracis* were noticed in the *Record* for 1877, has a second paper on the Method of Examining, Preserving, and Photographing Bacteria. The article is accompanied by three plates, each of which contains eight photographs of bacterial forms. Koch allows thin films of the fluid containing bacteria to dry upon a cover-glass, in order that the bacteria may become fixed. They are then treated with coloring reagents, and allowed to soften, so as to restore their form. They are then permanently mounted and photographed. The coloring matter which Koch found to give the best results was aniline brown. The mounting fluids used were Canada-balsam and a concentrated solution of acetate of potash. The process employed in photographing is given in considerable detail. The results were satisfactory, and in some cases the photographs even show the cilia, which are very difficult to detect in most cases.

The Development and Action of Bacteria have formed the subject of many papers written by chemists and medical men. Fritz, who has recently contributed so much to the knowledge of the *Schizomycetes*, which are concerned in the fermentation of different chemical substances, has, during the present year, given an account of a new nostoc-like species which is concerned in the production of butylic alcohol (see

"Ber. deutsch. chem. Ges.," 1878, xi., 1). A summary of recent British Investigations on Bacteria is to be found in the address of Sir J. D. Hooker, before the Royal Society of London, which was reported in *Nature*. It seems to be more and more the accepted opinion that the spores of the different bacteria can endure a greater degree of heat than the sterile conditions, and in several instances the spores have withstood a temperature of at least 220° Fahr. without apparent injury, whereas the sterile conditions of the same species were destroyed by a temperature considerably below the boiling-point.

Vegetable Physiology.

In the *Annales des Sciences* there is a number of interesting papers on different subjects relating to vegetable physiology. Van Tieghem relates his Experiments on the Digestion of Albumen. He made use of seeds containing albumen of two different kinds, as fleshy and farinaceous, and employed two different methods: first, where the albumen was isolated and submitted to the germinating process; and second, where the whole seed was allowed to germinate. He concludes by saying that the fleshy albumen has an activity of its own. It digests itself, and the embryo simply absorbs the products of this internal digestion. The farinaceous albumen, on the contrary, is passive, and is digested by the embryo itself. There is also a translation in the same journal of the article of Wiesner on the Influence of Light and Radiation of Heat on Exhalation. The theory of Wiesner is that luminous rays are transformed into calorific rays by the action of chlorophyll—certainly a brilliant discovery.

In the same journal are papers by Vesque on the Temperature of the Soil; on the Absorption of Water by the Roots; on Absorption compared to Transpiration; and on the Causes of the Ascent of the Sap. The Mechanical Theory of the Cell is discussed by Dr. Moritz Traube, in the *Botanische Zeitung*. Sachs, in reply, doubts whether the intussusception theory of Traube, in regard to the mechanical cell, can be fully applied to the living vegetable cell. A very spirited correspondence thereupon has been carried on between Traube and Sachs. In the "Beiträge zur Biologie," Just has an elaborate paper on the Influence of Heat on the Germination of Seeds.

Dr. E. Askenasy, of Heidelberg, has published a detailed

account of his Observations on the Distribution of the Intensity of Growth in Plants. He adopts a method of research somewhat similar to that employed by Naegeli, and illustrates it principally by the phenomena which are observed in *Nitella flexilis.*

The coloring matters of plants have been studied by Hollstein, who has published Observations of the Destination of Anthoxanthin Grains in certain Plants; by Dippel, in the Constituents of Chlorophyll; and by Nebelung, in Spectroscopic Observations of the Coloring Matter of some Freshwater Algæ.

The *Quarterly Journal of Microscopical Science* contains an article by F. Darwin on the Contractile Filaments of *Amanita muscaria* and *Dipsacus sylvestris.* The presence of such filaments in plants so different botanically as *Amanita* and *Dipsacus* would lead one to suppose that further search would show them to occur in many other plants. Mr. Darwin thinks that the occurrence of protoplasmic filaments in *Amanita* does not support the theory previously advanced by him that the filaments in *Dipsacus* act as absorbing agents.

Rees, who has been aided by a couple of assistants, publishes his Observations with regard to the Insectivorous Powers of *Drosera longifolia.* The observations are merely in confirmation of those previously published by Darwin.

In the *Bibliothèque Universelle*, of Geneva, De Candolle has an article on the Existence of Physiological Races in Species of Plants. He gives the results of his experiments in sowing seeds of the same species, which had been collected at Edinburgh, Moscow, Montpellier, and Palermo, and states that they in the main agree with the results obtained by Naudin and Radlkofer, previously referred to in the *Record.*

In the *Archives of Physical and Natural Sciences* of Geneva is a paper, by M. Alphonse de Candolle, entitled Feuillaison, Défeuillaison, Effeuillaison. By the first-named term the writer denotes vernation proper; by the second, the natural fall of the leaf; by the third, its removal by unnatural causes. He concludes from numerous observations that on comparing different species one cannot discover any direct or regular connection between the period of putting forth the leaves and that of the fall of the leaves. In different individuals of the same species it sometimes happens that those, as

the linden, which leaf out early, shed their leaves late, while in other species, as chestnut, ash, etc., the reverse is the case. Otto Kunze, in a series of papers issued as an appendix to the *Botanische Zeitung*, gives a very minute account of the modes adopted by different plants for protection and distribution.

And, lastly, we must mention a number of valuable papers on vegetable physiology presented by Professor Wiesner, at the sessions of the Imperial Academy at Vienna, the two most important being on the Undulating Notation of Internodes, and on the Influence of the Intensity of Light on Heliotropismus.

Herbaria, Gardens, etc.

The number of deaths during the year has been large. Sweden has lost its oldest and most celebrated botanist by the death of Professor Elias Magnus Fries, of Upsala. He may be called the father of mycology, and he was almost equally distinguished as a lichenologist. Zanardini was the oldest of Italian algologists, and Visiani the oldest phænogamic botanist of Italy. Raspail belonged rather to a former generation. Durieu de Maisonneuve, although very aged, was comparatively active. Dumortier was not only a good botanist, being a distinguished writer on *Hepaticeæ*, but also a statesman of reputation. Thomson and Kurz were well-known travellers and writers. The former accompanied Dr. (now Sir) J. D. Hooker on his Indian trip, and the latter was Curator of the Herbarium of the Botanic Garden of Calcutta.

Schwendener has been appointed professor of botany; and Eichler director of the Botanic Garden at Berlin. Schwendener is succeeded at Tübingen by Pfeffer, who is himself replaced at Basle by Vöchting. Eichler's former position at Kiel is filled by Engler, of Munich. Beccari has been made director of the Garden at Florence, the position formerly held by Parlatore. Pedicino succeeds De Notaris at Rome. De Notaris's herbarium has been purchased by the Roman government. Kerner has been made professor of botany at Vienna. Mr. Daniel Morris has been appointed Assistant-Director of the Royal Botanic Gardens, Ceylon. Dr. F. J. Kjellman has accompanied the Nordenskiöld Arctic Expedition as botanist. The Congress of Botanists, held at Paris in August, is said not to have been very successful, the attendance having been smaller than was expected.

AGRICULTURE AND RURAL ECONOMY.

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I. GENERAL CHARACTERISTICS OF RECENT PROGRESS.

UNION OF SCIENCE WITH PRACTICE IN AGRICULTURE.

In a late number of the *Journal* of the Royal Agricultural Society Dr. Voelcker says: "A characteristic feature of the last ten or fifteen years in relation to scientific agriculture is the closer approach of the man of science and the man of practice. Both appear to understand each other better. The mutual interchange of ideas, and the better acquaintance of the latter with the leading principles of chemistry, and that of the former with the rudiments of practical agriculture have materially promoted agricultural progress, and given a more decided and more widely extended direction to a rational plan of farming."

Of the results of this union of science with practice Dr. Voelcker says again: "In reviewing the progress of English agriculture since 1860, one must be struck with the powerful influence which the dissemination of sound scientific principles, the results of numerous chemico-agricultural researches, has exerted upon the various branches of practical agriculture. The improvements connected with cultivation and farm management are both numerous and important; but they chiefly spring from one source, which is in itself the most characteristic feature of the last thirty or thirty-five years, and which . . . may be described as the substitution of sound reasoning and arithmetical calculation for the empirical knowledge relied upon by our ancestors."

What Dr. Voelcker says of the present influence of science in England is likewise true on the continent of Europe, and emphatically so in this country.

STATUS AND PROGRESS OF AGRICULTURAL SCIENCE IN 1878.

In no previous time has agricultural thought been so on the alert, investigation so active, and practice so progressive as at present. Of the past year this is especially true.

Of the demand for science we have evidence in the tone of the agricultural papers, which formerly scoffed at science, but now devote columns to abstract articles on chemistry and physiology; in the interest of farmers, who demand the discussions, and even take part in them, in meetings and in print; and in the increased bestowal of money by legislatures, schools, and individuals for the endowment of experiment stations, and otherwise aiding agricultural research.

An idea of the amount of the investigation may be gathered from the fact that the *Centralblatt für Agrikulturchemie* for 1878 has culled abstracts of experiments and investigations in agricultural chemistry and allied sciences from ninety-two journals, and that the titles of these researches fill twenty-three octavo pages; while the *Jahresbericht der Agricultur-chemie* for 1877, just out, requires seven octavo pages for the names of the authors, thirty for the titles, and nearly seven hundred pages for the brief abstracts of their investigations.

The improved modes of culture, implements, and stock; the better saving of the products of the farm; the larger and more rational use of purchased fertilizers and foods; and, what is no less encouraging, the increased attention given to careful experiments by farmers—these all bear testimony to the increase and the profit of the application of science to the management of the farm.

Agricultural Science in Europe.

The bulk of the abstract agricultural research is done in Germany, where science is found as useful in farming as in war, and between one and two hundred chemists and physiologists are employed in not far from ninety experiment stations and other institutions in studying the perplexing problems of farm science. Similar work is being done in all the other European countries, except Portugal and Turkey. Accounts of some of the more interesting results are given in the following pages.

Agricultural Science in the United States

has made much more marked progress in the past year than ever before. The Connecticut Experiment Station and the Bussey Institution have published reports of high scientific as well as practical value. The North Carolina Experiment Station is actively at work. The Massachusetts Agricultural College and the New Hampshire Board of Agriculture have taken decided steps towards the establishment of experiment stations. In a number of educational institutions, notably Cornell University, the Michigan, New Hampshire, and Maine agricultural colleges, and the University of Virginia, experimental work has been active. The Vermont Agricultural College has instituted an extensive series of field experiments among the farmers of that state. A similar enterprise undertaken by the *American Agriculturist* has led a large number of farmers in various parts of the country to make experiments with fertilizers on a common plan, but under different circumstances as to soil, crop, etc. Several state departments and boards of agriculture, notably that of Georgia, have likewise induced farmers to experiment largely. The agricultural departments of Georgia and Virginia have both published reports and other documents containing valuable information and promising well for the agriculture of their states. A number of private individuals, with the rest the Sturtevant Brothers, of Framingham, Mass., have made and continued interesting experiments on the growth of corn; and, finally, Professor Collier, Chemist of the Agricultural Department at Washington, has undertaken some work in agricultural chemistry in a way that can be made very useful to the agriculture of the country.

II. THE ATMOSPHERE AS RELATED TO VEGETABLE PRODUCTION.

AGRICULTURAL METEOROLOGY.

Dr. Lorenz, in a "Proposal for a System of Meteorological Observations in Austria," classes the meteorological data which interest agriculturists in four groups:

1. A physiological group, having to do with the relations of heat, moisture, precipitation, and barometric pressure to

the functions of the elementary organs of plants and animals. These belong to physiology, and the meteorologist need not concern himself with them.

2. A physical group, which have to do with the influence of local causes—*e. g.*, the covering of the soil by vegetation, and especially by forests, upon individual climatic phenomena.

3. A prospective group, which have to do particularly with the judging and forecasting of the weather.

4. A retrospective group, the summarizing of which for long periods would throw light upon the relations of the climate to the distribution and growth of organic soil-products, and show how the laws thus discovered may be made useful in the choice and treatment of crops.

Of the physical data he says, "To make clear what is the effect of vegetative covering (forests, etc.) upon climate is one of the most important objects of present investigation," and wisely adds that this can best be done by men especially trained for such work. Not weather statisticians merely, but professional meteorologists who are also familiar with agriculture and forestry are the men from whom the best fruits of such study must come. Dr. Lorenz gives plans for meteorological observations, and results of compilations which are well worthy the study of meteorologists, though hardly in place here (*Mittheilungen aus dem förstlichen Versuchswesen Oesterreichs*, ii., 73).

ATMOSPHERIC ELECTRICITY.

Influence of Atmospheric Electricity upon the Nutrition of Plants.

We noticed last year the interesting experiments of Berthelot, which showed that under the influence of the silent electrical discharge free nitrogen of the air is taken up by various organic substances, and enters into combination with them. This, of course, bears directly upon the important question of the assimilation of nitrogen by plants. Some experiments to test the question as to the effect of atmospheric electricity on the growth of plants have been made by Grandeau. Plants of the same species and as much alike as possible were grown under identical conditions, save that one was in the open air, while the other was covered with a screen of wire-netting—a "Faraday cage"—which per-

mitted the free access of light, air, and moisture, while it protected the plant from the action of the electricity of the atmosphere. Tobacco, giant maize, and Chiddam wheat were thus grown. Grandeau concludes as follows:

"1. I consider it demonstrated that atmospheric electricity is a decidedly preponderating factor in vegetable assimilation. Plants deprived of its influence have elaborated in equal times, and under circumstances otherwise the same, from 50 to 60 per cent. less living substance than those grown in ordinary conditions.

"2. Plants slightly elevated above the soil, as grass and forage plants, are likewise influenced to a notable extent (33 per cent.) by atmospheric electricity.

"3. The percentage of protein compounds does not seem to depend upon the action of atmospheric electricity. It remains proportional to the total product in plants withdrawn from its action.

"4. Plants not exposed to the electrical action contain a less percentage of water and a greater of ash in the dry substance than others.

"5. Nitrification in the soil does not, in my experiments, seem to have been aided by the action of atmospheric electricity."

The bearing of these conclusions upon the effects of forests upon plant-growth Grandeau considers important. He also calls attention to the experiments of Mascart, which sustain his views (*Jour. d'Ag. Pratique*, 1878, ii., 44).

Influence of Electricity upon Water-Evaporation and upon Plant-Growth.

Mascart has made some interesting experiments upon the influence of electricity upon the evaporation of water. Dishes containing water or moist earth were subjected to the action of electricity from conductors connected with a Holz machine kept constantly running, while at the same time parallel series of dishes were connected with the ground. From those under the action of electricity more water was lost by evaporation than from the others. He infers that this phenomenon must be general, and that the *rôle* of electricity in nature, in generating water-vapor from water, soil, and plants, must be an important one.

III. THE SOIL AS RELATED TO VEGETABLE PRODUCTION.

One of the most marked and withal most fortunate phases of the present progress of agricultural investigation is the increased attention given to the study of the soil. The failure of the theories which a quarter of a century or more ago promised such great things from soil-analysis has been followed by a reaction, and agricultural chemistry has busied itself mostly with the laws of vegetable and animal production. The laws of plant-nourishment and growth having been more clearly learned, the need has become apparent of going back to the soil and finding how it furnishes food, what else it has to do to help crops to grow upon it, and what are the ways by which we may increase its capacities for so doing. The result is that an increasing number of investigators are directing their attention to the physics and chemistry of the soil.

PHYSICAL PROPERTIES OF THE SOIL.—AGRICULTURAL PHYSICS.

Among the best indications of the development of science are the journals devoted to its special departments. Agricultural chemistry has for some years been represented by a number of journals intended more or less exclusively for its furtherance, but covering also more or less territory outside of chemistry. With the year 1878 a new journal has appeared with the title *Forschungen auf dem Gebiete der Agrikulturphysik*, and devoted exclusively to agricultural physics, under which title, according to the prospectus, the physics of the soil, the plant, and the atmosphere . . . can properly be classed. The editor, Dr. Wollny, is one of the foremost investigators in this direction. The journal fills most admirably a very important place in the development of agricultural science.

The first number opens with an article on the Present Status of Agricultural Physics, by Dr. Liebenberg. It begins as follows: "The fact is becoming more and more generally recognized that the influence of the soil upon the life and growth of the plant is determined not only by its chemical, but no less, and perhaps even more, by its physical, characters. A result of this is that investigation has, in the last

few years particularly, busied itself more and more with the building-up of this department of the science of the soil. By such studies, in connection with a fuller understanding of its chemical composition, must the true conception of the soil as the home of plants be formed, and thus a fruitful source of information be gained to clear up the still unexplained phenomena of plant-life."

Among the most important factors for the fertility of the soil are its relations to water and to heat. These, with the texture, doubtless have as much and often a good deal more to do in deciding how much a soil will yield than the amount of plant-food it contains. As we follow the investigations by which these regulators of fertility are being found, we cannot help being impressed by their simple obedience to the lately established laws of physical science.

RELATIONS OF THE SOIL TO HEAT.

Von Liebenberg has called renewed attention to the need of more accurate study of the relations of the soil to heat. The sources of heat in the soil are the sun, the heat of the interior of the earth, and chemical processes going on within it. To understand the relations of the soil to heat it is necessary to study the factors; namely, its thermal capacity, specific heat, and its conducting, absorbing, and emitting powers. According to general physical laws, a soil will grow warm the faster in proportion as its specific heat is smaller and its conducting and absorbing powers larger. It will cool the more slowly in proportion as its specific heat is greater and its emitting and conducting powers less. A series of experiments are detailed, from which perhaps the most important conclusion is that the main factors of the capacity of the soil for heat (by weight) are its contents of humus and of water (*Forschungen auf dem Gebiete der Agrikulturphysik*, i., 3).

The Thermal Capacity of the Constituents of Soils

has been studied by Lange in a very thorough and philosophical manner. He first discusses the question from the standpoint of the mechanical theory of heat, and then describes an elaborate series of experiments, by which the conclusions are substantiated and new facts brought out. The

experiments were made by the "method of mixtures," with an apparatus consisting of an oven and a calorimeter, and ingeniously arranged for the purpose. Coarse and fine sand, powdered quartz, marble-dust, kaolin, and peat were tested. He concludes that, of the constituents of the soil, compared by weight, water affects its thermal capacity most, humus (peat) next, while the kaolin (clay) and marble (carbonate of lime) stand far below and near each other in their influence. As regards fineness and coarseness of the soil, both theoretical considerations and actual experiments led to the conclusion that the size of the particles has no influence on the specific heat (*Forschungen auf dem Gebiete der Agrikulturphysik*, i., 109).

The Propagation of Heat in the Soil.

Pott has conducted a long series of experiments on the propagation of heat in the soil by conduction, working with the chief constituents of soils—quartz, clay (kaolin), humus, and carbonate of lime. The quartz was the best, and carbonate of lime the poorest, conductor. Dense, compact soils conduct heat better than looser, coarser better than finer, and moist better than dry soils. Stones increase the conducting power. It appears, however, that the conducting power of soils for heat is not so great as has sometimes been supposed (*Landw. Vs.-St.*, xx., 273).

Haberlandt has reported some new experiments upon the relative conducting power of wet and dry soil. He concludes that (1) the conducting power is greater in wet soil than in dry; (2) at high temperatures the greater conducting power of the wet soil is more than counterbalanced by the greater evaporation; (3) the temperature at which these two factors are in equilibrium—*i. e.*, at which the soil loses as much heat by evaporation as it gains by conduction—is highest in sandy, and lowest in peaty, soils; and (4) the differences in temperature between dry and wet soil are very small, not exceeding 1.50° C. "The characterizing of moist soils as 'cold' is therefore out of the question."

Effect of Compactness and Looseness of the Soil upon its Temperature.

An elaborate and extremely interesting series of investigations on this subject has been made by Wollny. Boxes 1

meter (39.4 inches) square and 30 centimeters (11.8 inches) deep, without bottoms, were set into the ground and filled with soil of four different kinds. In parallel trials one soil of each kind was left to settle itself, while the other was compressed by pounding so as to reduce the volume by $\frac{1}{6}$ to $\frac{1}{10}$. Observations of temperature were made with corrected thermometers, graduated to tenths of a degree centigrade, in the soils, at a depth of 10 centimeters, and in air, in the shade, 1 meter above the soil. The experiments were made in August, 1875; June, 1876; June, 1877; and from April to October, 1877. In short periods in June they were made every two hours during the twenty-four. In the series from April to October they were made daily at 7 A.M., 12 M., and 5 30 P.M. Over 12,000 observations were made. In general, the compact soils were warmer by day and in warm weather, and colder by night and in cold weather, than the loose soils. The differences in temperature were, however, very slight, averaging from 0.1° to 0.9° C. The variations of temperature were greater in the compact than in the loose soils. Wollny shows that these phenomena cannot be due to differences in thermal capacity, radiation, permeability to air, or content of water, and must be ascribed to the superior conductivity of the compact soils. The heat, having less distance to pass from particle to particle, and less air to impede it, in the compact soil, would naturally leave and return to it more readily; and hence the compact soil would be the more susceptible to changes of temperature outside (*Forschungen auf dem Gebiete der Agrikulturphysik*, i., 133).

The Absorption and Emission of Heat by Soils

have also been studied by Lange, in several series of experiments. The absorption experiments were made with materials in cylinders so arranged as to prevent absorption or emission as far as possible, except from the surface, where the changes in temperature were determined by a thermometer. The emission experiments were made by aid of a thermopile. Quartz, sand, kaolin, marble, humus, and peat were used, in their natural condition and covered with lamp-black. Lange concludes that (1) the influence of color on the thermal economy of the soil is very great, the

darker coloring favoring both absorption and emission; (2) the finest material absorbs and emits best; and (3) the surface of moistened materials is warmed much more slowly than when they are dry, because of the loss of heat in evaporation of the water (*loc. cit.*, i., 379).

The Influence of the Color of Soil upon its Temperature.

This has been made the subject of an elaborate investigation by Wollny. Five series of experiments were made with sand, clay, and peat, in boxes. These materials were in one series left in their natural color; in the other four were colored, in parallel trials, white with sand, and black with Frankfort-black —these materials being spread over their surface. Observations of temperature of air and of soil, at depths of two, four, and nine inches, were made at intervals of two hours, day and night, in the months of June, August, and October. Among the conclusions are: (1) that during the warmer season the soils with dark surface were the warmer; (2) that the daily variations are larger in the darker soils; (3) that the differences in temperature (in 1) are greatest at the maximum, and very slight at the minimum daily temperature; (4) that the darker soils cool faster at night than the lighter; (5) that the differences induced by color decrease downwards in the soil and in colder weather, until they disappear; (6) and that the above phenomena are, however, altered by various circumstances, especially by the amount of humus in the soil (*loc. cit.*, i., 43).

The Influence of Plant-covering and Shade upon the Temperature of the Soil.

Wollny has also experimented at length upon this subject. He finds that (1) the temperature of the vegetative layer of the soil is materially influenced by a covering of living plants, or remains of plants—*e. g.*, straw, manure, wood, etc.; (2) soil thus covered is cooler in warm seasons, and warmer in cold, than bare soil; (3) the influence of such coverings on the soil temperature depends upon the physical peculiarities and the thickness of the shaded layer; (4) snow tends to decrease variations in soil temperature, and thus protects plants against injury; and (5) the variations of temperature in soils covered with plants, straw, manure, wood, and snow are less

than in bare soil. In soils covered with stones, the opposite is true.

MM. Becquerel have been for some time engaged in the study of soil temperature. In the report of observations for 1877, M. Ed. Becquerel shows that in accordance with previous observations a soil covered with herbage at a depth of two inches averaged through the year a little warmer than corresponding uncovered soil.

Influence of Exposure on Soil Temperature.

Wollny found, in a series of experiments near Munich, that the warmest slope was, in spring, a southwesterly; in summer, a southeasterly; in early fall, southerly; and in late fall southwesterly. Trials in beds showed, as would be expected, that the southern slope was warmest, the level surface next, the eastern and western slopes next, and the northern slope coldest.

RELATIONS OF THE SOIL TO WATER.

Mr. H. P. Armsby, Chemist to the Connecticut Agricultural Experiment Station, has prepared a valuable paper on the Present State of Knowledge Regarding the Relations of the Soil to Water, as a prelude to a series of investigations on this very important subject. In view of the results of experiments on the one hand and the action of physical laws on the other, he considers that "there are three points in regard to the relations of the soil to water which are of agricultural importance:

"1. *Permeability.*—The rapidity with which the water that falls upon the surface of the soil in the form of rain, etc., soaks downward through it.

"2. *Water-holding Power.*—The amount of water which is held in the various layers of the soil, where it may serve to nourish vegetation.

"3. *Evaporation.*—The rapidity with which water evaporates from the surface under different conditions."

Roughly summarizing the statements which are given in a good deal of detail, it may be said that the above factors are each affected by the fineness of the particles of the soil, the texture, whether loose or compact, and the porosity of its materials. Some of the more important conclusions follow.

Permeability of the Soil to Water.

In general, if the soil be saturated with water, the downward flow will be faster in coarse and loose, and slower in fine and compact soils. But when rain falls on a dry soil, after it works down to a point where interstices are filled by capillarity with water from below, the downward flow would probably be faster in the finer soil.

Water-holding Capacity of the Soil.

As regards the "absolute water capacity" of the soil—the amount it will retain and hold for the use of plants—it may be said that, in general, falling water will be held more firmly, and hydrostatic, or "bottom," water will, by capillarity, be drawn up higher in the finer and more compact than in the coarser and looser soils. Porosity of particles would tend to equalize distribution and make upper layers more moist. If we have a fine, compact soil over a loose subsoil, water falling on the top will not be drawn downward so forcibly as if the subsoil were finer and had more capillary power; that is to say, "a soil thus situated is not so well drained as if the subsoil were as fine as itself. The reason why such a soil is dryer than one on a fine subsoil is, that the water held by it soon dries out in fair weather, and the subsoil cannot raise water fast enough to supply the loss."

Evaporation of Water from the Soil.

Aside from temperature and exposure, the main factors of surface evaporation from the soil are, (1) capillarity, and (2) extent of surface exposed to evaporation. The most important factor is capillarity—that is, the rapidity with which the soil permits water to rise in it to supply a deficiency at any point, and hence to keep up a supply to be evaporated from the surface. In general, the finer the soil the greater the capillarity down to a certain smallness of grain. It is probable that the pores may be so small as to retard the motion of the water. As regards texture, close packing would, like greater fineness, tend to aid capillarity, until the pores become so small as to retard the flow.

As regards the effect of evaporating surface, it is to be

noted that in a loose soil a great deal of water may evaporate from points below the top. Commonly, the looser the soil is, the more surface will it expose to evaporation.

Effect of Loosening the Surface of the Soil upon Evaporation.

The above considerations help us to understand better why it is that, as Nessler has shown, "the general opinion that a loose soil dries faster than a compact one is not always correct. There are two processes to be distinguished: in the first place we have the evaporation from the top of the soil, and in the second place that from layers below the top. Loosening the top of the soil helps the second process by exposing more surface to the air, but it may hinder the first process by decreasing capillarity. With loose materials, like a sandy soil, cultivation, while increasing the surface, might not decrease capillarity very much, and so might increase evaporation.

"In the majority of cases, however, loosening the upper layers seems, so far as experiments have been made, to decrease the rate of evaporation by decreasing capillarity. Not only would the water be transmitted less readily by the loose portion, but it would pass with difficulty from the fine interstices below to the large ones above.

"Loosening the upper layer would seem likely to affect especially a soil composed of porous materials, or one which, like a clay, is broken up by tillage into porous fragments, by decreasing the number of points of contact."

Influence of Hoeing and Rolling the Soil.

In the article on the present status of agricultural physics, elsewhere referred to, Von Liebenberg discusses the effects of the use of the hoe and the roller upon the moisture in the soil, and concludes that "hoeing, although confined to the surface, tends to retain the moisture in the soil; rolling, to remove it—two facts which, though apparently in conflict with the ordinary assumption in practice, are, nevertheless, true. The advantages of rolling are incontestable, and the roller cannot be dispensed with, only its good effect does not depend, as is commonly held, upon its holding the water in the soil. In most cases, aside from those in which it is used to break down lumps and even-off the ground before drill-

ing, the roller is applied immediately after the seed is put in. What is accomplished by this is, that the seed is pressed tighter in the soil and brought into better contact with the soil-moisture; but, at the same time, more moisture is brought to the seed by the rolling, since the compacted soil-layer draws more water from below. That is, water is not retained in the soil by rolling, but it is brought just where it is most wanted—namely, near the seed. Further, the roller is often used after the seed is up and the plants have attained a certain height. Although here an advantage, perhaps, likewise comes from bringing up water from lower layers to the roots that are still too short to reach it, and to the just-forming root-branches, yet the main use is to press the young plant tightly in the soil and give it a firm hold there."

"Hoeing helps to hold the moisture in the soil; the looser the surface of the field is kept, the more moisture will the soil retain. We shall always hoe when the surface is crusted; for, aside from the other disadvantages the crust brings, it has the same ill-effect as rolling—it abstracts moisture from the soil."

Experiments on Evaporation of Water from the Soil.

In the report of the Connecticut Experiment Station for 1877, Professor S. W. Johnson describes some experiments undertaken to obtain more light upon this subject. Clayey loam, peat, and emery were placed in cylinders, kept constantly supplied with water at a uniform level below, and weighed daily to determine loss by evaporation. In general, the evaporation from the surface increased with the fineness of the particles. There seems to be a degree of fineness, however, at which evaporation attains its maximum, and beyond which it decreases again. These results, like those obtained by Nessler, Wagner, and Schleh, lead to the inference that evaporation is more rapid from compact than from loose soils.

PHYSICAL PROPERTIES OF CLAY SOILS.

The Properties of Clay.

Professor Johnson has also called attention to the properties of clay as shown by the investigations of Schloessing, Hilgard, and other experimenters, and late observations by him-

self. "It is highly probable that all clays contain kaolinite as the chief chemical ingredient of their clayey portion, but more or less in admixture with other hydrous aluminous silicates, and with silicates of iron as well as with alumina and iron hydrates." The clay which pure water takes up from clayey soils "is a mixture of all the very finest kinds of matter which the earth may contain, and its properties vary according to the kinds and states of that matter." The characteristic ingredient of clays, whatever it may be, (1) is so fine that much of it cannot be defined by the microscope; (2) remains for weeks and months suspended in water from which sand, silt, and rock-dust have settled out; (3) can be coagulated and precipitated out, as Schloessing has shown, by very small quantities of common salt, and still smaller proportions of salt, potash, lime, and magnesia; or, as Professor Johnson has lately noticed, by freezing. As Hilgard has shown, (4) it becomes, "on drying, a hard, often horny, mass, difficult to break, and somewhat resonant;" (5) "when dry, adheres to the tongue so tenaciously as to render separation painful; (6) but imbibes water with great energy, and swells to many times the bulk it has when dry; (7) swells less readily in presence of much iron; and, finally, (8) when moistened, can be worked into a plastic condition, and becomes "exceedingly tenacious and sticky." In brief, clay "belongs to the class of bodies designated by Graham as *colloids* (glue-like), and confers on the soil peculiar and valuable properties."

Influence of Clay in the Soil.

"When a dry clay soil is copiously rained upon, or exposed to the abundant pure water of melting snow, its 'clay' swells, assumes a gummy or clayey consistency, and, by enveloping the sand and silt grains, confers upon the whole mass its own sticky qualities. When soluble salts of the surface-soil are completely washed out of it, then the clay enters into suspension, and is carried down into the pores of the soil and clogs them up. . . . Thus it comes that clay lands are so muddy and impervious to rain in spring and autumn, and that the water they contain dries out slowly, as it does from dissolved glue, gum, or jelly. The sprinkling of the wet and sticky clay with a weak brine or with a much weaker solution of a lime-salt, either sulphate of lime (gyp-

sum or plaster) or a solution of lime in carbonated water, or the sprinkling of these salts dry on the wet surface, where they speedily dissolve, coagulates the clay as rennet curdles the casein of milk—*i. e.*, the lime-salts separate the clay atoms from the water in which they were suspended, and shrinks them together into distinct curd-like masses. Thus the clogged pores between the sand-grains are opened and channels formed which permit the clear water to run off."

Reasons for Effects of Lime and Mineral Salts on Clay Soils.

"The coagulation of clay by soluble saline matters assists in explaining some facts long, if not widely, known in agriculture. It has been found in some regions of Germany that the application of lime to clay lands is an effectual means of loosening the texture of even the stiffest soils. It is doubtless the bicarbonate of lime which acts in this case. The effect lasts for only a term of years, because the lime gradually dissolves away; and as it disappears from the surface, the clay recovers its original impervious quality. Mr. D. G. Mitchell, of Edgewood, near New Haven, has found that a soggy and nearly worthless hill-slope has become dry and valuable for pasture, mainly as the result of an application of lime. Mr. Lawes, the veteran English experimenter, informs us that the continued use of nitrate of soda for many years as a fertilizer on clay land has noticeably improved its texture and relieved its heavy quality. The often-observed good effects of spreading out stable-manure on the ground during winter in improving the texture of the soil at time of spring tillage may be due in part to the effect of the soluble salts in coagulating the clay and preventing the clogging and puddling of the soil."

CHEMICAL PROPERTIES OF THE SOIL.—SOIL-ABSORPTION.

It should, perhaps, be said, by way of preface, that the absorptive power of the soil, and its ability to hold the valuable ingredients of plant-food—ammonia, potash, lime, phosphoric acid, etc.—and not suffer them to be leached away through its lower layers into streams and lost, is one of the chief factors of its fertility. It is believed that the absorption of bases is due mainly to zeolitic silicates, hydrous silicates of

alumina with other bases, as lime, magnesia, potash, soda, etc. These "double silicates" are somewhat soluble in acids.

Absorption by Exchange of Bases.

Van Bemmelen has published a long series of investigations on soil-absorption, which throw a great deal of light on the ways in which bases replace each other and are otherwise absorbed in the soil. His work adds much strength to the opinion which is becoming prevalent, that absorption is due to chemical rather than physical processes.

The agency of the soluble (zeolitic) silicates was tested by first determining the absorptive power of soils which contained them; then extracting them by hot hydrochloric acid, and noting the loss of absorptive power; and, finally, by treating the extracted soil with alkalies and alkaline earths, by which bases were restored, and with them the lost absorptive power.

His experiments show very strikingly how absorption with change of bases is effected. When solutions of salts of alkalies or alkaline earths come in contact with the zeolitic silicates, the silica of the latter gives up some of its bases to the solution, taking bases from the solution in return. The silicates part most readily with lime, then with soda, and then magnesia, retaining potash most firmly. Conversely they absorb potash most readily, and then the others in the inverse order, showing the least affinity for lime. In general, strong acids—*e. g.*, sulphuric acid and chlorine—seem loath to give up their bases to the soil unless they get other bases in return. The zeolitic silicates are rich in bases which are easily exchanged. If a solution of chloride of potassium, for instance, be brought in contact with such silicates, the latter may give up some of their lime to the solution, and take potash from it in return; but the soil cannot get much of the potash from the salt unless it has the double silicates with their bases for the barter. This much has been understood, though not in so complete detail before. Van Bemmelen shows, in a very striking way, how one base may be driven out by a second, this latter replaced in its turn by another, or by the first, and so on.

Absorption without Exchange of Bases.

Van Bemmelen shows further how soils can absorb alkalies and alkaline earths from their solutions without giving other bases in return. This is accomplished when the bases to be absorbed are caustic, or combined with weak acids—*e. g.*, hydrates, carbonates, phosphates, and borates. The bases seem to be taken up by hydrated silica in the soil, which can easily combine with free bases. To explain how the silica gets the bases from the acids named, Van Bemmelen assumes a dissociation to take place, as set forth by Berthelot, the neutral salt being split up into acid-salt and free base, which latter goes to the silica. On this hypothesis a solution of carbonate of potash, for instance, ought to lose its potash in successive portions until half is absorbed, the other half remaining as bicarbonate. Actual experiments gave results surprisingly near the theory.

Restoration of Absorptive Power.

By boiling soils with strong hydrochloric acid, the soluble silicates would be decomposed, and more or less of their bases taken away. Van Bemmelen finds that soils thus treated lose most of their absorptive power. Conversely, it would appear that if the bases could be restored they might absorb again. It was found that such was the case. Soils thus extracted and afterwards treated with carbonate of soda were able to absorb considerable potash. The explanation is that new basic silicates were formed with soda, which latter could then be exchanged for the potash. In like manner it was found that a soil from which the bases had been extracted could absorb potash from chloride if some carbonate of lime was added.

Basic chloride of aluminum is shown to play an important part in some of these reactions also (*Landw. Vs.-St.*, xxi., 135; xxii., 295).

Absorptive Powers of Different Layers of the same Soil.

Orth, whose studies of soils are well known, and who has shown very clearly the importance of knowing about the lower layers as well as the surface, has been investigating the absorptive powers for ammonia of different layers of the

same soil, in samples taken from a large number of places. The admixture of humus in the surface-soil, the disintegration, and other circumstances were found to have great influence upon the absorption. The ploughing of a strongly absorptive clay requires care, or a diminished yield may result. In laying bare the roots of some trees near Berlin, the soil among the roots was found to have become bleached, while the surrounding soil was yellowish-brown from the presence of iron, showing that iron had been removed; 100 grams of the brown sand absorbed ammonia corresponding to 12 centigrams of nitrogen, while 100 grams of the bleached absorbed only 8.5 centigrams.

Use of Lime and Marl in Soils.

In the very interesting article on the Influence of Chemical Discoveries on the Progress of English Agriculture, from which we have already quoted, Dr. Voelcker says: "The investigations on the absorption of potash by various soils has also thrown a new light on the special use of lime and marl on poor sandy soils. Every farmer knows how essential lime is for the healthy growth of every kind of agricultural produce. On soils destitute of lime, most crops, especially green crops, are subject to disease, and consequently roots fail altogether on such land, even if it has been liberally manured with good farm-yard manure or guano. . . . The remedy for such failures, which are not at all uncommon in localities where poor sandy soils prevail, is a good dose of lime or marl, and then, and only then, farm-yard manure or guano may be applied to the greatest advantage. . . . The most liberal application of farm-yard manure of the best quality never produces so beneficial or lasting an effect on poor sandy soils as when they have been previously well marled or limed. There are some soils which swallow up manure with, so to speak, an insatiable appetite, without ever feeling the better for the manure—they are appropriately called very hungry. On all such soils much manure is wasted, or the most is not made of it if, previously to the application of farm-yard manure, guano, etc., the land has not received a good dose of lime."

Value of Lime in Poor Sandy Soils.

"My filtration experiments point out the reason why marl or lime is particularly valuable on poor sands.

"In passing a solution of sulphate of potash through a poor sandy soil, I found a weighable quantity of sulphate of ammonia in the filtrate, which was not the case when the same solution was passed through a marly soil. The power of soils to retain ammonia is generally assumed to be greater than their power of retaining potash. Here, however, an instance is presented to us in which a salt of potash, by acting on the ammoniacal combination in a soil, overcomes the supposed superior affinity for potash. Contrary to all expectation, ammonia, in combination with sulphuric acid evidently supplied by sulphate of potash, passed into the solution, while potash took its place and was retained in the soil. The sterile land used in this experiment hardly contained any lime; while the marly soil, it need hardly be said, contained it in large proportion. Lime acts beneficially on sandy soils, not merely in a direct manner, by supplying a deficient element of nutrition, but also because it preserves in the soil the more valuable fertilizing matters which, like salts of potash or ammonia, rapidly filter through sandy soils, unless a sufficient quantity of marl or lime has been previously applied to the land. By these means the bases of the more valuable saline constituents of rotten dung or of guano are retained in the land, while acids filter through it in combination with lime—a constituent which is, comparatively speaking, inexpensive" (*Jour. Ag. Soc.* xiv., 2, 1878, pp. 812, 813).

FURTHER CONCERNING CHEMISTRY OF SOILS.

Carbonic Acid in Soils.

Ebermeyer has been investigating the question of the carbonic anhydride in the air and soil of forests as compared with free air and soil of open lands. The air was tested in a wood of fir and beech, in open uncultivated soil, in a garden, and in a meadow. Samples of air from above and below the surface of the soil were taken three or four times a month, from January to August. The results show that (1) the

air in the wood was almost twice as rich in carbonic anhydride as in the open—at least in summer; (2) the wooded soil, on the contrary, had much less carbonic anhydride in summer; the meadow land, which was in good condition, having six times as much at a depth of half a meter, and five times as much at one meter as the wood-soil; (3) with increase of temperature the carbonic anhydride increased much more in meadow than in forest land; and (4) the carbonic anhydride appears to diffuse very slowly, that from soil under acacia bushes having little more than half as much as uncovered soil close by. These various results are ascribed to a difference in the temperature of the soils in summer, the greater porosity of the meadow soil, and the more intimate mixture of vegetable matter in the cultivated soil. Since the carbonic anhydride is one of the most efficient agents in disintegrating the materials of the soil, it is evident that the preparation of plant-food will go on much more slowly in wood than in cultivated ground.

Fertility of Volcanic Soils.

The cases in which chemical analysis of a soil accords with its observed fertility are not so many as to be uninteresting when they occur. Truchot has lately analyzed some volcanic rocks and soils which come from them, and with these a granite and an alluvial soil. The lava soil was the most fertile. The soil and the rock it came from were both very rich in lime, potash, and phosphoric acid. The granite soil was less fertile. Both it and the granite rock had extremely little lime and phosphoric acid, and not much potash. The alluvial soil, which was the richest, had likewise the largest percentages of these ingredients.

Analysis of Soils.

The questions to which decided and satisfactory answers are frequently given by analyses of soils may, according to Dr. Voelcker's experience, be summed up as follows:

"1. Whether or not barrenness is caused by the presence of an injurious substance, such as sulphate of iron or sulphide of iron, occasionally occurring in peaty and clayey soils?

"2. Whether soils contain common salt (land flooded by sea-water), nitrates, or other soluble salts, that are useful to

vegetation in a highly diluted state, but injurious when they occur in land too abundantly?

"3. Whether barrenness is caused by the absence or deficiency of lime, phosphoric acid, or other important elements of plant-food?

"4. Whether clays are absolutely barren and not likely to be materially improved by cultivation; or whether they contain the necessary elements of fertility in an unavailable state, and are capable of being rendered fertile by subsoiling, deep cultivation, steam-ploughing, and similar mechanical means?

"5. Whether or not clays are usefully burned, and used in that state as manure?

"6. Whether or not land will be improved by liming?

"7. Whether it is better to apply lime or marl or clay on a particular soil?

"8. Whether special manures, such as superphosphate or ammoniacal salts, can be used (of course discreetly) without permanently injuring the land; or whether the farmer should rather depend upon the liberal application of farm-yard manure that he may restore to the land all the elements of fertility removed in the crops?

"9. What kinds of artificial manures are best suited to soils of various composition?"

We may add, with due respect to Dr. Voelcker's great knowledge of the subject, that his estimate of the value of soil-analysis is fully as high as agricultural chemists generally would put it. It is to be noticed, also, that the above questions are, in Dr. Voelcker's opinion, "frequently," but not always, answered by soil-analysis.

NITRIFICATION.

"The formation of nitrates in the soil, under favorable conditions as to moisture, temperature, and aeration, is a reaction well known and much studied. It is a process of great technical importance, being the only natural source of saltpetre. It is also of the highest importance to the scientific agriculturist, nitrates being invaluable as plant-food, and their loss by drainage one of the most serious difficulties with which the farmer has to contend." The nitric acid in the soil comes from nitrogenous vegetable or animal matter

and from ammonia—both of which are oxidized in the soil—and, in small part probably, from the air. How nitrification (the oxidation of nitrogenous matters) takes place is one of the most interesting problems of agricultural chemistry.

Nitrification by Organized Ferments.

We noted last year some experiments by Schloessing and Müntz, which showed that the oxidation of nitrogen compounds may be induced by organized ferments, and that it is probably a function of a low form of vegetable life, though the experimenters were careful not to say that this is the only cause of nitrification. They further stated that this theory was regarded as probable by Pasteur as far back as in 1862.

Experiments on Nitrification by Warrington.

Desirous of testing the question more fully, Mr. R. Warrington has made some experiments at the laboratory of Messrs. Lawes and Gilbert, Rothamsted, England. One ground for the conclusions of Schloessing and Müntz was that antiseptics, which are fatal to such organisms as those supposed to induce nitrification, did actually stop it. Warrington put portions of rich, moistened garden soil into glass tubes, and forced through them air freed from ammonia. In the first case the air passed through pure; in the second it was freighted with vapor of carbolic acid; in the third, with carbon disulphide; and in the fourth, with chloroform. In the soil through which the pure air passed considerable nitric acid was formed; in the others much less—the antiseptics hindered nitrification. These results confirmed those of Schloessing and Müntz.

The next question was whether, and under what conditions, nitrification could be induced by substances supposed to contain nitrifying organisms. Very dilute solutions of ammonium chloride were put in bottles and allowed to stand some time, and showed no signs of nitrification. Two were then "seeded" with extract from a soil taken from a "fairy ring"—that is, abounding in fungoid growth which was supposed to include the organisms to whose agency nitrification was attributed. One "seeded" and one "unseeded" bottle were placed in the light; another similar pair were kept in the dark. In the seeded bottle in the light no change took

place; in that in the dark the ammonia, after some time, had entirely disappeared, and nitric acid had taken its place. In the unseeded bottles no nitric acid at all appeared. The theory would imply that the bottle in which all the ammonia had been oxidized should contain the organized ferment; if so, then this solution ought to be able to "seed" the other. The trial proved that such was actually the case. The solution which before the "seeding" had remained unaltered, afterwards showed nitric acid. The conclusions of Schloessing and Müntz were again confirmed, with the addition of the fact that darkness seemed to be essential to the nitrifying process (*Jour. Ch. Soc.*, 1878, i., 44).

Professor Storer on the Ferment Theory of Nitrification.

In the course of some experiments undertaken to test the action of certain oxidizing agents on ammonium compounds, Professor Storer has obtained a number of facts confirmatory of this theory. In a series of bottles holding various materials, three contained extract of peat, and showed evidences of nitrification, while the others did not. But when the peat had been previously boiled with hot muriatic acid, no oxidation appeared. This accords with the supposition that the treatment with hot acid had destroyed the ferment germs which the peat had harbored, and which had caused the nitrification (*Am. Jour. Sc.*, 1878, xv., 444).

Further Experiments by Schloessing and Müntz.

Since heating kills fermenting organisms, it ought to stop nitrification. In continuing their investigations, Schloessing and Müntz found that the nitrifying power of vegetable earth is destroyed by heating an hour at 100° C. = 212° Fahr.; and that earth so heated and exposed to air purified by ignition does not nitrify, but that when a little vegetable mould is added nitrification recommences. It is stopped also by boiling. When it has been stopped by heating or by chloroform, oxidation still goes on (*Comptes Rendus*, lxxxv., 1018).

What Kinds of Organisms Cause Nitrification?

Pasteur has shown that moulds and mycoderms cause oxidation of organic matter. Schloessing and Müntz, continuing their investigations, have tried the action of *Pencillium glau-*

cum, *Aspergillus niger*, *Mucor mucedo* and *racemosus*, and *Mycoderma vini* and *aceti*. These organisms were grown in media supplying ammonia or organic nitrogen. No formation of nitric acid could be detected. Instead of oxidizing nitrogen, these organisms were found to feed upon nitric acid as well as on ammonia. The consumption of nitrogen compounds by their growths tallies well with the old observation that mould in nitre beds is prejudicial to the formation of saltpetre. There is apparently no loss of nitrogen during the growth of mould until fructification commences. Rapid combustion of organic matter then takes place, and free nitrogen is evolved. At the same time ammonia may be produced. It would seem, then, that these organisms, which are recognized as active oxidizers, are not the ones that produce nitrification (*Comptes Rendus*, lxxxvi., 892).

To resume, it seems clear that the oxidation of nitrogen compounds in the soil with nitric acid is due, at least in part, to living organisms, organized ferments, but that the organisms that do this work are not the ones that cause alcoholic, acetic, and other familiar kinds of fermentation.

Agency of Metallic Oxides in the Formation of Nitrates.

Reichardt cites and repeats some experiments by Hünefeld on the capability of certain oxides to cause the oxidation of free nitrogen, and concludes that this power is possessed not only by the higher oxides of manganese, as has been previously observed, but by magnesia even in the form of the common basic carbonate. He considers this of high importance in explaining the formation of nitrates in the soil (*Jour. f. Landw.*, 1878, 167).

IV. THE PLANT.

CHEMISTRY AND VEGETABLE PHYSIOLOGY.

Though the subject of vegetable physiology belongs properly to botany, brief reference to a few of the more interesting features of plant-growth may not be out of place here.

In a lecture before the London Chemical Society, on the Chemical Aspect of Vegetable Physiology, Vines has discussed the conclusions arrived at by chemists and vegetable physiologists concerning some of the substances that compose the tissues and are found in the cells of plants, the

way they are formed, the transformations they undergo, and their significance in the economy of the plant, and in so doing gives an interesting summary of the past progress and present status of our knowledge of these subjects.

Chlorophyl and the Formation of Starch.

At the beginning of the present century, the sum total of the knowledge on this point was due to the observations of De la Hire, Priestley, Ingenhousz, Sénébier, and De Saussure, and amounted to this—that the green parts of plants exposed to sunlight decompose the carbonic acid of the air, evolve oxygen—less, however, than was in the carbonic acid—and at the same time increase in weight. Since then it has been observed by Mohl, and later by Nägeli and Cramer, that starch grains are formed in the chlorophyl corpuscles; by Sachs, that this formation of starch is dependent upon light; by Godlewsky, that it goes on only when carbonic acid is supplied; by Nobbe, that the agency of potassium is necessary to the process; and by Moll, that the carbonic acid from which the starch is formed is imbibed by the leaves, and not by the roots. In short, we know now that carbohydrates, chiefly starch, are formed in the chlorophyl grains of the leaf; that the process is dependent upon light, supply of carbonic acid, and co-operation of potassium; and that the carbonic acid probably comes from leaves alone.

It is still a question whether chlorophyl is transformed itself into starch, or is only an agent which effects the combination of carbon and carbonic acid with hydrogen and oxygen of water into starch. Sachsse favors the view that chlorophyl is first formed by union of carbonic acid with water, and then turned into starch or other carbohydrates, and gives good grounds for his belief. His latest investigations strengthen this hypothesis.

What Becomes of the Carbohydrates that are Formed in the Leaves?

The fate of the carbohydrates, the raw material of the plant, is probably as follows:

1. One portion is transformed into cellulose, and goes to form the cell-walls in growing organs. This cellulose is subsequently converted into lignine or cork, gum, and mucilage.

2. Another portion is devoted to (*a*) the nutrition of existing protoplasm, and (*b*) the formation of new protein material by combining with nitrogenous materials—*e. g.*, ammonia and nitric acid. Our knowledge on this point is still very indefinite, however.

3. A third portion probably undergoes decomposition to form coloring matters, acids, etc., and by oxidation, or otherwise, to furnish energy for the plant.

4. The remainder is stored up in seeds, stems, leaves, etc., as carbohydrates, oil, or fat.

Chemistry of the American Grape.

Professor Goessman, of the Massachusetts Agricultural College, has been for some time engaged in studies of the chemistry of the American grape, its growth, composition, and the effect of fertilizing materials upon it. The juice of the Concord grape collected on the 17th of June was watery and of a yellowish-green color; it turned purple by heating with a slight excess of ammonia or potassa, showing, as Professor Goessman says, "that the coloring matter which is characteristic of the ripe grape is already, in some concealed form, present at a very early stage of its growth."

Acids and Sugar in Grapes at Different Periods of Growth.

From a tabular statement of analyses of grapes at different periods of growth, "it will be noticed that with the middle of August began a remarkable change in the growth of the grape. The free acid became most prominent in the juice about the first week in August, sank to less than one half of its quantity towards the close of that month, and amounted at the beginning of October to one fifth only of the largest quantity noticed in August. The sugar began to increase in the juice at the time when the free acid had reached its highest amount, and when the chlorophyl began to suffer a transformation of its green color into a purple pigment; its increase was, however, in a much larger ratio than the decrease of free acid." The loss of free acid from the juice seems to be "due, in part at least, to the circumstance that the acid has partly formed insoluble acid combinations with potassa and with lime." . . . "In consideration of these observations, it seems but reasonable to conclude that Liebig's

view, which assumes a conversion of the acid of the grapes in the later stages of their growth into grape-sugar, does not agree with our present information. Dr. Neubauer, in his interesting investigations of the German grapes, came to similar conclusions. . . . The sugar increases during the last period of ripening but little, and, apparently, in part from concentration of the juice by loss of moisture. . . . The aromatic principles become more prominent at the close of the ripening process, in all probability in consequence of a reaction of the albuminoids on the grape-sugar. They consist usually of combinations of alcohols with fatty acids (compound ethers)."

Feeding Capacities of Plants.

Researches in the laboratory and experiments in the greenhouse and in the field have told us pretty definitely what are the ingredients of plant-food, and whence nearly all of them come, but we are still very much in the dark about many of the details of the ways in which plants gather their nourishment from soil and air. It is a well-attested fact, though we know as yet very little about how or why it is so, that different kinds of plants have different capacities for making use of the stores of food that soil and air contain. Clover will get plenty of nitrogen where wheat will fail for lack of it. Nitrogenous manures help clover but little, and are almost a specific for wheat; and this notwithstanding clover contains a great deal and wheat but little nitrogen. On the other hand, the growth of clover is favored remarkably by mineral and especially potassic fertilizers, while potash usually does but little good for wheat, oats, barley, and the like, except on soils whose available stock of it is very low. Phosphates are almost a specific for turnips.

More light has come upon these questions from the experiments by Messrs. Lawes and Gilbert in England than from any other source; though Ville, in France, has done a great deal by experiments, writings, and formulas for fertilizers to promote their discussion and solution. With the increasing use of artificial fertilizers, they have come to be among the most important with which the farming of to-day has to deal.

The Feeding Capacity of the Maize-Plant.

In his lately published book on "Manures," Mr. Joseph

Harris devotes ten pages to fertilizers for corn. He says that we know less about the requirements of this crop than any other we raise. The great question is its power to gather its nitrogen from soil and air, whether it is, like wheat, an exhausting or, like clover, a "renovating" crop. Mr. Lawes has lately written several letters on this same subject to prominent agriculturists in this country. He is inclined to class corn with the cereals, where it belongs botanically, but urges the need of experiments to decide the question. Ville classes corn with sugar-cane, turnips, and rutabagas. A considerable light is thrown upon the subject by the series of co-operative experiments with fertilizers made by farmers in various parts of the country, and described elsewhere.* Corn grown in ordinary soils was most benefited by phosphoric acid, next by potash, and least by nitrogen. Concerning the question of the nitrogen supply, the experiments bear quite united, though not complete, testimony. They imply that corn can get a great deal of nitrogen from natural sources, and is in this respect more nearly allied to the legumes than to the cereals.

COMPOSITION OF PLANTS.

Of the late investigations into the composition of plants, some of the most interesting in their practical bearings are those upon the nitrogen compounds. It has become customary to base the valuations of foods and the proportions for mixing them upon their percentages of albuminoids, carbohydrates, and fats. It is likewise the custom to estimate the albuminoids by multiplying the amount of nitrogen by the factor $6\frac{1}{4}$, it having been found that the albuminoids, albumen, fibrin, casein, and the like, are essentially similar in composition, and contain nitrogen in about the proportion named. The small variations from this proportion of nitrogen are commonly overlooked for the sake of uniformity. One source of error here, however, is the assumption that all the nitrogen exists as albuminoids. In the light of later research this error is becoming more and more apparent and important. Besides ammonia and nitric acid which occur in plants, there are numerous compounds classed as amides, asparagin, betain,

* See "Farm Experiments with Fertilizers," p. 560.

etc., which have a different composition from the albuminoids, and doubtless a much lower value in nutrition.

Nitrogenous Constituents of Beets, Mangolds, and Potatoes.

Schulze and Urich find beet-roots to contain, besides albumen, betain and a substance like aspargin, the quantity of amides being greater than the albuminoids. The juice of mangolds contained albuminoids, nitrates, betain, and the ammonium salts of glutamic and aspartic acids.

The same chemists found the nitrogen in potatoes to exist in part as albumen, and in part as aspargin, solanin, and other amides; 37.2 per cent. was in the form of coagulable albuminoids; about half, 56 per cent., existed in non-albuminoid forms (*Landw. Vs.-St.*, xx., 193, and xxi., 63).

Nitrogen Compounds in the Cereals.

The cereals also contain a considerable proportion of nitrogen in other forms than albuminoids. Wigner has investigated the nitrogenous constituents of wheat, barley, and oats. The meal, bran, or flour was treated with a solution of carbolic acid faintly acidulated with nitric acid, which coagulates soluble albuminoids, and, after warming, standing, and filtering, was washed with a carbolic-acid solution, dried, and the nitrogen determined. This unextracted material is assumed to contain all the true albuminoids. The author concludes that of the nitrogenous compounds of the cereals, the non-albuminoids make up from 15 to 20 per cent. of the whole. As to the nature of these non-coagulated compounds, all that can be said is that nitrates, nitrites, some alkaloid, and gluten are present.

It is interesting to note that a very large proportion of these non-coagulable materials is stored in the exterior of the grain. In fifteen samples of wheat the "true gluten" formed from 70 to 95 per cent. of the whole nitrogenous matter, while in brans from the same wheat it was from 42 to 88 per cent.

Application in Estimating Feeding Values.

What the nutritive values are of the amides and other non-albuminoid nitrogenous compounds in plants is not yet determined. They may have a value akin to gelatin, which, though it cannot take the place of albumen or fibrin in nu-

trition, yet retards their transformation, and thus saves them. At any rate, it is evident that the facts which researches like the above are bringing out may necessitate some changes in the common ways of calculating nutritive values of foods.

V. MANURES AND VEGETABLE PRODUCTION.

The ways to restore the fertility of the soil occupy more of the thought of the farmers of our older states to-day than any other subject connected with their farming. The main question concerns the sources, nature, and effects of manures. Inside this, the special subject of "commercial," "artificial," or "chemical" fertilizers attracts the most attention.

ARTIFICIAL FERTILIZERS.

Continuous Use of Chemical Manures.—Experiments of Messrs. Lawes and Gilbert.

In a paper read before the Society of Arts, in London, in December, 1877, Mr. Lawes summarized the results of some of the famous Rothamsted field experiments as follows:

"*Permanent Grass.*—The application of artificial manures alone, containing nitrogen, phosphoric acid, and potash, for twenty-two years in succession, has given an average annual crop of hay of nearly three tons per acre. Twice during the period a second crop has been cut without further manuring; and it has on each occasion yielded nearly two and a half tons more.

"*Permanent Wheat.*—In like manner, artificial manures used alone, supplying nitrogen, phosphoric acid, and potash, have given an average, over twenty-five years, of thirty-six and three-fourth bushels of dressed grain, and more than two tons of straw per acre, per annum. The produce of the present year was forty bushels of dressed grain, and two tons fourteen hundred-weight of straw. No dung has been applied to this land for thirty-eight years.

"*Root Crops.*—In 1876, the produce of roots (mangels), with artificial manure alone, containing nitrogen, phosphoric acid, and potash, was twenty-two tons eleven hundred-weight, and in the present year (1877) it has been twenty-

two tons two hundred-weight. No dung has been applied to these plots for nearly forty years.

"From these illustrations, it must be evident to you that manures supplying nitrogen, phosphoric acid, and potash will keep up the fertility of my soil, and enable it to produce crops of hay, corn, and roots, in full agricultural quantity, for very many years in succession. Nor is this result dependent on anything exceptional in the quality of my particular soil; on the contrary, I do not hesitate to give it as my opinion, that cultivated soils generally, whether in Great Britain or elsewhere, which have become impoverished by cropping, would, in a greater or less degree, be restored to fertility by the application of manure supplying, in an available condition, one or more of the three constituents nitrogen, phosphoric acid, and potash."

Experience on the Farm of Mr. Prout, in England.

In 1861, Mr. Prout bought a worn-out farm of 450 acres, in Hertfordshire, twenty miles from London, improved it by ditching, tillage, fallowing, etc., and began to raise grain, wheat and barley, with some clover, by the use of artificial fertilizers—bone-dust, mineral superphosphate, Peruvian guano, and nitrate of soda—keeping no live-stock but eight horses and one cow, and selling all the produce from the farm except what was needed to feed these animals. He uses some 6000 dollars' worth of artificial fertilizers yearly, and makes a clear annual profit of $4500. The farm has nearly doubled in value, and there are no indications that the nine years' cropping, with no return but artificial fertilizers, has in any way deteriorated the land.

Experiment in Corn-growing by the Sturtevant Brothers.

The Sturtevant brothers of South Framingham, Mass., four years ago set apart nine and a half acres of their farm for an experiment on corn-growing with chemical fertilizers. In the *Scientific Farmer* for November, 1878, they sum up their experience as follows:

"The field was in sod from 1872 to 1875, and previous to 1872 had been cropped with corn, fodder-corn, and oats, on portions. The 1874 crop of hay was scarcely half a ton per acre. Two rows, seventy-two rods long, were planted the first

year on the unmanured portion, and yielded 2.46 bushels of unmerchantable corn and 3.77 bushels merchantable, or twenty-one bushels per acre. During these four years of harvest, 1875 to 1878 inclusive, we have removed *per acre two hundred and forty-three bushels of corn and sixteen tons of stover;* and have applied per acre, in round numbers, the Stockbridge formula for two hundred and eighty bushels of corn and its corresponding amount of stover. We hence have applied the elements nitrogen, phosphoric acid, and potash, and removed in crop approximately as below:

	Nitrogen.	Phosphoric Acid.	Potash.
Have applied.....	359 lbs.	174 lbs.	432 lbs.
Have removed.....	348 "	196 "	576 "

* * * * * *

"For the four years of cropping we have been at an expense per acre as below:

Labor and manure account, 4 years, per acre.....	$221.41
Cr.	
16 tons stover, at $8 per acre.....	128.00
Total cost of 243 bushels of corn per acre.....	$93.41

Or 38.44 cents per bushel.

"In the presence of these figures, who can say that chemical farming has not been successful in this experiment?"

ARTIFICIAL FERTILIZERS IN ENGLAND.

To farmers in this country, whose success is getting to depend so largely upon the right use of artificial manures, the results of the experience of their English brethren, who are going over the same ground in advance of them, cannot fail to be of interest. From the article, by Dr. Voelcker, on the Influence of Chemical Discovery on the Progress of English Agriculture, previously referred to, we quote the following:

"The manufacture of artificial manures, more especially that of superphosphate of lime, is carried out in England at present on a very large scale, millions of pounds sterling having been embarked in this recent branch of applied manufacturing chemistry. There are in England at present probably a dozen or more manufacturers of artificial manures, each of whom produces annually from 45,000 to 50,000 tons and upwards of artificial manures, and many more mak-

ers turn out from 1000 to 20,000 tons each per annum. An idea of the magnitude of the manufacture of, and trade in, artificial manures in England can be formed from the fact that the importations into England of phosphatic minerals, bone-ash, and phosphatic guano, from all parts of the world, for use as raw materials for the manufacture of artificial manures, probably exceed 500,000 tons per annum."

Fertilizers for Root Crops.

"By far the largest quantity of all manufactured manures is used in England for root crops. There are many parts of England where turnips and swedes are grown with no other manure than mineral superphosphate, containing on an average 21 to 25 per cent. of soluble phosphate of lime [$=9\frac{1}{2}$ to $11\frac{1}{2}$ per cent. of soluble phosphoric acid], at the rate of three to four hundred-weight per acre. On cold, clay soils, in a fair agricultural condition, it has been found that three hundred-weight of such a mineral superphosphate will produce at least as heavy a crop of swedes and turnips as a manure containing, in addition to soluble phosphate of lime, ammonia or nitrogenous matter. On light land, however, the use of purely phosphatic manure cannot be relied upon for producing a good crop of roots. On such land artificial manures are seldom used alone, but usually in conjunction with half a dressing of common dung. Dissolved bones, Peruvian guano, or compound artificial manures, containing from 2 to 3 per cent. of ammonia, are greatly preferred to mineral superphosphate as a manure for root crops on light land and on loamy soils out of condition.

"Nitrate of soda has also been used of late years in England with considerable advantage, in addition to dissolved bones, or a mixture of superphosphate and guano, and some salt, as a manure for mangolds. A dressing of one and a half hundred-weight of nitrate of soda, three hundred-weight of Peruvian guano, two hundred-weight of superphosphate, and two hundred-weight of salt per acre is considered a somewhat heavy but well-paying manure for mangel-wurzel."

Fertilizers for Grain Crops.—Guano and Nitrate of Soda.

"Both raw and dissolved Peruvian guano are largely used by the farmers of Great Britain. Of late the consumption

of nitrate of soda has been very much increased, and many farmers now use it as a top-dressing for wheat and barley. For the latter crop it is usually employed in conjunction with superphosphate of lime, two to three hundred-weight of superphosphate and one and a half to two hundred-weight of nitrate of soda being considered a good dressing per acre."

Manures for Permanent Pasture.

Of the relative merits of artificial and farm manures for permanent pasture, Dr. Voelcker says:

"Unfortunately, the application of artificial manures to permanent pastures is often disappointing in an economical point of view. As a rule, no artificial manuring mixture gives so favorable a return as good farm-yard manure, or the manure produced by the consumption of cake, more particularly decorticated cotton-cake, on the pasture. In many cases the most profitable way to improve permanent pasture is to feed off the grass, giving from three to four hundred-weight of decorticated cotton-cake per head of cattle; and, on the whole, those farmers who apply farm-yard manure liberally to pasture-land, and grow their roots and cereal crops with artificial manures, derive more advantage from this practice than others who apply artificial manures to pasture-land, and common dung to cereal and root crops."

Potash Salts.

"Potash salts are not much used in England for manuring purposes. Experience has shown that on the great majority of soils, in fairly good agricultural condition, the addition of potash salts to other manures produces no decidedly beneficial effect upon the crops to which it is applied. On poor, sandy land, and on worn-out pastures and peaty soils, however, potash salts, in conjunction with dissolved bones or superphosphate, or a mixture of superphosphate and guano, have been used in England, as in other countries, with marked beneficial effect. In artificial manures for potatoes the admixture of potash salts to phosphatic and nitrogenous fertilizing matters has also been found useful."

Common Salt.

"Common salt is used in England principally as an addi-

tion to manures for mangolds, and, mixed in equal proportions with nitrate of soda, as a top-dressing for spring wheat or barley. It is also useful on light land in dry seasons."

Application of Farm-yard Manure.

"In accordance with the teachings of modern chemistry, the most advanced farmers in England apply to the land farm-yard manure, fresh from the stables or cattle-sheds, if possible, in autumn or winter. The manure then has ample time to become rotten, and by degrees the nitrogenous constituents of the manure are transformed into nitrates, of which there will be a ready supply in spring when vegetation makes a fresh start."

This method, also in use among farmers on the Continent, would, perhaps, apply better to their warm, mild climate than to the longer and colder winters of our Northern States.

FARM EXPERIMENTS WITH FERTILIZERS.

Following the suggestions of the leading agricultural chemists in Europe and in this country, and the example set the year before by the Connecticut Experiment Station, the *American Agriculturist* proposed to its readers last season a series of experiments, and arranged to provide them with samples of fertilizers, for the purpose, of tested quality, at prices just covering the cost. The Vermont Agricultural College distributed a number of the sets among the farmers of that state; the Maine Agricultural College made several series of experiments with them; representatives of agricultural societies and prominent farmers in various parts of the country joined in the enterprise; and the parties who put up the fertilizers introduced them among their customers; so that the experiments were made from Canada to Florida, and from Maine to Wisconsin. With each lot were sent explanations and directions, and blanks for reports, with places for a number of pages of details as to soil, tillage, manuring, weather, produce, etc., which any who might choose were requested to fill and return. Some sixty of these reports were sent in. They show a very high degree of care and thoroughness in the experimental work; form a valuable contribution to our knowledge of the ways in which plants get

their food and fertilizers affect their growth; and, as an exhibition of what intelligent farmers can do to get the knowledge they need to improve their farming, are very interesting indeed.

The following statements, condensed from a full account in the "Report of the Connecticut Board of Agriculture for 1878," may be in place here:

Experiments were proposed (1) for testing the deficiencies of soils and the action of manures, and (2) for obtaining more general information. The three ingredients of plant-food most important in fertilizers, because most often deficient in the soil—nitrogen, phosphoric acid, and potash—were used, each by itself, two by two, and all three together. The nitrogen was supplied by nitrate of soda at the rate of 150 to 200 pounds per acre; the phosphoric acid by superphosphate from dissolved bone-black, 300 pounds per acre; the potash by German "muriate," 150 to 200 pounds per acre. Parallel trials were made with other fertilizers, including farm manures.

Effects of the Different Fertilizing Materials.—Artificial vs. Farm Fertilizers.

The nitrate of soda alone and combined with the other materials frequently brought profitable returns with potatoes, but seldom paid for itself in the increase of corn. With potash salts the increase of corn was often, and that of potatoes generally, enough to bring a profit. The superphosphate gave paying returns in the majority of cases on all the crops. As would be expected, the "complete fertilizer," containing all three ingredients, brought the largest crops, excelling the farm manures, whose composition and amounts were, however, variable and indefinite. Twenty-seven experiments with corn, on soils, good, bad, and indifferent, though mostly poor, and in all varieties of climate and season, gave an average of 48.6 bushels per acre of shelled corn with the complete fertilizer, against 45.9 bushels with farm manures. Nine experiments with potatoes gave an average of 177 bushels with the chemicals and 133 with the manure. The products with chemicals excelled those with farm manures not only in quantity, but in quality as well.

The Differences in Soils,

as shown by the experiments, are, of course, very wide. In some cases every plot which had superphosphate gave a good yield; while every one without it failed, the crop rising and falling with the phosphoric acid, and paying very little attention to the other ingredients. In other cases the effect of the potash salts was equally marked, the crops repaying the cost tenfold, and failing every time without them. In still others, all the materials evidently increased the crops enough to make them profitable; while in yet others none of the manures produced any marked effect. Among the important

Principles Respecting the Deficiencies of Soils

and the action of fertilizers upon them, which the experiments illustrate, are: (1) soils vary widely in their capacities for supplying crops with food, and consequently in their demands for fertilizers; (2) some soils will bring good returns for the fertilizers given them. Others, without previous amendment, by tillage, draining, irrigation, use of lime, or otherwise, will not; (3) the only way to find what a soil wants is to study it by careful observation and experiments.

Effects of the Fertilizers on Corn.

Phosphoric Acid.—In eight experiments phosphoric acid was decidedly the regulating ingredient, the crops responding uniformly to the superphosphate and paying comparatively little attention to the other materials. In fourteen experiments it took a relatively less important, but still prominent, place. In six it produced little or no effect, the average increase with it being less than 4 bushels per acre.

Potash.—In four experiments potash was decidedly the regulating ingredient. In fourteen, the potash salts were more or less efficient. In ten, the increase with them was less than 4 bushels per acre.

Nitrogen.—In no experiment was nitrogen the regulating ingredient. In sixteen, the effect of the nitrate of soda was more or less marked. In ten, the increase fell short of 4 bushels per acre.

In a special series of experiments a mixture of superphosphate and potash salts, furnishing 48 pounds of phosphoric

acid and 75 pounds of potash per acre, was taken as a basis, and nitrogen added in different proportions and combinations. The amounts of phosphoric acid and potash were about such as occur in a crop of 50 to 56 bushels of corn with stover. The nitrogen was given in successive portions of 24, 48, and 72 pounds, or one third, two thirds, and the full amount in the same crop. Duplicate trials were made with nitrogen, in nitrate of soda, in sulphate of ammonia, in dried blood, in a mixture of all three, and in Peruvian guano. Estimating the fertilizers at market prices, plus $5 per ton for freight and applying, and a bushel of corn with its stover to contain $1\frac{1}{3}$ pounds of nitrogen, and to be worth 80 cents, the effects of the nitrogenous fertilizers in these and in the previous experiments may be summarized as follows:

With nitrogen.		In number of trials	The average increase was	The nitrogen paid for itself in trials	The nitrogen failed to pay for itself in trials	The average loss was
Pounds.	Amount contained in corn crop of					
24	18 bush.	29	5.9 bush.	8	21	$0.90
48	36 "	15	7.6 "	1	14	$4.45
72	54 "	9	9.3 "	0	9	$8.51

The nitrogenous fertilizers gave paying returns in nine trials out of fifty-three. The loss was larger or smaller in proportion as more or less nitrogen was used.

As regards the action of the different compounds of nitrogen, the Peruvian guano brought the largest increase; the mixture of nitrate of soda, sulphate of ammonia, and dried blood next; then followed in order nitrate of soda, sulphate of ammonia, and dried blood, which was worst of all. The Peruvian guano appears at a somewhat unfair advantage, however, because it had rather more phosphoric acid than the mixtures in which other forms of nitrogen were used. On the whole, the results of these field trials by farmers imply that superphosphate and potash salts, or these with Peruvian guano, are as profitable fertilizers as farmers can buy for corn.

VI. THE NUTRITION OF DOMESTIC ANIMALS.

Investigations on the feeding of domestic animals during the year has been continued with unabated activity, but has

brought comparatively little that is new in principle or of special popular interest. The German experiment stations, where the bulk of the most accurate work is done, are occupied mainly in pushing the inquiries referred to in previous reports. In this country the analysis of foods and experimental tests and application of the later theories of feeding are among the most interesting topics we have to note.

FEEDING EXPERIMENTS.

Digestion of Foods by the Horse.

In continuation of the experiments by Wolff and associates at Hohenheim, on the digestion of foods by the horse, reported last year, an ingenious apparatus has been constructed by which the animal can be kept regularly at work, and the amount regulated at will and accurately measured. Thus far the digestion of the foods has not been materially affected by the amount of work done. As was found in previous experiments, the horse digested less from hay than sheep did. It was further noticed that the decrease in digestion which comes with decrease in the amount of nitrogen in the hay was greater in the horse than in the sheep. The experiments indicate that the horse digests somewhat less from coarse foods—hay, straw, and the like—than sheep; but about as much from concentrated foods—grain, etc.—as other domestic animals.

Source of Muscular Force.

In the experiments of Wolff above referred to, it was found that as the muscular exertion of the horse increased, the secretion of nitrogen in the urea increased also, thus implying a greater consumption of muscle—an observation contrary to those of Voit, Pettenkofer, Fick and Wislicenus, and others. Steps have been taken to verify the experiment. It is noticeable, by the way, that though the source of muscular force, whether from consumption of the nitrogenous or the carbonaceous tissues and food ingredients, is far from being settled, yet, of late, numerous chemists and physiologists are inclined to ascribe it to the nitrogenous materials.

Experiments at the New Hampshire Agricultural College.

One of the first experimenters in this country to test the theories of feeding based upon the late German experiments was Mr. J. W. Sanborn, Farm Superintendent of the New Hampshire Agricultural College. During a period of four years he has been feeding rations of poor hay, straw, cornstalks, etc., which lack albuminoids and fats, with oil-cake and other materials which supply them. His experiments substantiate the view that such mixtures of poor and rich foods serve just as good a purpose as the best hay, and at considerably less cost.

FEEDING STUFFS.—DIGESTIBILITY, VALUE, AND USE.

Digestibility of Green and Dry Fodder.

Weiske and associates have tested the digestion of green and dried esparcet by sheep. They conclude that the food does not become less digestible in the simple process of drying; but that in ordinary practice the hay is less digestible and less valuable than the green fodder, because more or less of the richest portions—leaves, etc.—are lost in curing and housing. This is quite in accordance with the results obtained by Wolff, Kühn, and other experimenters.

They also conclude that the water in green foods does not increase the transformation of albuminoids in the animal body; whereas, as is well known, water, consumed by itself, does increase the consumption of albuminoids, and is, in so far, productive of waste in the animal economy.

Maize vs. Oats for Horses.

The Omnibus Company of Paris, which employs ten thousand horses, has been making some experiments, extending over two years, with the view of partially substituting maize for oats in its system of feeding, which allowed 19 pounds of oats per horse each day. The experiments were first made with a limited number of horses, and were so successful that the new system was finally extended to the whole, thus producing a saving of nearly half a million francs a year. It was ascertained that 11 pounds of oats and 7 pounds of maize were safe proportions for the new feed of grain. The horses showed

no falling-off in the way of work, but displayed less energy and fire. Any tendency to indigestion from the use of the maize is cured by adding sea-salt to the feed. The results thus obtained are confirmed by the experiments of the Cab Company. This company has also substituted maize for oats, with a total saving per year of over one million francs, the animals showing no decrease of vigor or power of endurance. At present the rations of the horses are prepared according to chemical analysis, the feed of oats being diminished from 16 to 2 pounds by augmenting, in proportion, the beans and maize, the latter double the ratio of the former.

Ensilage.

The preservation of green fodder by "ensilage" is receiving increased attention not only in France and other countries where it has for some time been practised, but of late in this country also. Ensilage consists in covering green fodder with a layer of straw and earth either in pits below or in mounds above the surface of the ground. In this covered mass fermentation goes on, and certain chemical changes take place, which M. Grandeau states to be as follows:

1. The sugar already formed in the plant ferments and produces alcohol and a certain amount of acids.

2. The starch and lignin are partially transformed into sugar under the influence of the acids formed, the amount of such changes depending upon the length of time the fodder remains covered.

3. The nitrogenous and fatty materials become condensed on account of the destruction of non-nitrogenous matters. In this way the relative amount of nutritive nitrogenous substances is increased. This process of curing can be applied to corn fodder, turnip-tops, cabbage-leaves, and to frozen or diseased roots.

M. Goffart has experimented largely with ensilage, and the result is that he cures all his hay and green fodder by fermentation. He finds the advantages of so doing to be these:

1. The fodder, no matter when gathered or in what condition, can be successfully preserved. Frozen maize can be kept in good condition by such treatment.

2. The fermented maize was found to be more tender than that treated in the usual way.

3. It increases the relative amount of assimilated nitrogenous materials. Direct experiments in feeding corroborated the truth of this statement.

4. M. Goffart finds himself able to keep more stock, and to fatten them more quickly than when using the old methods of curing fodder.

Corn Fodder and Ensilage.

M. Lecouteux has written much upon the subject, especially with reference to the application of the process to corn fodder. His reasons for the growing of corn fodder to be treated in this way are as follows:

1. Corn fodder gives a larger yield per acre than any other crop.

2. This yield permits the keeping of more cattle, by enabling a large territory to be devoted to grazing.

3. Corn is less exacting upon the mineral elements of the soil than other plants that produce less.

4. Corn gives a quick return for capital expended, being a powerful grower, and producing vegetable matter rapidly.

The reasons for "ensilage" are:

1. Green-corn fodder has heretofore been in use only two or three months in the year. By this process it can be had at any time.

2. The corn undergoes a change that renders it a more rational fodder.

MISCELLANEOUS.

Among the many other topics of interest we note the following:

DAIRYING.

Here again, as in the feeding of stock, we have to report a good deal of investigation and enlarging of former results, but little that is novel in the science, or the practice, of dairying. Among the promoters of the science in this country Professor Caldwell, of Cornell University, may be especially mentioned.

The discussions of dairy matters in the agricultural journals and meetings have been very active, and the improvements in practice among dairymen rapid and gratifying. The International Dairy Fair in New York in December, 1878,

though hardly "international," was still a success, and doubtless did much to promote the interests of dairying in general, and, with the rest, the improvement in butter- and cheese-making which is needed to promote their profitable export to Europe.

THE SUGAR-BEET INDUSTRY.

The Sugar-Beet Enterprise in Maine.

The *American Cultivator*, noticing the success of the first attempt at the production of beet-sugar in Maine, where, as will be remembered, it has received pecuniary support from the State, says: "It has remained for a few enterprising pioneers in the beet-sugar industry in Maine, headed by that indefatigable beet-sugar maker Ernest Thomas Gennert, to achieve a most decided success during the past season in the Pine-tree State. Sugar-beets have been raised in Maine, some individual cultivators having produced fifteen, and even twenty, tons to the acre; they have been found to average in saccharine matter higher than beets grown in Germany or France. Practical and efficient machinery has been erected at moderate cost, and first-quality granulated sugar has been produced from these beets, demonstrating beyond a question that sugar-beet raising may be made a remunerative occupation for many New England farmers, and that beet-sugar refineries may be made paying investments in this section of the country if under skilful management. No difficulty presented itself that has not been surmounted, no drawback occurred that may not be easily overcome. Within the brief period of about six months Mr. Gennert has shown the world that he could buy sugar-beet seed in Germany in the spring, ship it to the State of Maine, stimulate the raising of beets, establish a refinery, and astonish the people of New England with the finest sugar of home production refined in November of the same year."

According to the *Maine State Press*, the works of the Maine Beet-sugar Company had on October 30 turned out 94,000 pounds of granulated sugar. The large value of the pulp for cattle-feeding adds to the prospect of success in the Eastern States.

The Sugar-Beet in Virginia and North Carolina.

Professor Page, of the University of Virginia, reports experiments on the growth of the sugar-beet. "The poorest lands, treated with about four hundred pounds of superphosphate of lime per acre have produced beets richest in sugar, and imported seeds have given beets richer in sugar than the native." The sugar in the crops of 1878 varied from 9.3 to 13.6 per cent.

Dr. Ledoux, director of the experiment station at Chapel Hill, N. C., in a report of 50 pages, summarizes the history of the sugar-beet industry in this country, gives results of experience in Europe, and reports results of a large number of experiments on the growing of the beets in North Carolina in 1878. Of the samples grown in different parts of the state, five gave from 10.2 to 11.5 per cent. "Of the remaining sixteen lots, more than three fourths go over 5 per cent.—by no means a very bad showing."

THE DISPOSAL OF THE SEWAGE OF CITIES.

Experience in England.

Dr. Voelcker sums up the results of experience in the disposal of sewage in England as follows:

"1. In my judgment, the most economical plan to dispose of town-sewage is to carry it, if possible, bodily far enough into the open sea to destroy any chance of its being brought back again by the tide.

"2. When sewage cannot be taken out into the sea, and land fit for downward intermittent filtration can be acquired, the sewage, partially clarified by subsidence, may be dealt with partly in the way of ordinary irrigation, with a view of realizing a profit in growing Italian rye-grass and other crops, and partly by way of concentrated or downward intermittent filtration, with a view of getting rid of the excess of sewage for which the sewage farmers cannot find a profitable use.

"3. When such land cannot be procured, recourse should be had to the purification of sewage by chemical precipitating agents.

"4. Town-sewage, in my opinion, far from being a valu-

able agricultural commodity, is a nuisance which can only in exceptional cases be turned to profitable account. It cannot, therefore, be reasonably expected that the agriculturist should have to pay the costs which the disposal of sewage entails, and which ought to be defrayed by the rate-payers, who enjoy the luxury and comfort of a system of water-closets and thorough town-drainage."

The Sewage of Paris.

The sewage of Paris (which includes only part of the refuse of water-closets, that from many houses being taken to cesspools and carted off), amounting to some 73,000,000 gallons daily, is taken from the city sewers to Asniers, in the suburbs, where about one third is now used for irrigation, and the rest let into the Seine. The irrigation by this means of some thousand acres on the peninsula of Gennevilliers is the beginning of an attempt, thus far very successful, to prevent the pollution of the river and utilize the material for agriculture. The water is pumped up some twenty to thirty feet, and carried, by gravity, over the land, the distribution being accomplished by ditches. The water is completely purified. Garden crops are raised of great size and the best quality in the market. The rent of the lands supplied with sewage has increased fourfold. The expense of the enterprise was borne by the city. Sanitarians and agriculturists are alike gratified with the outcome.

ENGINEERING.

By WILLIAM H. WAHL, Ph.D.,

PHILADELPHIA, PA.

THE JETTY WORKS AT THE SOUTH PASS OF THE MISSISSIPPI,

from all that can be reliably ascertained, do not appear to have effected much, if any, improvement in the condition of the channel, by reason of the work done in 1878, over that of 1877. This will appear from the following tabulation of the surveys of the government engineer appointed to inspect the work, and whose reports we present from the 28th of July, 1877—when the jetty work was sufficiently advanced to manifest a decided improvement in the navigability of the channel—to the 13th of July, 1878, since which time no reports have appeared, the epidemic of yellow fever presumably having forced the temporary suspension of the work.

REPORTS OF GOVERNMENT ENGINEER CAPT. M. R. BROWN FROM THE JETTIES.

Date.	Depth at Flood Tide.	Depth at Low Tide.	Width at Bottom.
July 28, 1877,	20.00 feet.	Not reported.	146 feet.
Sept. 28, "	20.00 "	20.50 feet.	230 "
Oct. 31, "	20.00 "	19.50 "	210 "
Dec. 31, "	21.30 "	19.70 "	212 "
Feb. 3, 1878,	22.00 "	21.10 "	190 "
March 4, "	22.70 "	Not reported.	110 "
May 23, "	22.30 "	" "	Not reported.
June 3, "	22.20 "	21.40 feet.	100 feet.
June 19, "	22.00 "	21.40 "	160 "
July 2, "	21.90 "	21.30 "	150 "
July 15, "	22.00 "	21.20 "	150 "
Head of Passes.			
June 4, 1878,	22.90 feet.	23.40 feet.	Not reported.
July 13, "	21.70 "	21.90 "	Not reported.

The jetties have now been completed, and their permanent effects in scouring a channel will not long be a matter of

doubt. Before another year we shall doubtless be able to record the success or failure of the experiment which Captain Eads has pushed forward with such admirable perseverance and energy. The act of Congress relating to this work, it will be remembered, provided that the same should be undertaken at the risk of the contractor; and that payments should be made of specified sums in instalments as rapidly as a channel of specified depth and width should be obtained—the completion of the work being based on the obtaining of a channel thirty feet in depth and two hundred feet in width, for maintaining which permanently a specified yearly payment is also provided for.

THE SUTRO TUNNEL,

the approaching completion of which we noted in last year's *Record*, together with a brief outline of the character and magnitude of the work, reached the Comstock Mines during the past year, connection with the 1650-foot level of the Savage Mine having been effected on the night of July 8, 1878. Much remains to be done before the objects of its projectors will be in condition to be realized; but its beneficial effects in improving the drainage and ventilation of the deep workings, and in reducing their temperature, which have been very serious and expensive drawbacks to the profitable exploitation of the Comstock Mines, are said to be already very plainly manifest. It will no doubt soon be settled in what way it can be made most useful, and whether the advantages gained by draining, ventilating, and cooling the deep workings will or will not be seriously impaired by choking it with trains of cars, as it is thought will be the case, if the ores are to be taken through the tunnel to be concentrated and reduced at Carson, where the mouth of the tunnel is located, and to which place the Tunnel Company contemplate the removal of most of the mining and milling operations now carried on at Virginia City. Under any circumstances, however, the value of the tunnel is conceded on all hands; and the editor of the *Engineering and Mining Journal* even affirms that "there can be no doubt, that in one way or another, it will be the salvation of the deep workings on the Comstock lode."

THE INTEROCEANIC CANAL.

The interest which the subject of the canalling of the American Isthmus has lately excited in France, and to which we referred in brief in our *Record* of 1877, appears to have culminated during the past year in the formal ratification of a contract between the government of the United States of Columbia and the International Committee for the Construction of a Canal across the Isthmus of Darien. This appears to be in keeping with all precedent upon this subject—first a survey, then the location of a "favorable" route, then some enthusiasm, followed by the ratification of a treaty with unlimited concessions, then some more enthusiasm, and nothing more.

The contract above referred to specifies that the canal shall be completely neutral and open to the commerce of the world, and that it shall be completed before the year 1895. The concessions embrace the free use of all building materials on the Isthmus, the grant of a strip of land two hundred yards wide on both sides of the projected line, and the right to select, at pleasure, one million acres of land in addition to the foregoing grant. The details of the project that have as yet appeared are, in the main, the same as published in last year's *Record*—the line favored by the present projectors being that located by Lieutenant Wyse of the French Navy, starting on the Atlantic side from the Point of Gande, along the Tupisa and Tiati valleys, to the river Tuyra, close to where it discharges into the Gulf of San Miguel, on the Pacific side. The total length of this line would be about seventy miles. Another and shorter route was located by the Wyse party, as would appear from the proceedings of the late meeting of the International Congress of Commercial Geography, held at the Trocadero Palace in Paris, of which no details have been published, save that its entire length would not exceed 50 kilometers (31.05 miles). Both of these routes, it is further stated, will require tunnels of 14 and 7 kilometers (4.34 and 8.68 miles) respectively. It would appear to be probable that this last route is not far from being identical with that from the Gulf of San Blas (on the Atlantic) to the mouth of the Bayano (on the Pacific), which has been steadily urged by the veteran engineer Traut-

wine as being one of the shortest (about thirty-five miles) and most practicable.

From what we can glean of the presentation of the subject at the Congress, M. de Lesseps estimated that the cost of either of these lines would not exceed $100,000,000—about the cost of the Suez Canal. (Lesseps is reported as saying that the expense of the American canal would be something like 300,000,000 francs; but that a capital of 500,000,000 francs would amply cover all expenses.) This estimate, it would seem, is, to some extent, based upon the experience gained at Suez; but the engineering and climatic difficulties to be encountered in cutting across the American Isthmus are so much greater than those encountered at Suez, and the elements of uncertainty as to possible cost so numerous, that the estimate of $300,000,000 named in our last *Record*, by a most careful and experienced engineer, will doubtless be much nearer the truth.

In view of the difficulties and uncertainties that surround this important problem, and of the fact that even with the most sanguine estimates of its utility fully realized, it would scarcely be possible that it should give its undertakers any return for the enormous expenditures which its construction and maintenance would involve, it does not appear to be within the range of probability that it will ever be undertaken by private enterprise; and among those who have given the subject the most attention, the opinion grows stronger with every year that the American canal must be built—if at all—by the great commercial nations of the world, as a work of international character.

A RAILWAY ACROSS NEWFOUNDLAND,

a long-mooted project, has again been revived by an act of the local authorities, proposing to grant an annual subsidy of £24,000 to any company that shall construct and maintain such a line, in addition to which liberal concessions of crown lands are to be granted. The chief arguments used by the advocates of this scheme are, that the construction of such a road as the one proposed would open up immense deposits of useful minerals, great pine and spruce forests, and vast tracts of land capable of yielding abundant harvests of cereals; and that it would bring America and Eu-

rope about one thousand miles nearer, and shorten the ocean voyage by this distance, by rendering possible the establishment of a steamship line from St. Johns, having direct railway connection with New York and other centres of traffic in the United States.

THE CAPE COD SHIP-CANAL

project, so long mooted, was ably advocated during the past year by Mr. Clemens Herschel, of Boston. He pointed out that, while for purposes of commerce the building of the Hoosac Tunnel had materially aided the city in question by enabling it to compete with New York and Philadelphia for the Western trade, so far as ocean outlet is concerned, it still remained landlocked, save due eastwards, where passage to Liverpool is unblocked. To overcome these natural obstacles the proposal is made to make a short-cut ship-canal from deep-water at Barnstable Bay to deep-water at Buzzard's Bay. The line of canal proposed is seven and a half miles through a low valley, the soil of which is described as "a diluvium of sand and gravel, with some boulders." At the narrowest point the valley is two hundred and twenty yards wide, and an average depth of eighteen feet at mean low-water would require but thirty-five feet of easy cutting. Mr. Herschel's plan contemplates a canal twenty feet below sea-level at the southern, and twenty-two and a half feet at the northern end, giving at high-water twenty-two feet at the southern and twenty-seven at the northern. The width on bottom would be sixty feet, with side slope of one and a quarter, giving a surface width of one hundred and eleven to one hundred and thirty-four feet. Buzzard's Bay has a natural harbor, but a small auxiliary harbor will be required at Barnstable. Part of the Old Colony Railroad must be re-located; there must be a drawbridge for the railroad and highway, and one ferry each at North and West Sandwich. The total estimates for this work figure up to $1,984,900. Mr. Herschel advocates a free channel with natural current, and he forcibly points out the inconveniences and dangers of the present roundabout route.

DELAWARE AND MARYLAND SHIP-CANAL.

In pursuance of an act of the last Congress, appropriating

$15,000 for the survey of a route for a ship-canal to connect Baltimore with the ocean, Major Hutton, Chief of Maryland Division of United States Engineers, has been actively engaged in examining the several routes that appear to be available for that purpose. Three routes are spoken of. One would use the Choptank River (some fifty miles from Baltimore) as far as what is known as Indian Creek, thence directly across to the northwest fork of the Nanticoke, and thence in a straight line to Broadkiln Creek, some three miles above the breakwater. This line will be about forty miles in length. A second route proposes to strike the St. Michael River (about forty miles from Baltimore) at Royal Oak, from there to the Choptank to a point above Lord's Landing, thence to Cabin Creek, from which the line will be carried directly to the Broadkiln on the Delaware. Another route is from the Sassefras River (thirty-five miles from Baltimore) across to Deep Water Point, making use of Blackbird Creek. From what can be learned, however, the most desirable seems to be the Chester River route, which runs from Baltimore to Queenstown (twenty-eight miles), and then directly to the Broadkiln on the Delaware, a distance of fifty-five miles. For this improvement the following advantages are claimed, viz.: by connecting the Chesapeake and Delaware bays it will shorten the distance from Baltimore to the ocean by about two hundred miles; and, furthermore, the commerce of that city would be materially benefited. The city of Baltimore was authorized by the Legislature of Maryland at its last session to appropriate $500,000 towards the completion of the canal, which, with the assistance of Congress, is expected to be shortly realized.

A canal across the peninsula of Matanzas Inlet on the Atlantic to Fort Wood or Clay Landing on the Suwanee River in Florida is projected. It would require about seventy-five miles of canal, but would have an excellent harbor on both sides, with no obstructions. It would, it is said, reclaim at least 1,000,000 acres of fertile land, and would shorten the route between New York and New Orleans by about one thousand or twelve hundred miles, saving about two thousand miles on the round trip.

THE IMPROVEMENT OF CHARLESTON HARBOR,

it is reported, is shortly to be undertaken by the government. The plan approved is said to be the same in principle with that now being employed at the mouth of the Mississippi. The bar, at the entrance of the harbor, and jetties are to be constructed which shall confine the volume of water now spread over a wide area to a channel of half a mile in width. The outflow between the projected jetty-heads, which would have a largely increased velocity, is looked to to scour out a channel of from twenty-one to twenty-four feet depth at mean low-water; the present depth is only about ten or twelve feet. The carrying-out of this improvement will, "it is confidently believed, make Charleston harbor one of the best on the coast."

IMPROVEMENTS ON THE KANAWHA.

Large benefits are expected to result from the completion of the improvements of the navigation of the Kanawha River, which have been for some time in progress under government auspices. From the Ohio River to Connelton (a distance of eighty-five miles) slack-water navigation will be provided for by ten locks and dams, which are being substantially constructed of hewn stone, at a cost of about $250,000 for each dam with lock.

HIGH-LEVEL STREET-RAILWAYS OF NEW YORK.

The last year witnessed the practical completion of the several lines of elevated street-railways, which have been so long contemplated and discussed as a means of solving the problem of rapid transit. There are now in regular operation two lines of elevated railway, forming four continuous iron bridges running lengthwise of Manhattan Island—two on the east side and two on the west—and which, on the completion of the numerous branches in contemplation, will have an aggregate length of about forty miles. Tasteful station-houses are located at convenient distances apart along the routes; and trains are run in both directions at intervals of a few minutes. The utility of the lines in performing the work for which they were intended is universally admitted; but serious complaints are made of the noise, the obstruction of

the streets, the cutting-off of the light to the lower stories of the buildings along certain parts of the lines, the annoyance of flying sparks and cinders, and other minor evils. The chief objection, however, appears to be the noise of the passing trains, which, it is anticipated, may be materially diminished by the interposition of mechanical devices for the purpose.

A line of elevated railway for the facilitation of the freight business of the Pennsylvania Railroad has been proposed by the company on Market Street, Philadelphia, to connect their depot in West Philadelphia with the freight depot at Sixteenth Street; but, in view of the objections that have been so persistently urged against the elevated-railway experiment in New York, it appears to be doubtful whether the consent of the municipal authorities will be given.

THE MADEIRA AND MAMORÉ RAILROAD,

the undertaking of which by enterprising American contractors was duly noted in last year's *Record*, appears to have been vigorously pushed forward during the past year. The work appears to be one of almost unexampled difficulty, and thus far no reliable account of progress made has been published, though a number of vessels have been sent out to the locality with large supplies of men and material. At the time of this writing there are rumors that the contractors will be obliged to abandon the enterprise because of difficulties of a financial nature, interposed by foreign bondholders, who have instituted legal proceedings, thus locking up during their continuance the funds that were anticipated to be available for the prosecution of the enterprise. It is to be hoped that these rumors are exaggerated.

PROJECTED DRAINING OF THE ZUYDER-ZEE.

During the past year, the publication of the more important details of this immense work, that has been for some time in contemplation, has attracted the extended comment of the engineering journals. The project which in its general features has been practically decided upon—should the work be undertaken in the future—is that of the hydraulic engineer Beijerinck. This officer, who was intrusted some years ago by the Netherland Landed Credit Company to make a

preliminary examination of the subject, reported the conclusion that the drainage of the entire Zuyder-Zee was both technically and financially impracticable, but that that portion lying south of the Issel Delta offered no insurmountable technical obstacles, and was financially feasible. He proposed, accordingly, the draining and reclamation of a district lying south of a dike to be built from a point on the eastern extremity of the North Holland coast-line at Enckhuysen, across the island of Urk to the Haatlander Canal on the Overyssel coast, and the promotion of landing facilities north of the dike. The district thus bounded by the projected dike and the dam of Schneelingwolde, near Amsterdam, would comprise (without the island of Marken) an area of 195,000 hectares (one hectare=2.471 acres), or, allowing for dikes, ditches, canals, and roadways about 19,000 hectares, an area of 176,000 hectares—that is, a district ten times greater than that of the Haarlem Sea would be reclaimed, and the area of the kingdom of Holland would be increased by about one eighteenth. It is understood that the government of the kingdom has granted to the company above named a concession to execute the work in question, which company has decided upon the general plan of Beijerinck, modified, however, in certain details to meet certain objections raised by the adjacent provinces of Friesland, Overyssel, Gelderland, Utrecht, and North Holland. The cost of this great undertaking is computed by an official commission at 123,500,000 Dutch guilders ($49,400,000), and the time requisite for its completion sixteen years. The completion of the dike, which is the most important feature of the work, will require, according to estimate, eight years; and the pumping-out, one and three-quarter years.

The advantages that are expected to be gained by the execution of this work are the direct enrichment of the country by the addition of an extensive and fruitful territory, in which the speedy growth of cities, towns, and villages would increase the industry and commerce of the adjacent provinces; the material improvement of the commercial highways to Amsterdam; a desirable perfecting of the net-work of railways, and an incidental improvement in the discharge of existing water-ways.

ST. GOTHARD TUNNEL.

Work has been uninterruptedly pushed forward during the past year. The contract of M. Favre, its constructor, requires the tunnel to be completed by October, 1880, under heavy pecuniary penalties for every day its completion is delayed beyond the appointed period. The tunnel has proved to be more difficult than was at first supposed; and, owing to the mistakes of engineers, the work will cost not less than $55,000,000, or twenty millions more than the original estimates.

A DEEP SEA HARBOR FOR THE PORT OF BOULOGNE

is said to have been decided upon by the French government, and an appropriation of $3,500,000 has been made for it. The plans said to have been approved are those of M. Stoecklin, and involve a solid stone jetty on the southwest 2235 yards long, a wooden jetty on the northeast 1570 yards long, and a solid stone breakwater on the outer or western boundary 545 yards long. Between the breakwater and the jetty will be two entrances, respectively 272 and 163 yards wide; and in the middle of the harbor a stone jetty will be provided 436 yards long and 218 yards wide, where steamers may embark and land passengers at all stages of the tide. The new port will have a mean depth of twenty-one feet.

THE CHANNEL-TUNNEL PROJECT,

so far as the English are concerned, remained *in statu quo* during the past year. On the French side, however, the experimental borings were continued, and are said to have been confirmatory of the geological theories upon which the feasibility of the undertaking is based. Incidentally it may be noted that during the year a project has been broached for tunnelling the Channel from the English coast to the Isle of Wight, the increase of traffic between the last-named and the mainland having rendered such a means of safe and rapid communication very desirable.

The project of flooding the Sahara still continues to have in Mr. Donald Mackenzie an indefatigable and enthusiastic advocate, but no practical progress towards its realization is to be recorded.

BRIDGING THE FIRTH OF FORTH.

A project which will present, if possible, even greater difficulties than the construction of the Tay Bridge, elsewhere referred to, is the bridging of the Firth of Forth, which, it is said, has been decided upon, and so far advanced that plans have been selected, and the immense capital that will be required for the work actually secured. The bridge, from what has transpired, is to be a two-span suspension structure, the depth of the estuary making it impossible to find foundation for piers save on the Island of Inchgarvie. On each side of the Firth will be located a composite pier, composed of four sets of iron columns, resting on substantial basements, and immense chains, securely attached some distance inshore, will be carried over the tops of these piers and of two smaller ones on the island above named. These chains will support the two lattice girders, each 1600 feet in length. The height of the spans will be 135 feet above high water. The approaches on each side from the high ground to the water's edge will be a series of spans carried on brick columns.

A RAILWAY BRIDGE ACROSS THE TAY, AT DUNDEE,

said to be one of the longest bridges in the world, and to have been a work of extreme difficulty, was completed during the past year. Its exact length is 10,612 feet. The number of spans is 85, of varying width. The chief difficulty which the engineers encountered arose from the varying character of the bed of the river. Near the shore the rocky bed was easily reached, and the piers thereon were built throughout of brick. Further out, however, the rock-bed suddenly shelved downwards to a great depth, and was overlaid with clay and gravel. Here it was necessary to construct, at great labor, large cylinders of masonry filled in with concrete, as a foundation, on which, above high-water mark, iron columns supporting the superstructure were erected. The structure at the centre of the stream is 130 feet above high-water mark.

THE RAILWAY BRIDGE

over the Duoro River, which was completed during the past year by the Northern Portugal Railway, is described as a

fine piece of engineering. The valley is narrow, the river-bed is composed of mud and sand to the depth of 50 to 180 feet, and the river is subject to great and rapid freshets, which sometimes raise the surface forty feet in twenty-four hours. On these and other accounts it was decided to be impossible to attempt to locate a pier in the river, and it was therefore spanned by a single iron arch of 525 feet spring, or a little larger than the central span of the great St. Louis Bridge. The arch abuts against piers of masonry on each bank. The mounting of the arch presented great difficulties, but was accomplished by the help of steel cables. The two halves met at the key with great precision.

AN UNDERGROUND RAILWAY FOR PARIS

is proposed, and if report may be credited, the following plans have met with approval. The central station will be located at the Gardens of the Palais Royal, from which three lines will radiate: one to the Exchange, the Opera, the railway station of St. Lazare, thence to the Batégnolles, communicating with the Great Western Railway and the Chemin de Fer de Ceinture; a second to Les Halles, the Boulevard Sebastopol, Boulevard de Strasbourg, the Great Eastern and Great Northern Railways (from the Boulevard de Strasbourg a branch line would lead to the Vincennes and Lyons Railway stations, passing beneath the Seine to the left side of the river); and a third to the Rue de Rennes, the Mont Parnasse Railway stations, and the station for Sceaux and Gentilly. The cost of this underground net-work is estimated at $30,000,000, and, according to statement, will be borne jointly by the state, the Department of the Seine, and the municipality.

STEAM-HEATING FOR CITIES AND TOWNS.

The experiment of heating the city of Lockport, N. Y., with steam, by what is now generally called the Holly system, is believed to have given general satisfaction. Some five miles of mains and laterals, protected by a non-conducting envelope, were in use during the last winter. The system has lately been introduced into Springfield, Mass., and its trial in several other localities is spoken of.

UTILIZATION OF SOLAR HEAT.

Reports from the Paris Exhibition bring us some interesting statements concerning M. Mouchot's persistent and laudable efforts to perfect an apparatus for utilizing the solar heat for the preparation of food, distillation of alcohol, etc., and as a motive power. From published accounts, he has been able, to a notable extent, to perfect his apparatus for these purposes. He has succeeded, we are told, with the aid of a mirror less than one fifth of a square meter, in roasting a pound of beef in twenty-two minutes, in completing a stew in an hour and a half that required four hours with a wood fire, and in raising to the boiling-point in half an hour three quarters of a litre of cold water. For producing power, M. Mouchot employed a conical solar receiver, the mirror of which had an aperture of twenty square meters, in the focus of which is located an iron boiler, weighing, with accessories, 200 kilograms (1 kg=2.2 lbs.), and having a capacity of 100 litres (1 litre=1.05 quarts). On September 2 this apparatus was put in operation, and in half an hour the water was raised to boiling, and ultimately a pressure of six atmospheres was obtained. On September 29 a pressure of seven atmospheres was obtained in two hours, notwithstanding several passing clouds. The solar engine has for a number of years been made the subject of special study by engineers of eminence (Ericsson among the number), and if ever ultimately perfected, it may attain to a position of great importance in countries where the uniform intensity of the solar heat throughout the greater part of the year is now regarded as a misfortune. The probable development of this form of motor may, however, be regarded as highly problematical.

STEAM ROAD-WAGONS.

Some attention was drawn during the summer of 1878 by the trial-tests of steam road-wagons, in competition for the prize of $10,000 offered by the Legislature of the State of Wisconsin. Two machines appeared as contestants, but only one was able to go through the prescribed conditions of performance. This wagon made the trip from Green Bay, by way of Beloit, to Madison, over the common high-road, a distance of 201 miles, at an average speed of six miles an hour, draw-

ing a heavy load in a wagon weighing 3500 pounds over all grades met. The running time for the 201 miles was thirty-three hours, and at one point it made twenty-one miles in two hours and ten minutes, recording one mile in four minutes thirty-six seconds. In their report to the Governor the commissioners say: "The wagon has hauled loads, ploughed, and otherwise accomplished in a successful manner every test mentioned in the law or suggested by the commission. They are not, however, satisfied that this machine is, in the language and spirit of the law, a cheap and practical substitute for the use of horses and other animals on the highways and farms." The chief objection of the commissioners is understood to relate to the cost of operating the machine. The experimental trial, nevertheless, is universally conceded to have demonstrated a very decided advance in this field of invention.

TECHNOLOGY.

By WILLIAM H. WAHL, Ph.D.,
PHILADELPHIA, PA.

COMPARATIVE MERITS OF DYNAMO-ELECTRIC MACHINES.

A most valuable and practical contribution on the subject of Dynamo-electric Machines was made during the last year by a committee of the Franklin Institute. The report of the sub-committee on Electrical Measurements, by Professors Houston and Thomson, is of such special value that its conclusions may be properly condensed in this place. The machines that were submitted to the comparative tests were a Gramme, a large Brush, a small Brush, and a Wallace-Farmer machine; and regret is expressed by the committee that it was not in their power to include a machine of the Siemens type (which lately received a very favorable endorsement from Professor Tyndall) in the list of those investigated. The conclusions reached by the gentlemen above named are, briefly condensed, as follows: The Gramme machine, considered as a means for converting motive-power into electrical current, is pronounced to be the most economical, giving a useful result in the arc equal to 38 per cent. (of power utilized), or of 41 per cent. after deducting friction and the resistance of the air. In this machine the loss by friction and local action is the least, the speed being comparatively low.

The large Brush machine gave in the arc a useful effect equal to 31 per cent. of the power used, or, after deducting friction, $37\frac{1}{2}$ per cent. It is but little inferior, in this respect, to the Gramme, but has the disadvantage of higher speed, and consequently greater percentage of loss of power by friction. This loss, the committee note, is nearly compensated by the advantage possessed by this machine over the others of working with a high external compared with the internal resistance, thus assuring comparative absence of heating in the machine. The small Brush is ranked by the

committee as the third in efficiency, showing in the arc a useful result equivalent to 27 per cent. of the power employed, or of 31 per cent. after deducting friction. The committee state further concerning this apparatus, that although somewhat inferior to the Gramme, it is nevertheless admirably adapted for the production of intense currents, and has the advantage of being capable of furnishing currents of widely varying electro-motive force. It possesses the advantage of division of the conductor into two circuits, simplicity and ease of repair of the commutator, and comparative freedom from heating.

The Wallace-Farmer machine, according to the committee's report, does not return to the effective circuit as large a proportion of power as the other machines (14 per cent., or 15½ per cent., deducting friction), although it uses in electrical work a large amount of power in small space. The cause of this low economy the committee attribute to the expenditure of a large proportion of the power in producing local action. They express the opinion, however, that by remedying this defect an admirable machine would be produced.

TELEGRAPHY.

In this department the progress made during the past year is specially noteworthy. The most prominent advances to be noticed are the invention of the microphone, by which minute sounds are rendered audible; the improvement of the phonograph, or talking-machine, the announcement of which invention was made in our last volume, but which was not practically brought out until the early part of 1878; and the considerable progress of the problem of electric lighting, which we have esteemed of sufficient importance to be given a separate consideration. The *Telegraphic Journal*, referring to the telephone, the phonograph, and the microphone, tersely defines their functions and utility as follows: "We have now a command over sound similar in kind to that which we possess over light. For the telephone is for the ear what the telescope is for the eye; the phonograph is for sound what the photograph is for light; and the microphone finds its analogue in the microscope." The last-named instrument has already received some highly useful applications, and as it is improved, and its capabilities are better understood, its utility

will doubtless be vastly extended. Sir Henry Thompson, and others following him, have successfully applied it in surgical operations and in medical examinations; Rosetti has employed it in the detection and observation of obscure seismic phenomena; and Houston and Thomson have applied it as a relay for the telephone. The utility of the telephone likewise has manifested itself in its extensive introduction into practical use; and we may note, as one of the most useful developments during the past year, the establishment of a system of telephone exchanges, by which a number of persons, who subscribe for the purpose, are brought into communication with each other through the medium of a central station.

The past year also witnessed the practical solution of the problem of duplexing submarine cables, by which their capacity for transmission has been materially increased; Muirhead's duplex system having been applied to the Madras-Penang section of the Eastern Telegraph Company's lines, and to that of the French Atlantic Cable, and Stearns having duplexed one of the Anglo-American lines. The quadruplex system, which was first introduced upon the postal telegraph system of England, in 1877, is reported to have proved so successful that it has been introduced upon additional circuits.

The gradual completion of the extensive net-work of underground cables, for some time in course of construction in Germany, to connect the principal cities of that empire, argues well for the success of the system in general. The latest information we have on this point gives the underground cable lines in Germany an extent of 2044 kilometers (1267.28 miles), in the following divisions: 1. Berlin, Halle, Frankfort-on-the-Main, with the branch lines, Halle-Leipsic and Frankfort-on-the-Main-Strasburg; 2. Berlin, Potsdam, Magdeburg, Cologne; with Cologne, Elberfeld, Bremen; and 3. Berlin, Hamburg, Kiel. The underground lines already laid are reported to give the utmost satisfaction; and the entire length of the lines that have been decided upon, and which are either at present in course of construction or will be shortly completed, is 16,121 kilometers (9995.02 miles). In this country the underground system—even in the cities, where their use is almost universal abroad—does not appear

to have received any attention, if we except the experimental trial of a short line of the Brooks system (covered wire conductors, laid in tubes, with paraffine oil as an insulator), in Philadelphia.

THE ELECTRIC LIGHT.

The scientific questions which of all others have attracted the most general and widespread popular interest during the past year are those pertaining to the improvement of the electric lighting systems and their possible adaptation for domestic purposes. One of the chief causes, doubtless, of the prominence attained by this subject, aside from its own merits, is to be credited to the fact of the introduction in Paris, during the period of the Exhibition just closed, of the electric light for the illumination of public squares, streets, gardens, halls, and places of amusement upon a scale not hitherto attempted; and the possibility that the rapid improvement of the electric light, which will reasonably be expected to follow upon the efforts of the numerous inventors who are engaged in the effort to solve the problem of adapting it for general illuminating uses as a substitute for gas, might soon be crowned with success, has caused much uneasiness among the gas fraternity, whose important vested interests, it is feared, would in consequence suffer serious depreciation in value. From all that can be learned, however, the difficulties that surround the problem of adapting electric lighting to domestic uses, as a practical substitute for coal-gas, are of such a serious nature that their removal, although it may be successfully accomplished sooner or later, is scarcely to be expected as an event of the immediate future. Upon the question of the relative cost of the electric light as compared with gas, the comparison being based upon the quantity of light produced, the electric light has decidedly the advantage of the other. In point of purity likewise it is incontestably superior to gas, over which it possesses other and important hygienic advantages. There are other qualities, however, equally important, which the electric light must be demonstrated to possess before it can figure as a rival to present methods of domestic illumination. It must be susceptible of perfect subdivision. The dazzling glare and intensity of the electric light in its present form, while it may be manageable in large open spaces, halls, factories, and public buildings, where it

may be diffused by suitably arranged reflectors and globes, would be utterly unsuited for the wants of the private dwelling. For this purpose there is demanded not a single light of a thousand candles, but rather fifty lights of twenty candles; and not only this, but the luminosity of the fifty lights must be as controllable as our gaslight is, so that one or all of them may be used as may be required; and each of the fifty must be so manageable as to be competent to yield such a proportion of its light up to its maximum of twenty candles as may happen to be needed—just as a gaslight may be turned on or off. And all this must be accomplished without loss of current, and without additional expense. The distribution of the current, and its indefinite ramification, from central stations must be controlled with little comparative loss, as gas is now conveyed in the mains and distributing pipes; and the preventives against interruptions of communication must be practically perfect in operation; and the mechanism of the lamps, or burners, must be simple, and not liable to become disordered by reason of ordinary usage. These are the salient requirements of a practical household light, which any substitute for gaslight must possess; and though they are by no means impossible to realize in the electric light, it will be obvious that inventors have still much to do before the problem is successfully solved. In recording the progress made during the past year in this field of research, the name of Jablochkoff, with his electric candle, is perhaps most prominent. In America, several notable contributions to the subject have been made. The most novel, and perhaps the most suggestive, is the plan proposed by Messrs. Houston and Thomson, of Philadelphia, to employ the "extra spark," a phenomenon which appears whenever an electrical current, which flows through a conductor of considerable length, is suddenly broken. As this "extra spark" will appear, although the current is not sufficient to sustain an arc of any appreciable length at the point of separation, the system which these investigators propose, permits the use of feebler currents for producing an electric light than that ordinarily required. In this plan one or both the electrodes (of carbon or other suitable material) are caused to vibrate to and fro from each other, at such a distance apart that in their motion towards each other they touch, and then recede to a

regulated distance. These vibrations are controlled by automatic mechanism, and are made to follow each other so rapidly that the effect of the rapid succession of sparks is to the eye a continuous light.

At the time of this writing much interest is manifested at the assertion that Mr. Edison has succeeded in effecting the practical subdivision of the current, and that he has devised a novel system of lighting, which, though no statement from the inventor has yet appeared, is reputed to depend upon the resistance interposed by platinum surfaces.

Upon this point, it may be of interest to note that Messrs. Houston and Thomson, who have carefully studied the question of the economical production of light from electrical currents, have inferred that the employment of platinum, or similar resistant substances, whose temperature of fusion and vaporization is low as compared with that of carbon for the production of light, must be far less economical than the use of the arc itself. Until Mr. Edison's plans are made public, however, it would be premature to pass judgment upon them.

The Sawyer-Mann electric lamp may finally be mentioned as the latest American contribution to this important subject, which is claimed to have overcome most, if not all, of the objections before advanced. The lamp employed by these inventors is enclosed in a hermetically sealed tube of glass filled with nitrogen-gas, a slender pencil of carbon completing the circuit between what would otherwise be the two carbon poles. This rod, or pencil, becomes luminous throughout its entire length, and by its incandescence furnishes the light in place of the ordinary voltaic arc. The sealing of the apparatus in an atmosphere of nitrogen is for the purpose of preventing its burning away, which would speedily occur in the air. An essential feature of the invention is said to be "an ingenious device for dividing the current, and for maintaining a constant resistance in the circuit, whether the lamps are on or off." This invention is of so recent a date that no record of its actual performance is at hand from which to judge of its merits, though from the description it would appear to be very promising. The device of using a continuous rod of carbon placed in an atmosphere which is a non-supporter of combustion is not a new one, having been em-

ployed as early as 1874 in the electric lighting system of Messrs. Ladiguin and Kosloff, of which an account will be found in the *Record* of that year.

Whether or not we are on the eve of a quiet revolution of the present system of domestic illumination, as many are disposed to believe, the idea appears to be a most erroneous one that the gas companies will find their occupation and their revenues gone. For, supposing the extreme case that the perfection of the electric light should have caused it to be very generally used for domestic illumination, there is still no reason for the belief that the demand for gas will be lessened by the cessation of its use for illumination; on the contrary, there is excellent reason to believe that the gradual withdrawal of gas as a lighting agent would go hand-in-hand with its increasing employment as a heating agent, a consummation that far-sighted engineers have long since predicted.

THE FUEL OF THE FUTURE.

No less important than the foregoing subject is that of gaseous fuel for domestic and industrial uses, the ultimate success of which (which has long been prophesied by progressive engineers) will carry with it consequences far more revolutionary than those which may result from the general introduction of electric lighting. The Lowe water-gas process, the successful operations of which in the direction of supplying cheap illuminating gas for cities and towns have been from time to time recorded in our annual volumes, and which since our last *Record* has been placed in operation on the largest scale for lighting the cities of Indianapolis and Baltimore, may be said to have given to engineers certain positive data as to cost of production, which seem to fully warrant the prediction that the present wasteful and inefficient use of fuel will sooner or later have to give way to improved systems, in which fuel, in gaseous form, will supersede the use of solid fuel in cities and towns both for domestic and industrial purposes. The advantages of gaseous fuel (the question of its economical production being assumed) in respect to the economy and completeness of its combustion, perfect manageability, absence of dust, dirt, and ashes, and its high calorific value and general convenience, are so universally acknowledged as to require no

explanation. It is, therefore, a matter of peculiar interest to record the fact that during the past year certain substantial improvements in the mode of producing gaseous fuel were made by Mr. M. H. Strong, of Brooklyn, the operation of which appears to have demonstrated its entire practicability. Retaining the general principle of the "water-gas" process of Lowe, this inventor conceived the idea of employing coal in pulverulent form — aiming to utilize coal-dust (culm), because of its abundance and cheapness—with the idea that in this form it would be peculiarly fitted for rapid and economical decomposition by contact with highly heated steam. Acting upon this principle, Mr. Strong has contrived a modification of the generating and superheating apparatus of Lowe, in which highly heated steam, instead of being led through a mass of incandescent coal, as is the practice with the Lowe system, is allowed to act directly upon the finely divided carbon. As our purpose here is to record results, we must refer our readers for the details of the apparatus to the elaborate descriptions that have appeared in the technical papers during the past year. Experiments made at Mount Vernon, N. Y., continued during several months, to test the capabilities of the Strong system, demonstrated that 50,000 cubic feet of water-gas could be obtained from 2240 lbs. of anthracite coal, or, stated differently, at a cost of from 6 to 8 cents per 1000 feet. They further demonstrated that this weight of fuel, including the quantity used under the boiler, afforded the basis of a safe estimate for a reasonably large scale of operations, since, in practice, better results have been obtained. The labor necessary to produce half a million cubic feet of this gas in twenty-four hours is affirmed to be three men on the shift. Dr. Gideon E. Moore gives the following as the composition by volume of the gas obtained by the mode above described:

Oxygen	0.77 per cent.	Carbonic oxide	35.88 per cent.
Carbonic acid	2.05 "	Hydrogen	52.76 "
Nitrogen	4.43 "	Marsh-gas	4.11 "
Total			100.00 per cent.

The same chemist has published an admirable investigation of the calorific elements of the Strong gas, and of its heating power in comparison with other fuels. He reaches the apparently paradoxical result that the practical heating

effect of the gas will be to that of the coal from which it was directly derived as 2.78 to 1; the great advantage in favor of the gaseous fuel being due to the fact that this form of fuel permits of a more perfect utilization of its theoretical heating power in practice, while with coal the effective heat-value is greatly lessened by elements of waste, which under the conditions of practical use it is found impossible to obviate.

Regarding the practical value of the Strong gas for metallurgical purposes, Dr. Moore's opinion is no less favorable. It has a higher calorific value than the Siemens gas (which, as incidentally remarked, contains by volume 69 per cent. of nitrogen), and, aside from the question of economy, this investigator affirms it to possess for use in metallurgy the special advantages of affording a high and easily regulated temperature, and a relatively small volume of products of combustion compared with the heating effect it yields. "It is, in fact," he affirms, "the most concentrated form of gaseous fuel hitherto attainable for this application." It may be well to observe, regarding this highly important consideration, that the conclusions of Dr. Moore respecting the comparative heating value of this form of gaseous fuel, favorable as they are, would in general practice for miscellaneous uses be much more so, inasmuch as his conclusions are based upon the best standard of comparison available—namely, the evaporation of water in average boiler practice. With regard to this fact it must, however, be observed that in no department of practice is coal used so economically as in steam-making; so that it is fair to presume that in domestic use and the industrial arts in general, aside from considerations of increased convenience, uniformity of heating, and manageability, the comparative economy of the gaseous fuel would be greater than Dr. Moore has shown.

When the possible future of gaseous fuel is considered in connection with the slow progress that is being made towards the perfection of electric lighting for domestic purposes, it seems more reasonable to anticipate the speedy extension of existing gas-works to supply heating gas than to suppose them to be in imminent danger of finding their occupation gone, as many over-sanguine advocates of the electric light do not hesitate to predict.

GAS-ENGINES.

The past year also witnessed the first practical introduction into this country of a most ingenious improvement in gas-engines, known as the Otto "Silent" gas-engine, a German invention, and an improvement of the Langen-Otto gas-engine, that attracted such attention in the machinery department of the Centennial Exhibition from the novelty of its mechanism. We have no space to enter into details of this new machine further than to state that, as its name indicates, it is noiseless in action; that the consumption of gas is automatically regulated by a governor of peculiar construction in accordance with the amount of work thrown on the engine; that the speed of the engine remains at all times uniform; that it is very economical, requiring but 21½ cubic feet of gas per indicated high-pressure per hour; and that it is available for higher powers than has been the case with former gas-engines.

Where moderate and intermittent power is required, as, for instance, for running hoists in stores and warehouses, printing-presses, ventilating large buildings, and the like, where power is wanted perhaps but a few hours during the day, and at irregular intervals, the advantages of this class of engines over the steam-engine is apparent, since the engine is always ready to be started and to give out at once its full power. There is no boiler requiring firing, no coal, ashes, dirt, or pumps.

THE INCRUSTATIONS ON BRICK WALLS,

which in damp localities, or after a heavy rain has soaked them, causes such a disfigurement of brick house-fronts in many cities and towns, has been made the subject of two very good papers during the past year, which satisfactorily bring out all the causes that contribute to this nuisance. Mr. William Trautwine shows that one cause of the trouble is to be found in the very general substitution of coal for wood in burning bricks (and the lime used in the mortar). As this coal always contains more or less sulphur, the author advances the opinion that the sulphurous vapors generated in the kiln by its combustion (together with air and moisture) around and through the clay of intensely heated bricks for several days would suffice to convert a certain variable per-

centage of the magnesium and lime silicates of the brick-clay into sulphates. When the bricks become wet, these compounds dissolve, and in dry weather succeeding storms, the solution evaporating from the surface of the bricks leaves them coated with these compounds, which have the property of efflorescing in dry air. Analysis of this incrustation showed it to consist mainly of sulphate of magnesia and lime, thus confirming, so far as it goes, Mr. Trautwine's explanation. Another source of the trouble (which in Philadelphia and vicinity exists in aggravated form) is ascribed to the formation of the efflorescing sulphate of magnesia by the decomposition of mortar. Much, if not all, of the lime used in the locality above named is burned from a magnesian limestone (having almost the chemical composition of a dolomite), and the result is a mixture of lime and magnesia, which, being very susceptible to the action of sulphurous vapors diffused everywhere in cities by the burning of vast quantities of coal, is gradually decomposed, yielding sulphate of lime and of magnesia. The last-named salt being highly soluble in water, it becomes, by diffusion and absorption in the neighboring bricks, the chief cause of the defacement of the same, the sulphate of lime being but slightly soluble. Mr. Pemberton, following after the above-named author, insists more positively that the main cause of the trouble is in the mortar, as just described, and that the formation of sulphates in the bricks during their manufacture in a coal-burned kiln, while it doubtless contributes something towards producing the disfiguring incrustation, is responsible for only a trifling share of it.

IRIDESCENT GLASS,

said to be produced by the action of the vapors of chloride of tin upon the finished wares at a high temperature, has become a popular novelty in glass during the past year. The iridescence, though decided enough to yield beautiful effects, is not intense. More intense effects are produced with a dark and more or less opaque body; the mode of production of the latter is not generally known. Attention has been pointedly called to the disposition manifested by articles of glass hardened by the La Bastie process to fly into fragments spontaneously and violently. Siemens affirms that glass compressed by his process is free from this disadvantage. The

attempt has been made to use the toughened glass as a substitute for metal in making printer's type, though with what success does not appear.

ARTIFICIAL PRODUCTION OF CORUNDUM GEMS.

Considerable interest was attracted during the past year by the success of Messrs. Fremy and Feil (the first a chemist of celebrity, and the last a leading glass-maker) in producing, by artificial means, considerable masses of the precious stones known as the ruby and sapphire, which rank next in value to the diamond, in such quantity and quality that the value of these hitherto costly products of nature threatens to be seriously impaired, and sufficient to meet the future wants of the jeweller and watchmaker. The experimenters above named are not the first who have succeeded in producing these colored varieties of corundum by artificial means, but all previous efforts in this direction have been failures, because of the microscopic minuteness of the crystals produced.

In their experimental operations Messrs. Fremy and Feil operated upon from fifty to seventy-five pounds of material, and subjected it for a lengthened period (about three weeks) to the highest temperature attainable in a glass-furnace. The reaction they designed to accomplish was the decomposition of an aluminous silicate (pure porcelain earth) by means of a metallic oxide (oxide of lead). As carried out at the glass-works of Mr. Feil, a mixture of equal parts of porcelain clay and red-lead was subjected in a fire-clay crucible to the heat of the glass-furnace for several weeks. To prevent the loss of the charge, from the effect of the lead oxide on the silica of the crucible, this was placed, for precaution, within another. At the close of the operation, and on the cooling of the charge, the contents of the crucible was found to consist of two layers, the upper one vitreous, and consisting chiefly of silicate of lead; the lower one crystalline, and containing clusters of geodes made up of beautiful crystals of alumina. By the addition to the charge of bichromate of potassa, these crystals were obtained of the rose or deep-red color of the ruby, while the blue of the sapphire was perfectly obtained by the addition of a slight percentage of cobalt oxide.

These crystals were found, on examination, to have the same chemical composition, the same hardness, the same specific gravity, and the same crystalline form as the natural ruby and sapphire, and were, in fact, not to be distinguished therefrom.

At the same meeting of the French Academy at which Messrs. Fremy and Feil described their process, M. Monnier stated that he had succeeded in obtaining artificial opals by cautiously pouring oxalic acid upon a sirupy solution of silicate of soda.

THE AMMONIA PROCESS OF SODA MANUFACTURE.

In the *Record* for 1873 we noted that much interest had been attracted at the Vienna Exhibition by the demonstration of the fact by M. Solvay, a Belgian manufacturer, that soda could be successfully produced upon the commercial scale in competition with the time-honored process of Leblanc. The distinguished chemists Hofmann and R. Wagner, in their reports on the chemical industries of that exhibition, were so favorably impressed with the eminent merits of the ammonia process that they coincided in the opinion that it was destined in time to entirely supersede the process of Leblanc, which for more than half a century had held its own against all rivals. At the time of the Vienna Exhibition the yearly production of soda by M. Solvay amounted to about 8,000,000 pounds. In the five years that have elapsed since that time the annual production of soda by the ammonia process has risen to 88,000,000 pounds, one establishment (that of Verangéville-Dombasle) producing one half of this total. The soda produced by the ammonia process is said to be almost chemically pure, being almost perfectly free of sulphate of soda and iron. This fact, taken in connection with its cheapness, renders it not only well adapted for all the industrial uses to which Leblanc soda is put, but for special uses—glass-making, for instance—makes it of peculiar value. From the foregoing *résumé*, showing the steady growth of the ammonia-soda process, and its present important position, it would appear as if the prediction ventured by Messrs. Hofmann and Wagner in 1873, regarding its future importance, was in course of rapid realization.

LAMP-BLACK FROM NATURAL GAS.

The manufacture of lamp-black from natural gas, to which public attention was first drawn by the presence of some interesting samples of the manufacture in the Ohio section of the Philadelphia Exhibition, appears to be a growing industry. Near Gambier, O., there is an establishment employing special burners and other apparatus for the purpose, and producing no less than sixteen tons of so-called "diamond-black" per annum. The number of burners employed is 1800, consuming 275,000 cubic feet of natural gas per day. The product is said to be very fine and smooth, free from grit, and of an intense black color. It is quite free from oil, and on this account readily mixes with water, and does not discolor ether, as common lamp-black does. Only a barely visible trace of ferruginous matter is left behind when a platinum dish of the "diamond-black" is burned, and this is doubtless derived from scrapings from the metallic surfaces on which it was originally deposited. It is sold in considerable quantity to the makers of printer's and lithographic inks, and some has even been shipped to Europe. Professor Mallet, who has examined it, declares it to be an exceptionably pure form of carbon. As a new industry that has attained important proportions, it is worthy of record.

NEW CALEDONIA NICKEL.

The display of this metal and its ores from the French penal colony of New Caledonia is affirmed by Professor Silliman to have been one of the most remarkable exhibits in the metallurgical department of the late Exhibition at Paris. Hitherto the mine possessing the greatest commercial importance as a producer of nickel has been the well-known Gap Mine, in Lancaster County, Pa., worked with such success by Mr. Joseph Wharton. The Gap ore is what is known to mineralogists as *nickeliferous pyrrhotine*—a white sulphide of iron, carrying about 3 per cent. of nickel, and exceedingly difficult to work. The extensive deposits of New Caledonia yield an ore which, if not an entirely new mineral, is nevertheless new in its metallurgical relations, being a hydrous silicate of nickel and magnesia (called *garnierite* or *naumeite*) of an apple or pear-green color, and carrying

about 10 per cent. of nickel. It is completely free from all traces of sulphur, arsenic, iron, and copper; and if cobalt is found with it, it is in very minute quantities. Over 20,000 tons of this ore, it is said, have been shipped to France and England from New Caledonia; and the production of nickel therefrom, on account of its freedom from the above-named troublesome elements, and from the lead, bismuth, and antimony which are found in the German nickel ores, is effected with comparatively little difficulty and cheaply. The price of nickel, in consequence, has fallen to three or four shillings, from the twelve to sixteen shillings which was the old market figure for nickel. These new ores appear, therefore, to have done for nickel what the Australian tin deposits have done for the last-named metal, at least for the time, in reducing its price to considerably less than one half its long-established value. Considering the wide range of uses to which nickel is applied, and for which it is known to be adapted, the discovery of new sources which appear to promise a supply large enough to permanently reduce its price, and to proportionately extend its applications in the useful arts, is a subject for congratulation. Professor Silliman, however, is careful to add that "we are by no means sure, as yet, that the Caledonian deposits are as permanent as the hopeful owners have represented." The same gentleman notices from the Exhibition that very decided advances have been made in England in working the platinum metals. He notices likewise the production by an English house of an excellent alloy for subsidiary coin, consisting of aluminum ninety-eight and nickel two parts. It is silver-white, hard as silver, unoxidizable, and extremely light.

PLATING METALS BY GALVANIC MEANS.

A process for platinum-plating has been devised by Boettger, which is claimed to yield a coating of fine color, great tenacity, and durability, qualities in which all previous processes were deficient. The improvement referred to depends upon the fact which Boettger has observed, that the neutral citrate of soda will dissolve very readily large quantities of the platin-ammonium chloride, which is the plating solution commonly used, and with which the difficulty has been met that, owing to its difficult solubility in water, only a

small quantity could be obtained in solution, so that the prepared bath could not be operated with for any length of time. He therefore recommends the preparation of a bath, by treating at the boiling temperature any desired quantity of freshly precipitated platin-ammonium chloride with a saturated solution of citrate of soda. The result is the immediate formation of a deep orange-colored solution, very rich in platinum, which will afford, with two Bunsen cells, a handsome, homogeneous, and tenacious platinum coating. Gaiffe has likewise recommended the use of a cobalt plating, obtained by galvanic means with a neutral solution of double sulphate of cobalt and ammonia, for its hardness and beauty, as a protective coating for plates used in copper-plate engravings.

The disaggregation of metallic tin is a curious phenomenon to which the attention of metallurgists was prominently drawn last year by the publicity given abroad to several remarkable cases where it had been noticed. The fact appears to be established that for some reason, at present quite unintelligible, metallic tin will at times become so granular and friable that it may readily be crumbled between the fingers. This disintegration cannot be ascribed to any impurity that the metal contains, since it has been noticed to occur with metal containing only traces (0.3 per cent.) of foreign metals, no sulphur or phosphorus, and no oxide. It has been observed to occur in organ-pipes, but cannot be ascribed to the effect of vibration, as in other cases (and the recent cases referred to) it has occurred in tin that had been stored in warehouses, at a tolerably uniform temperature, and untouched for some time.

The influence of carburation upon nickel has been studied by Boussingault with the view of ascertaining whether such carburation would affect it like iron, and also to ascertain whether its combination with steel would render the latter less oxidizable. His results showed that while he was able to carburize nickel as readily as iron, the metal showed no increase in elasticity, hardness, and tensile strength. It did not possess the property of tempering, and the alloy with iron rusted easily unless the same contained a large percentage of nickel.

THE PROTECTION OF IRON SURFACES

against atmospheric influences by providing them with a skin of oxide, obtained either by the action of superheated steam or hot air allowed to act upon the iron kept at a high temperature, appears to have demonstrated its utility for the purpose. From the discussion which the presentation of the plans of Barff, Bowers, and others called forth in the technical societies, the general principle was held to be correct, that "metals are best protected against atmospheric influences by a film of their own oxide."

BALATA,

which is described as the milky sap of the Bully-tree, has lately become an article of commerce as a substitute for gutta-percha, which it resembles very closely, though affirmed to be superior to it in some respects. The following are some of its properties: It is tasteless, has an agreeable odor when warmed, may be cut like gutta-percha, is tough and leathery, and far more elastic than gutta-percha. Like the latter it becomes soft, and may be joined piece to piece at about 120° Fahr., but will not melt until 270° has been reached. It is completely soluble in the cold in benzole and carbon disulphide. Turpentine dissolves it on heating, while anhydrous alcohol and ether only partially dissolve it. It becomes strongly electrified by friction, and is a better insulator of electricity than gutta-percha, which latter property may make it valuable for electrical and telegraphic purposes. Caustic alkalies and muriatic acid do not affect it, but, like gutta-percha, it is destroyed by concentrated sulphuric and nitric acids.

Balata appears, therefore, to stand between caoutchouc and gutta-percha in its properties, on which account it may for many uses be found to be more valuable than either of them. Dr. Riegler, who described the new gum in a recent paper before the *Niederœsterr. Gewerbeverein*, after speaking of the abundance of balata, the increasing demand for elastic gums, and the reckless destruction of the trees which supply rubber and gutta-percha, declared it to be "a matter for congratulation that the world had been supplied with another and abundant source of elastic-gum, to swell the supply which

the rapid destruction of these trees threatened to seriously diminish."

NEW EXPLOSIVES.

Some interest attaches to several new explosives brought out during the past year, because of their novelty and possible utility; of these, two are worthy of special notice. One of these is the so-called "blasting-gelatine," invented by M. Nobel, the well-known inventor of dynamite. It is said to be formed by dissolving collodion-cotton in nitro-glycerine in the proportions of 10 per cent. of the former to 90 per cent. of the latter. The product is described to be a gelatinous, elastic, transparent, pale-yellow substance, having a specific gravity of 1.6, and the consistence of a stiff jelly. It is said to be less liable to be affected by blows than dynamite, and this indifference may be increased by the addition of from 4 to 10 per cent. of camphor. Experiment is affirmed to have shown that "blasting-gelatine" possesses, weight for weight, 25 per cent., and, bulk for bulk, 40 per cent., greater explosive energy than dynamite. It is further affirmed to be very stable, to be unaffected by water, and to be considerably cheaper than dynamite. An Austrian military commission is said to have pronounced favorably upon it for military and general engineering uses.

The second compound above referred to was lately brought to the attention of the Royal Dublin Society, by Professor Emerson Reynolds, of Trinity College. It consists, according to description, of 75 per cent. of chlorate of potassa, with 25 per cent. of a substance called "sulphurea." It is a white powder, which is said to ignite at a somewhat lower temperature than gunpowder, which it exceeds in explosive energy, and leaves about 15 per cent. less of solid residue. It has been used in small cannon, but its inventor claims it to be especially adapted for blasting, for shells, torpedoes, and similar purposes. One of its advantages is pointed out to be that it can be made at a moment's notice by a comparatively rough mixture of its ingredients, which can be stored or carried with perfect safety so long as they are kept separate. Of the nature of "sulphurea," nothing definite has appeared beyond the statement that it can easily be procured in any desired quantity from a product of the gas-works that is at present wasted.

INDUSTRIAL STATISTICS.

By WILLIAM H. WAHL, Ph.D.,
PHILADELPHIA, PA.

GENERAL REVIEW OF THE IRON TRADE OF THE UNITED STATES FOR 1877.

The annual report of the secretary of the American Iron and Steel Association, to which, as heretofore, the country is indebted for the most reliable statistics of this important branch of industry, represents, as intimated in our last year's *Record*, the year 1877 to have been more prolific of financial disaster to the American iron trade than any previous year since the panic. There appears to have been an increased demand for certain of our iron and steel products, but the advantages accruing from this increase were wholly enjoyed by consumers, since, so far as the producers were concerned, prices were too low to be profitable, having reached lower figures for nearly every species of product than have ever before been quoted in this country; and a still further decrease appears to have been continued during the year 1878. Mr. Swank's summary of this topic exhibits the depressed condition of the American iron trade at the close of 1877 too plainly to require further comment. "The year 1877 was one of extreme discouragement to American ironmasters and their workmen, and during the first half of the year 1878 there has been no material change for the better—no rift in the dark clouds."

PRODUCTION OF PIG-IRON IN 1877.

The report of the Association for the year 1877, which has lately appeared, places the production of pig-iron in the United States during that year at 2,314,585 tons of 2000 pounds, a gain of 221,349 tons (or about 10½ per cent.) over that of the previous year (1876). These figures, while they indicate that a healthful reaction has set in, fall far below the producing capacity of the country, as will subsequently be shown.

The figures for several previous years are given herewith for comparison:

Years.	Product.	Years.	Product.
	Net Tons.		Net Tons.
1872	2,854,558	1875	2,266,581
1873	2,868,278	1876	2,093,236
1874	2,689,413	1877	2,314,585

Of the total production of pig-iron in 1877, 1,061,945 net tons were made with bituminous coal (or coke), 934,737 tons with anthracite, and 317,843 tons with charcoal. The States of Connecticut, New York, New Jersey, Pennsylvania, Maryland, Georgia, Alabama, Texas, Kentucky, Tennessee, Indiana, Illinois, and Missouri increased their make of pig-iron in 1877. The increase of product over that of the previous year (1876) was mainly of anthracite iron in the three Middle States and Maryland. New Jersey, however, shows the largest proportionate increase, having doubled its product. Pennsylvania alone produced 1,153,356 tons, or almost 50 per cent. of the total production. The secretary estimates the total number of completed furnaces in the country at the close of 1877, which were either in blast or ready to be blown in, at 716, as against 712 at the close of 1876. At the close of 1876 there were of the whole number (712) 236 in blast and 476 out of blast; and at the close of 1877 there were of the whole number (716) 270 in blast and 446 out of blast; thus showing for 1877 a gain of 34 active furnaces. The number of new furnaces erected in 1877 was 17, and the number abandoned during that year was 13, a net gain of only 4 furnaces. The greatest activity in the construction of new furnaces was shown in the Hocking valley district of Ohio, where 9 furnaces were built.

Commenting on the great number of idle furnaces in the country at the close of 1877, the secretary notices that less than 300 furnaces produce all the iron that the country consumes. Most of the furnaces built since 1871 (145 in number), it is stated, embrace all the modern improvements in construction and equipment, and have been located with an eye to securing the greatest advantages with reference to the supply of raw materials and accessibility to the market; while some of the old furnaces, having been badly constructed and

unfortunately located, and being on these accounts unable to compete with their modern rivals in the production of cheap iron, may be looked upon as being permanently retired from the list of active furnaces. The proportion of these, however, the secretary is careful to add, will hardly exceed one tenth of the whole number of those that are now idle, the larger number of antiquated and badly situated stacks having either been torn down or permanently abandoned since 1873; and as all such actually abandoned furnaces have been from time to time carefully eliminated from the list of existing furnaces, the present number (716) includes a smaller proportion of stacks in danger of permanent abandonment than would at first be imagined. An increase in the demand for pig-iron, especially if accompanied by an advance of a few dollars per ton in price, would, in the opinion of the secretary, enable many old-style and out-of-the-way furnaces to go into blast with profitable results.

The total productive capacity of the existing furnaces is placed at about twice the present actual output—that is, about 4,000,000 gross tons—and the opinion is expressed that "less than ten years hence all of this capacity will be required to meet the wants of our people, and it will undoubtedly be utilized."

A COMPARATIVE TABULATION OF PIG-IRON BY STATES, for comparison with similar tables published in preceding volumes of the *Record*, is given on the following page, from the official statements of the Association.

PRODUCTION OF ROLLED IRON IN 1877.

The total production of rolled iron in the United States during the year 1877 is represented by the Association's statistics to have been 1,476,759 net tons, as compared with 1,509,269 tons in 1876, 1,599,516 tons in 1875, and 1,694,616 tons in 1874. The falling-off in the production of this class of our iron products, observable for the year 1877, is confined, as elsewhere observed, chiefly to the item of iron rails. In the last published statistics of the Association, the item of Bessemer steel rails, which had been included among rolled-iron products in previous reports, is separately classified, a fact which will account for the apparent discrepancy which

may be observed between the figures for rolled iron in this and previous volumes of the *Record.*

PRODUCTION OF PIG-IRON BY STATES.

STATES.	Furnaces, Dec. 31, 1877.	Condition of Furnaces on December 31.				Make of Pig-iron in net tons. (Tons of 2000 pounds.)			
		1876.		1877.					
		In.	Out.	In.	Out.	1874.	1875.	1876.	1877.
Maine	1	1	...	1	...	1,661	2,046	3,002	1,960
Vermont	2	2	...	2	...	3,450	2,400	550	210
Massachusetts	6	1	5	...	6	27,991	21,255	5,040	2,904
Connecticut	10	4	6	5	5	14,518	10,880	10,160	14,443
New York	59	23	34	24	35	326,721	266,431	181,620	230,442
New Jersey	19	4	14	7	12	90,150	64,069	25,349	52,909
Pennsylvania	278	113	166	131	147	1,213,133	960,884	1,009,613	1,153,356
Maryland	24	5	19	6	18	54,556	38,741	19.876	26,959
Virginia	33	6	27	5	28	29,451	29,985	13,046	12,434
North Carolina	7	...	7	...	7	1,340	800	400	325
Georgia	11	2	9	2	9	9,786	16,508	10,518	13,223
Alabama	13	5	8	7	6	32,863	25,108	24,732	41,241
Texas	1	...	1	...	1	1,012	.....	426	525
West Virginia	12	1	11	2	10	30,134	25,277	41,165	34,905
Kentucky	22	4	19	7	15	61,227	48,339	34,686	47,607
Tennessee	22	5	19	6	16	48,770	28,311	24,585	25,940
Ohio	107	38	62	49	58	425,001	415,893	403,277	400,398
Indiana	8	3	6	1	7	13,732	22,081	14,547	15,460
Illinois	12	3	9	2	10	37,946	49,762	54,168	61,358
Michigan	32	7	27	9	23	136,662	114,805	95,177	82,216
Wisconsin	15	5	9	4	11	50,792	62,139	51,261	22,205
Missouri	18	6	13	2	16	75,817	59,717	68,223	73,565
Oregon	1	...	1	...	1	2,500	1,000	1,750	.....
Utah	3	...	2	...	3	200	150	65	.....
Total	716	236	476	272	446	2,689,413	2,266,581	2,093,236	2,314,585

RECAPITULATION AND ANALYSIS.

KINDS OF PIG-IRON.	Furnaces, Dec. 31, 1877.	Condition of Furnaces on December 31.				Make of Pig-iron in net tons. (Tons of 2000 pounds.)			
		1876.		1877.					
		In.	Out.	In.	Out.	1874.	1875.	1876.	1877.
Anthracite	231	85	143	103	128	1,202,144	908,046	794,578	934,797
Charcoal	272	73	206	79	193	576,557	410,990	308,649	317,843
Bituminous coal and coke	213	78	127	88	125	910,712	947,545	990,009	1,061,945
Total	716	236	476	270	446	2,689,413	2,266,581	2,093,236	2,314,585

CONDITION OF THE BLAST-FURNACES OF THE UNITED STATES, OCTOBER 1, 1878.

For convenience of comparison with similar statements in previous volumes of the *Record*, there is herewith given a statement of the actual condition of the blast-furnaces of the country down to the most recent period to which accurate

reports are available. These are compiled from the latest published quarterly report of the *Iron Age*, and represent the condition of things on October 1, 1878:

	Charcoal.	Anthracite.	Bituminous or coke.
Total number of stacks	269	223	213
Number reported in blast	83	88	80
Number reported out of blast	186	135	133
Capacity per week of those in blast (tons)	7,079	17,660	19,360
Capacity per week of those out of blast (tons)	13,790	24,360	29,360

Total furnaces in blast, October 1, 1878	251
Total furnaces out of blast, October 1, 1878	454
Weekly capacity of furnaces in blast (tons)	44,099
Weekly capacity of furnaces out of blast (tons)	67,510

Compared with the condition of things at or about the same period of 1877, the above figures for the several classes of furnaces in and out of blast have maintained about the same relations, save that the percentage of charcoal-furnaces in blast in 1878 has slightly diminished.

PRODUCTION OF IRON RAILS (BESSEMER EXCLUDED).

The production of iron rails in the year 1877, from the Association's figures, was 332,540 net tons, a smaller production than that of any year since 1864. This decline the secretary ascribes chiefly to the popularity of Bessemer rails, and, in part, to the continued depression of the general business of the country, which still restricts the building of railroads. The production of this class of rails has steadily diminished since 1872, the figures of the single year 1877, as compared with those of 1876, showing a falling-off of not less than 134,628 tons (or about 30 per cent.). This steady falling-off will appear from the accompanying tabulation:

Years.	Net Tons.	Years.	Net Tons.
1872	905,930	1875	501,649
1873	761,062	1876	467,168
1874	584,469	1877	332,540

RAIL PRODUCTION IN 1877 (BESSEMER INCLUDED).

The total rail production in 1877 was 764,709 net tons, as compared with 879,629 tons in 1876, 792,512 tons in 1875, and 729,413 tons in 1874. Of the total rail product of 1877, 332,540 tons were iron, and 432,169 tons Bessemer steel;

showing that, while the production of iron rails was decreased by 134,628 tons, that of Bessemer rails increased 19,708 tons. The total rail production of 1877 was less than that of 1876 by 114,920 tons, a decline of 13 per cent. The production of Bessemer rails, which has been gradually gaining upon that of iron, not only overtook, but considerably surpassed that of iron rails in 1877 by about 100,000 tons.

THE BESSEMER-STEEL INDUSTRY.

The number of Bessemer-steel establishments in the country at the close of 1877 was 11, showing therefore no increase during that year. The same remark will apply to the year 1878, for which year, however, no reliable statistics of production can at this time be given. The total productive capacity of the existing works may be estimated approximately at about 700,000 gross tons yearly, a quantity which, from the present business outlook, will be sufficient to meet the demands of the country for some time to come.

The Association's figures show that the quantity of pig-iron and spiegel converted by the Bessemer process in the country during 1877 was 562,227 net tons, as compared with 539,474 tons in 1876, and 395,956 tons in 1875. The amount of spiegeleisen used in 1877 was 48,229 tons, against 45,980 tons in 1876, and 33,245 tons in 1875. Net tons of Bessemer ingots produced in 1877, 560,587, against 525,996 in 1876, and 375,517 in 1875; net tons of rails in 1877, 432,169, against 412,461 in 1876, and 290,863 in 1875. The Bessemer industry has had an active existence in this country of eleven years, during which period there have been produced 1,595,197 net tons of rails. All of the eleven establishments in the country, with 22 converters, were active during the whole, or part, of the year 1877. As noted in last year's *Record*, the use of Bessemer metal as a substitute for wrought iron and other kinds of steel for miscellaneous uses continues to increase steadily. The details of production in net tons will appear from the subjoined table:

Items.	1874.	1875.	1876.	1877.
	Net Tons.	Net Tons.	Net Tons.	Net Tons.
Pig-iron and spiegel converted....	204,352	395,956	539,474	562,227
Ingots produced.....	191,933	375,517	525,996	560,587
Rails produced.....	144,944	290,863	412,461	432,169

STEEL OTHER THAN BESSEMER.

From the Association's statistics we may record the production during the year 1877 of 77,385 net tons of crucible, open-hearth, blister, and puddled steel, against 71,178 tons in 1876, 61,058 tons in 1875, and 49,681 tons in 1874. The above-named quantity was the product of 41 establishments, and of the total, 40,430 tons were crucible steel, 25,031 tons open-hearth, and 11,924 tons puddled and blister steel. Mr. Swank's figures for open-hearth steel for 1877, it may be observed, fall considerably below the production as given in our last year's *Record*, on the authority of Messrs. Richmond & Potts; the discrepancy, however, is only apparent, since the figures given by the last named are those of productive capacity, while Mr. Swank's figures represent actual production as derived directly from the makers.

The secretary of the Association notes that the production of open-hearth steel is steadily growing; and the same statement may with equal truth be applied to all our steel products, as witness the following official statistics:

STEEL OTHER THAN BESSEMER SINCE 1866.

Years.	Net Tons.	Years.	Net Tons.	Years.	Net Tons.
1866	18,973	1870	35,000	1874	49,681
1867	19,000	1871	37,000	1875	61,058
1868	21,500	1872	40,000	1876	71,178
1869	23,000	1873	52,000	1877	77,385

ALL KINDS OF STEEL SINCE 1872 IN NET TONS.

Kinds of Steel.	1872.	1873.	1874.	1875.	1876.	1877.
Crucible cast steel.....	29,260	34,786	36,328	39,401	39,382	40,430
Open-hearth steel.....	3,000	3,500	7,000	9,050	21,400	25,031
All other steel, except Bessemer.....	7,740	13,714	6,353	12,607	10,306	11,294
Bessemer steel ingots...	120,108	170,652	191,933	375,517	525,996	560,587
Total.....	160,108	222,652	241,614	436,575	597,174	637,342

PRODUCT OF FORGES AND BLOOMERIES.

The product of the forges and bloomeries for the year 1877 is placed by Mr. Swank at 47,300 net tons, a slight increase over the figures of the previous year.

GENERAL ANALYSIS OF TOTAL IRON AND STEEL PRODUCTION.

The following analytical statement of production in net tons of the various branches of the iron and steel industries, similar to that presented in previous volumes of the *Record*, brings down the statistical figures showing the condition of these industries to January 1, 1878—as near to the present as we may come with accuracy. For these figures, as for many others, we are indebted to the painstaking work of Mr. Swank, the secretary of the American Iron and Steel Association. The figures, it will be observed, indicate a moderate increase in the production of pig-iron as compared with that of the previous year (1876), a continued, though not large, diminution in the production of rolled iron, a considerable falling-off in the production of iron rails, and an increase in steel products of all kinds, although the increase in the production of Bessemer metal is not so pronounced as during several previous years. In the figures for all rolled iron Bessemer rails have been excluded.

Products.	1874.	1875.	1876.	1877.
	Net Tons.	Net Tons.	Net Tons.	Net Tons.
Pig-iron	2,689,413	2,266,581	2,093,236	2,314,585
All-rolled iron, including nails and iron rails	1,394,616	1,599,516	1,509,269	1,476,759
All-rolled iron, including nails and excluding rails	1,110,147	1,097,867	1,042,101	1,144,219
Bessemer steel rails	144,944	290,863	412,461	432,169
Iron and all other rails	584,469	501,649	467,168	332,540
Street rails, included in iron rails	6,739	16,340	13,086	7,015
Rails of all kinds	729,413	792,512	879,629	764,709
Kegs of cut nails and spikes, included in all-rolled iron	4,912,180	4,726,881	4,157,814	4,828,918
Crucible cast steel	34,128	39,401	39,382	40,430
Open-hearth steel	7,000	9,050	21,490	25,031
All other steel, excluding Bessemer	6,353	12,607	10,306	11,924
Total Bessemer steel	191,933	375,517	525,996	560,587
Blooms from ore and pig-iron	61,070	49,243	44,628	47,300

To the foregoing we are enabled to add, on the authority of Messrs. Richmond & Potts, the American agents for Sie-

mens's regenerative gas-furnace, the following facts relative to the number of Siemens's furnaces in the United States on November 30, 1878, and a reliable estimate of their productive capacity, viz.:

The total number of Siemens's furnaces in the United States to above date is 168, divided as follows:

For heating and puddling	101
For open-hearth steel-melting	27
For crucible steel-melting	40
	168

The number of furnaces built and in course of building during the year 1878 is as follows:

For heating and puddling	15
For open-hearth steel-melting	6
For crucible steel-melting	6
	27
Total furnaces to date	195

The annual productive capacity of the open-hearth furnaces above named is 140,000 gross tons.

The 40 crucible-furnaces have a capacity of 984 crucibles per heat, representing an annual production of 40,000 gross tons.

THE AMERICAN IRON TRADE IN 1878.

The despatch with which the returns of production now reach the office of the Iron and Steel Association, thanks to the effective system of obtaining facts and figures from iron-masters lately introduced and put into operation by its able secretary, Mr. Swank, enables us even thus early to give his estimates for 1878, based upon such full and reliable returns that he is able to affirm them to be very nearly correct.

PIG-IRON.

The production of 1878 is estimated to have been about 70,000 net tons greater than that of 1877, and is given as 2,382,000 tons, classified as follows:

Kinds of fuel.	1878.
Anthracite	1,039,000 net tons.
Bituminous	1,093,000 "
Charcoal	250,000 "
Total	2,382,000 "

At the close of the year, the secretary estimates the number of furnaces in the country to have been 700, of which 260

were in blast, and 440 out of blast. Pennsylvania made over 50 per cent. of the total product. The indications are also that the consumption of iron in the United States was greater during the past year than in 1877, since the reduction of stacks was about 126,000 tons. This fact, taken in connection with the increased production of 70,000 tons credited to the same period, warrants the inference that the increased consumption of 1878 was about 195,000 tons.

MANUFACTURED IRON AND STEEL.

The rolling-mills appear to have been generally more actively employed last year than during the previous year. Iron ship-building was more active; the elevated railroads of New York demanded a large quantity of finished iron; bridge-building showed an improvement; government work and other public improvements created an increased demand; the number of locomotives and railroad-cars was largely in excess of the previous year; and the number of miles of railroad completed was likewise greater. Ten of our eleven Bessemer works were busy during the whole of 1878.

A feature of special interest in connection with the interests of the iron-trade during the past year is the fact that the mileage of *new railroad* constructed in the United States was much greater in 1878 than in 1877. Taking the figures of *The Railroad Gazette*, which we have heretofore relied upon as the most trustworthy that could be obtained, we learn, upon the authority of that journal, that in 1878 there were laid 2688 miles of new railroad, against 2177 miles in 1877, 2657 in 1876, 1758 in 1875, 2305 in 1874, and 4069 in 1873. From these figures it will appear that the mileage of new road in 1878 has exceeded that of any year since the memorable year 1873, which ushered in the unprecedented financial storm from which the country has just emerged. The recovery of the railroad interests, which these figures demonstrate, is to be regarded as one of the most hopeful signs of returning prosperity.

The following figures give the production of manufactured iron and of steel during 1878:

Bessemer steel ingots	730,000 net tons.
Bessemer steel rails	600,000 "
Iron rails (same as last year, and probably a few thousand tons greater)	332,540 "

Total rail product in round numbers	930,000	net tons.
Rolled iron, excluding rails and including nails (same as last year)	144,000	"
Open-hearth steel (approximately)	50,000	"
Crucible, blister, and other steel (approximately)	50,000	"

The secretary, in summing up his review of the iron trade in 1878, is of opinion that the year, taken all in all, was a more active and prosperous one for the iron trade than either 1876 or 1877. There was an improvement in the demand for all iron and steel products, and prices, save in the case of pig-iron, were well maintained. He concludes that "the new year opens with the promise of a still more active and more prosperous business for our iron and steel manufacturers than the old year gave to them."

COAL PRODUCTION OF 1878.

The only branch of our coal industries of which accurate statistical information is available is the Anthracite Coal Trade of Pennsylvania, which is credited with a production of 18,275,000 tons (of 2240 pounds). This amount was divided among the several regions in the following proportions:

Wyoming region	7,925,000	tons.
Lehigh "	3,440,000	"
Schuylkill "	6,910,000	"
Total	18,275,000	"

This amount shows a falling-off of nearly three millions of tons as compared with the output of the previous year (21,323,000 tons); but the causes regulating the production of anthracite are so intimately connected with the business combinations of the great carrying companies that no inferences as to the bearing of the above figures upon the general business of the country would possess any value.

It may be of interest here to note that the total production of the anthracite region up to the close of the last year amounted to 400,162,832 tons, divided as follows:

Wyoming region	159,614,369	tons.
Schuylkill "	164,686,236	"
Lehigh "	75,862,227	"
Total	400,162,832	"

Concerning the production of bituminous coals (and coals other than anthracite), we have at the present time no relia-

ble sources from which to give an estimate. It is confidently asserted, however, that the combination of last year between the great mining and carrying companies to restrict and apportion the output of anthracite coal had a favorable effect upon the bituminous trade, which would otherwise have suffered a considerable falling-off of production by reason of the continued depression of manufacturing industries and high rates of transportation. From all the facts at our disposal, we infer that the production of bituminous coal during the past year will be found not to have varied notably from that of 1877—28,000,000 tons, but rather under than over this figure.

OUR SUPPLY OF ANTHRACITE AND ITS DURATION.

By the courtesy of Mr. R. P. Rothwell, Mining Engineer, and the editor of the *Engineering and Mining Journal*, we are enabled to present in the *Record*, from a forthcoming historical treatise on the Anthracite Coal-fields of Pennsylvania, the subjoined tabulation, which we believe is entitled to be considered as a closer approximation to the actual facts regarding the anthracite coal supply and its duration than any previous statements that have appeared.

The following figures, which may be looked upon as being as strictly reliable as the nature of the subject will permit, the estimates of average thickness of coal in the several regions and the quantities of the mineral being carefully deduced from extensive practical observation and study, are interesting and instructive in several ways. They show, in the first place, most glaringly the remarkable crudity and wastefulness of the existing methods of getting coal, the percentage of waste even in the most favored region reaching at the present time as high as 50 per cent. of the amount actually marketed; and they indicate that the amount of anthracite actually available for the future is much less than has generally been supposed even by those well informed on the subject. At the present rate of consumption—say about 25,000,000 tons annually—and allowing the same proportion of waste that occurs in present mining practice, the whole available supply of the anthracite region will be exhausted in 180 years; but as the rate of consumption must surely increase in the future, to keep pace with the growth of manu-

Field.	Area.		Average thickness of Coal.	Quantity of Coal.		Percentage of the whole.	Amount marketed to Dec. 31, 1877.
	Sq. Miles.	Acres.	Feet.	Per Acre. Tons.	Total Quantity. Tons.		Tons.
Wyoming...	185.00	118,500	19.00	34,580	4,097,730,000	36	151,475,872
Lehigh.....	43.75	28,000	20.25	36,855	1,030,120,000	9	72,422,227
Schuylkill...	215.00	137,500	25.00	45,500	6,256,250,000	55	157,776,236
Total.....	443.75	284,000	21.42	40,084	11,384,100,000	100	381,674,335

Field.	Amount exhausted, including waste.	Amount yet remaining.	Percentage of the whole.	Amount yet obtainable, allowing for waste.
	Tons.	Tons.		Tons.
Wyoming...	With 60% waste, 378,689,680	3,719,040,320	36	With 50% waste, 1,859,520,160
Lehigh.....	With 65% waste, 206,910,302	823,209,698	8	With 60% waste, 329,283,879.2
Schuylkill...	With 60% waste, 450,766,703	5,805,483,297	56	With 60% waste, 2,322,193,318.8
Total.....	1,036,366,685	10,347,733,315	100	4,510,997,358

factures, it is not at all improbable that the demand will be considerably increased within the next decade or two; so that the period at which the anthracite fields will have become practically exhausted will be materially shortened. A production of 100,000,000 tons, which is about the annual output of the coal-fields of Great Britain, would suffice to exhaust our anthracite in the brief space of 45 years; though the rapid development of the enormous deposits of bituminous coal in various parts of the country, and the exhaustless supplies of this form of mineral fuel that are available in nearly all parts of the country, render it scarcely probable that the consumption of our anthracite will ever reach these figures. It is well, nevertheless, that the popular notion that our anthracite supply is practically exhaustless should be distinctly understood to be a most mistaken one; and having recognized this unpleasant fact, it will behoove our mine-owners and operators to devise and introduce such improvements in the manner of mining coal as shall reduce the present large percentage of loss by waste to a more reasonable amount.

PRECIOUS METALS.

The *Engineering and Mining Journal*, from the most reliable data in its possession, estimates the production of pre-

cious metals in the United States during 1878 to have been at least $85,000,000, made up of

Gold	$41,000,000
Silver	40,000,000
Lead	4,000,000
Total	$85,000,000

NUMBER AND CAPACITY OF THE IRON AND STEEL WORKS OF THE UNITED STATES.

From the valuable "Directory to the Iron and Steel Works of the United States," prepared and published by the American Iron and Steel Association, we are enabled to present the number and capacity of the blast-furnaces, rolling-mills, steel-works, catalan forges, and bloomeries in every state and territory, as corrected to September 1, 1878, to wit:

Number of completed blast-furnaces	698
Annual capacity of all the furnaces in pig-iron (net tons)	5,868,000
Annual capacity of bituminous-furnaces in pig-iron (net tons)	2,587,000
Annual capacity of anthracite-furnaces in pig-iron (net tons)	2,281,000
Annual capacity of charcoal-furnaces in pig-iron (net tons)	1,000,000
Number of rolling-mills	340
Number of single puddling-furnaces in rolling-mills (a double furnace counting as two single ones)	4,463
Number of puddling-furnaces in steel-works and bloomeries	51
Total number of single puddling-furnaces	4,514
Number of trains of rolls in rolling-mills	1,252
Number of trains of rolls in steel-works of all kinds	95
Total number of trains of rolls	1,347
Annual capacity of all rolling-mills in finished iron (net tons)	4,461,000
Annual capacity of all rail-mills in heavy rails (net tons)	1,972,000
Number of Bessemer steel-works	11
Number of Bessemer converters	22
Annual capacity in ingots (net tons)	750,000
Number of open-hearth steel-works	14
Number of open-hearth furnaces	22
Annual capacity in ingots (net tons)	100,000
Number of crucible cast-steel works	38
Number of steel melting-pots	3,400
Annual capacity in ingots (net tons)	90,000
Number of miscellaneous steel-works	8
Annual capacity of same in merchantable steel (net tons)	22,000
Number of steel-manipulating works	23
Number of catalan forges (blooms from ore)	64
Annual capacity in blooms and billets (net tons)	65,000
Number of bloomeries (blooms from pig-iron)	58
Annual capacity in blooms (net tons)	65,000

In the above tabulation the producing capacity of the iron and steel works of the country has been stated by aggregating the individual returns of each establishment. Since, however, in practice, blast-furnaces and rolling-mills can never be operated uniformly to their full capacity, these aggregates with respect to them will never be actually realized. With regard to the forges, bloomeries, and steel-works, however, the summary is believed to represent, without much overstatement, their actual working capacity.

THE WORLD'S PRODUCTION OF IRON AND COAL.

It may be of value to introduce here a statement of the world's production of iron and coal, and of steel, which is given herewith, the estimates being based upon the most recent accurate information at disposal:

Countries.	Cast or Pig Iron.		Mineral Coal.	
	Years.	Gross Tons.	Years.	Gross Tons.
Great Britain	1877	6,300,000	1877	134,179,968
United States	1877	2,066,594	1877	50,000,000
Germany	1877	1,566,600	1877	48,337,950
France	1877	1,322,869	1876	16,773,779
Belgium	1877	418,366	1876	14,099,281
Austro-Hungary	1876	472,285	1875	12,852,048
China	.....	.....	1877	3,000,000
Russia	1875	420,484	1875	1,152,850
Australasia	.....	10,000	1875	1,250,000
Dominion of Canada	1876	7,500	1877	1,000,000
Sweden	1876	346,955	.....	.....
Grand Duchy of Luxemburg	1877	250,000	.....	.....
Spain	1872	73,000	1877	500,000
India	.....	.....	1875	500,000
Turkey	.....	40,000	.....	150,000
Italy	.....	25,000	1874	182,500
Switzerland	1872	7,500	.....	.....
Mexico	1876	7,500	.....	.....
Japan	1877	10,000	1874	390,000
Norway	1870	3,975	.....	.....
All other countries	.....	10,000	.....	1,000,000
Total		13,358,628		285,368,376

To the foregoing figures of pig-iron there should properly be added the known and estimated make of iron direct from the ore, by primitive methods, as practised in certain parts of this country, in China, India, and other countries. This Mr. Swank estimates at about 50,000 tons yearly; and if so added, would swell the figure of total production to 13,408,628 gross tons, or, in round numbers, 13,400,000 tons.

The world's steel product in 1877, based upon the latest reliable statistics, is as follows, in tons of 2240 pounds: Great Britain, 1,000,000; United States, 570,000; Germany, 370,000; France, 250,000; Belgium, 75,000; Austro-Hungary, 75,000; Sweden, 25,000; Russia, 15,000; Canada, Spain, Italy, India, Japan, and other countries, 20,000—making a total of 2,400,000 gross tons.

SILK MANUFACTURE.

The statement of the imports of raw silk at the ports of New York and San Francisco for the year 1878, which we have received through the politeness of the secretary of the Silk Association of America, indicates a steady growth of the silk industry in this country, showing as it does an increase in the consumption of the raw material. The figures for several years, presented for comparison, are as follows:

Year.	Bales.	Value.
1874	7,452	$3,627,367
1875	10,552	5,327,742
1876	11,237	5,600,877
1877	9,913	5,591,084
1878	13,698	6,774,305

An inspection of these figures will show that the number of bales imported in 1878 is so largely in excess of that for the previous year that the value also shows a considerable increase, although the price of raw silk is materially lower than at any time since the Rebellion. The general statistics of the trade, compared for a number of years, demonstrate its steady growth by illustrating that the falling-off of our imports of manufactured silk goods has been in close relation with the steady increase of their production here. During the past year, it may be noticed, the question of introducing the culture of silk in the United States has attracted widespread interest and enlisted the advocacy of many influential men. Prominent among these may be named Professor C. V. Riley, of the Department of Agriculture, whose able paper before the American Association for the Advancement of Science, on the feasibility of successfully establishing silk-culture as an American industry, is worthy of special notice.

MANUFACTURE OF COTTON.

The statistics of this branch of manufacturing industry are

very encouraging. The more important facts and figures bearing thereon are given below:

	Census, 1860.	Census, 1870.	Estimated, 1878.
Number of cotton-spindles....	5,235,727	7,132,415	10,500,000
Cotton consumed in pounds) gross (tare not deducted).)	415,000,000	396,000,000	698,000,000
Product, cloth, yarn, etc.) (pounds).....)	364,000,000	340,000,000	586,000,000
Corresponding to yards.....	1,200,000,000	1,445,000,000	2,637,000,000
Yards per pound.....	3½	4½	4½

The exports of domestic cotton goods for the years below, ending June 30, are as follows:

	Total values.
1875.....	$5,481,000
1876.....	9,062,000
1877.....	10,236,000
1878.....	11,435,000

The largest export of this class of goods, which was reached in the year ending June 30, 1878, amounted to 6¼ per cent. of the total production. The export trade has increased in the last three years at an average rate of about 60 per cent. yearly in quantity, and 36 per cent. in value. Capital invested in cotton manufactures, 1878, $208,000,000.

Our imports of wool, and manufactures thereof, for the nine months ending September 30, 1878, as per the statements of the Bureau of Statistics, were of the value of $23,878,631, a decrease of nearly nine millions as compared with the figures for the corresponding period of 1877. Our exports of these manufactures are as yet insignificant. Statistics of home production to date are not at present available.

For the twelve months ending December 31, 1878, the value of the exports of merchandise of the United States exceeded that of the imports by $305,343,028.

NECROLOGY.

Anderson, Andrews Anders. A well-known ornithologist, especially familiar with the birds of India. Died in July, 1878.

Asten, Professor Emil von. Author of several important papers on astronomical subjects, especially respecting the orbits of *Uranus* and the motion of Encke's comets. Died August 15th, at Kiel, in the thirty-sixth year of his age.

Back, Admiral Sir George. Well known in connection with arctic exploration. Accompanied Sir John Franklin, in 1818, in his overland expedition from Hudson Bay to the Coppermine River, after a still earlier experience in a voyage to Spitzbergen. With Franklin again in 1825, cooperating with Captains Beechy and Parry in their search for a Northwest passage. Appointed to conduct an expedition in 1833 for the relief of Sir John Ross; and closing his connection with arctic exploration by a voyage to Greenland in the *Terror*, in 1836, when he nearly reached Repulse Bay. Died in June, in the eighty-first year of his age.

Bardwell, Professor F. W. Employed for a time, after graduating at Harvard, on the *Nautical Almanac;* then Professor at Antioch College, and subsequently Professor of Astronomy and Engineering in the University of Kansas. Died at the age of forty-six.

Becquerel, Professor A. C. Member of the Institute of France, and the author of many valuable papers on electricity; for his discoveries, a recipient of the Copley Medal of the Royal Society of London in 1837. A Professor of Physics in the Museum of Natural History of Paris. Died January 19th, at the age of nearly ninety.

Behn, Professor W. F. G. Professor of Zoology in the University of Kiel, and also at Dresden; subsequently President of the Leopold-Caroline Academy of Naturalists. Died at Dresden, May 14th, in the seventieth year of his age.

Belgrand. A distinguished French engineer, and the projector of the system of sewerage in Paris. Died April 8th, in the sixty-eighth year of his age.

Belt, Thomas. An accomplished naturalist and geologist. Died in Colorado.

Berendt, Dr. G. Well known for his explorations in Mexico and Central America; an ardent student of the ethnology, geography, and natural history of these countries, and especially interested in the philology of the

aborigines. It is understood that his writings were bequeathed to the Berlin Museum. Died at Guatemala City, April 12th.

Bibra, Baron von. A remarkable combination of savant and naturalist, having written many important papers on chemical subjects, on the diseases of workmen in match-factories, on *materia medica*, and on archæology; also the author of many interesting novels and sketches. Died at Nuremberg on the 5th of June.

Blackmore, William. An eminent lawyer in London; the founder of the Blackmore Museum of Ethnology at Salisbury, England, which he endowed with a sufficient sum for its support. Died in April last.

Bleeker, Dr. Peter von. An eminent ichthyologist, who, at nineteen, went to Batavia on the medical staff of the East Indian army, where he studied zealously the natural history of the country, especially that of the fishes. Of these he made large collections, which served as material for extended publications, and which are now deposited in the British, Hamburg, and Netherlands museums. Died at the Hague, January 24th, at the age of fifty-nine.

Bloxam, Rev. Andrew. Well known as a botanist, especially in connection with the study of certain forms of *Rosaceæ*. Died February 2d, at the age of seventy-six.

Bonomi, Joseph. A distinguished Egyptian explorer, commencing his labors in 1824, and resuming them in 1842, after a visit to England. He arranged the Egyptian collections of the British Museum, and was for sixteen years Curator of the Soane Museum. Died March 3d, near London, at the age of eighty-two.

Booth, Rev. James. Known as an author of several mathematical papers. Received the presentation to the Vicarage of Stone from the Royal Astronomical Society, which holds the right of appointment. Died April 15th, at the age of seventy-one.

Borszczow, Elias. A Russian botanist. Director of the Botanic Garden of Kiew. Died at Kiew, May 12th.

Brüggemann, Dr. F. A valued collaborator of the British Museum, having been engaged about a year before his death in arranging and cataloguing its corals, of which he had determined 1500 species. For many years an assistant of Professor Hæckel.

Buxton, C. E. A student of the ornithology of Sumatra, of which he collected many rare species. Died while engaged in an exploration on the Niger.

Church, Professor Albert E. In charge of the chair of mathematics at West Point, having been connected with the institution for forty years. Author of "Elements of Differential and Integral Calculus," and "Elements of Analytical Geometry." Died March 30th.

Clarke, Rev. W. B. A well-known Australian geologist. Died at Sydney.

Cooper, T. T. Distinguished as an explorer and traveller in India, China, Australia, and elsewhere, his labors resulting in the accumulation of a large amount of geographical and statistical information, to be found in British official publications. Assassinated by one of his Sepoy guards on the Irrawaddy River.

Corbett, Dr. Joseph Henry. Formerly Professor of Anatomy and Physiology in the University of Dublin. Died in March.

Crespel, Captain. One of the Belgian Committee of the International African Association for prosecuting certain special explorations. Died at Zanzibar.

Curioni, Giulio. A distinguished chemist and geologist. Died at Milan, in his eighty-second year.

Daintree, Richard. A well-known Australian geologist. Died at Queensland, in his forty-sixth year.

Delafosse. Professor of Mineralogy in the Paris Museum of Natural History. Born in 1796, and elected Perpetual Secretary of the Academy of Sciences of Paris in 1857. Died October 13th, in the eighty-third year of his age.

Du Mortier, Barthélemy Charles. A Belgian botanist and zoologist, and well known for his investigations upon the fresh-water Bryozoans and Gasteropods. Died at Tournay, on the 9th of July, in the eighty-second year of his age.

Durien. See de Maissonneuve.

Durnford, Henry. Known as a zoological explorer in South America. Author of an account of the birds of Patagonia in the London *Ibis*. Died at Salto, in Bolivia, early in July.

Elton, Captain. A well-known African explorer, whose journals, drawings, and maps are of great value. Died while engaged in important explorations.

Ettingshausen, Baron von. Born at Heidelberg in 1796. Professor of Physics in Innspruck in 1821, afterwards Professor of Mathematics in Vienna, and finally Professor of Physics in that city, and Director of the Physical Institute of Vienna. A well-known author of works on mathematics, geology, and palæontology. Died at the age of eighty-two.

Fischer, Professor. Connected with the Laboratory of the Gymnasium of Prague, and eminent as a chemist. In a blind confidence that cyanide of potassium would be rendered harmless by combining it with sal ammoniac, he took this combination in the presence of fellow investigators, and died at the age of twenty-five.

Fordos, J. Vice-President of the Paris Chemical Society. Died in August.

Fries, Professor Elias M. A distinguished botanist of the University

of Upsala. Born August 15th, 1794. Died February 8th, at the age of eighty-four.

Gabb, William M. Born January 20th, 1839. Educated at the Philadelphia High-School, and early interested in mineralogy and palæontology. Elected a member of the Academy of Natural Sciences, he became a zealous student of the fossil invertebrates of the United States. In 1860 engaged by Professor J. D. Whitney in the geological survey of California, and in 1868 commenced the work of a geological survey of the lands of the San Domingo Land and Mining Company. In 1873 he undertook a similar service for the government of Costa Rica, at the same time making researches into the natural history and ethnology of the country, and sending valuable collections to the National Museum at Washington. Revisited San Domingo in 1876, but again returned to Philadelphia in March, 1878, where he died on the 30th of May, in the fortieth year of his age.

Girard, Professor H. Known in connection with the Stassfurt deposits. Recently Director of the Halle Museum. Died April 12th.

Griffith, Sir Richard. The oldest geologist of England. Died in October, at the age of ninety-four.

Grubb, Thomas. A mechanical engineer, and distinguished as a practical optician, having constructed some of the finest telescopes in Great Britain. Died September 19th.

Hailes, Daniel. Distinguished as one of the crew of Captain Nares, and one of the ten who planted the Union-Jack in latitude 83° 20′ 26″. Died, a victim of the ill-fated *Eurydice*, off the Isle of Wight, on the 25th of March.

Harkness, Professor Robert. Professor of Natural History in Queen's College, Cork. Died October 4th, at the age of fifty.

Hay, Arthur. Marquis of Tweeddale. President of the Zoological Society of London. A specialist in ornithology. Died December 29th.

Henry, Professor Joseph. The most eminent scientist of America; commenced his public career early in the present century, first at Albany, then at Princeton, and finally as the honored Secretary of the Smithsonian Institution, which position he occupied since 1846. Distinguished for many important discoveries and observations on physics, especially in connection with the electro-magnetic telegraph. Born in 1799. Died in Washington, May 13th, in the seventy-ninth year of his age.

Hermanauz, Professor C., of Vienna. Died in Japan, while on a tour round the world, in connection with agricultural research.

Hewitson, William. Well known for his publications on British Zoology and on butterflies, and for his liberal benefactions in the interest of the latter branch of natural history.

Hoffner, Ferdinand. Editor of the *Biographie Générale.* Died at Seine-et-Pise, May 8th, at the age of sixty-eight.

Jæger, August. Botanist. Died at Freiburg.

Kohl, Dr. Johann George. City Librarian of Bremen. Visited the United States some years ago, for the purpose of studying certain points connected with the early geography of America. Died on the 28th of October, at the age of seventy.

Kurz, Sulpiz. Curator of the Herbarium of the Calcutta Botanic Garden. Author of a work on the flora of British Burmah. Born at Munich. Died at Pulo Penang, aged forty-four.

La Marmora, General. An eminent Italian engineer and patron of scientific research.

Landvört, Schouw. Connected with the Geographical Society of Holland, and leader of an expedition for the exploration of the Interior of Sumatra.

Langethal, Professor C. E. A well-known botanist of Germany. Born at Erfürt in 1806. Died at Jena, July 25th, in the seventy-second year of his age.

Leymarie. Professor of Geology at Toulouse. Author of the first geological map of France. Died October 5th.

MacNab. Curator of the Edinburgh Botanic Gardens. Died November 20th, aged sixty-nine.

Main, Rev. Robert. Director of the Radcliffe Observatory at Oxford. Died on the 7th of May, at an advanced age.

Maissonneuve, Michel Charles Durien de. Honorary Director of the Gardens of Bordeaux. Died February 20th, at the age of eighty-two.

Malaguti, Professor. A well-known French chemist. An Italian by birth. An assistant for a time of Gay Lussac; occupied the chair of chemistry at Rennes at the time of his death, which took place April 24th, in the seventy-seventh year of his age.

Mello, Joaquim Covrea de. A botanist of Brazil. Died December 20th.

Montgomerie, Colonel. Connected with the Indian Trigonometrical Survey Department since 1852.

Mörch, Dr. An eminent Danish conchologist. Died at Nice in February.

Murray, Andrew. An author of works in several distinct branches of pure and applied zoology; his researches being more especially directed to scientific entomology in its applications to agriculture, forestry, etc. Author of a very important work on the geographical distribution of the Mammals. Born in 1812. Died January 10th, at the age of sixty-five.

Oldham, Professor Thomas. Well known as the Director of the Geo-

logical Survey of India. At one time filled the chair of geology in the University at Dublin, and occupied many other important posts as a geologist and mineralogist. Died at Rugby, July 17th.

Olney, Stephen F. An American botanist; devoted especially to the botany of Rhode Island. Died at Providence, R. I., July 27th, aged sixty-six.

Pfeiffer, Louis. A botanist and conchologist; especially known for his monographs of the land shells. Died at the age of seventy-two.

Pickering, Dr. Charles. Born in 1804. Becoming a resident of Philadelphia in 1827, he was for many years an active member of the Academy of Natural Sciences of that city. Was connected with the Wilkes Exploring Expedition. Travelled through portions of Europe, Asia, and Africa, in search of ethnological data. Author of several important works connected with his favorite studies, especially on the races and the geographical distribution of man, plants, animals, etc. Died in Boston, March 17th, in the seventy-fourth year of his age.

Quetelet, Ernest. Distinguished as an astronomer; connected with the Royal Observatory of Brussels for several years. Born August 7th, 1835. Died September 6th.

Raspail, V. R. An eminent French naturalist; a writer on systematic botany, vegetable physiology, and chemical jurisprudence. The inventor of a valuable microscope, still in use as a dissecting instrument. Died January 17th, in the eighty-fourth year of his age.

Regnault, H. B. Born in July, 1810. In 1840 appointed Professor of Physics in the College of France, and of Chemistry in the Polytechnic School. In 1854, a director in the porcelain manufactory at Sèvres. The author of many valuable works on the use of steam as a motive power. Died January 29th.

Rokitansky, Professor Karl von. President of the Vienna Academy of Sciences. Best known as a pathological anatomist. Died July 23d, at the age of seventy-four.

Secchi, Father. Director of the Observatory in the Collegio Romano. The founder of the society of Italian spectroscopists. At one time connected with Georgetown College, D.C. Died February 26th, at the age of fifty-nine.

Seubert, Moritz. A botanist. Died April 6th, at Carlsruhe, aged sixty.

Soleil. An eminent manufacturer of optical instruments in Paris. Died recently, in the eightieth year of his age.

Stål, Professor C. Author of important papers on the *Hemiptera* and *Orthoptera*. Connected with the State Museum of Sweden. Died June 14th, in the forty-fifth year of his age.

Stokes, Professor William, of Dublin. Died January 7th.

Thatcher, Charles. A well-known conchological collector. Died of fever at Shanghai.

Thomson, Dr. Thomas. A botanist, and well known as an assistant of Sir Joseph Hooker in Himalayan exploration, and in the Indian flora. At one time Director of the Calcutta Botanic Garden. Born at Glasgow, 1811. Died April 18th.

Visiani, Professor R. de. In charge of the department of botany in the University of Padua. Author of a "Flora Dalmatica," etc. Died May 4th, aged seventy-seven.

Wallis, Dr. Gustav. A distinguished German botanist. A collector of plants in Central and South America, and also in the Philippine Islands. It is said that 1000 new species were introduced by him into European horticulture.

Weber, Professor E. H., of Leipsic. Occupied the chair of physiology in the University of Leipsic. Author of several treatises on anatomy and physiology. Died January 16th, in the seventy-eighth year of his age.

Williams, Professor Gustav. A well-known African explorer. Connected with the Strasburg University. Died at the age of thirty-two.

Wiser, Dr. David. An eminent Swiss mineralogist. Died at Zurich, March 21st, at the age of seventy-six.

Wolfers, Professor. Editor of the *Astronomisches Jahrbuch.* Many years connected with the Berlin Observatory. Died in that city, April 22d, at the age of seventy-five.

Wollaston, Thomas Vernon. A distinguished British entomologist. Author of many valuable papers on the entomology of Great Britain, and of memoirs on the *Coleoptera* of the Madeiras, Salvages, Cape Verdes, and St. Helena. Died January 4th, at the age of fifty-seven.

Yandell, Dr. L. P. An eminent physician, and devoted to the study of the fossil forms of animal life, especially the Crinoids. Died at Louisville, Ky., February 4th, at the age of seventy-three.

Zanardoni, Professor Giovanni. Botanist. Died at Venice, April 24th, aged seventy-four.

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SELECT WORKS ON SCIENCE PUBLISHED DURING 1878.

The following enumeration continues the record of the principal works published in the various departments of science from the previous Annuals, and has been compiled in accordance with the same principles. In other words, it is necessarily a very partial enumeration, being, for the most part, confined to those works that have been noticed in several of the most prominent and widely circulated periodicals of the day; for the limitations of the *Record* preclude an exhaustive bibliography. The ground in this respect is covered by elaborate bibliographies, the chief of which are enumerated under the head of "Annual Records of Progress in Science." Those volumes that have features of general interest to commend them, or are of special scientific value, have, for the most part, been included. A few, however, of an exceptionally bad character are noticed with a word of caution.

Whenever the volumes catalogued could be referred to without excessive loss of time or expense, they have been consulted, and the titles taken, or corrected directly from them. Unfortunately, this means of verification or correction could only be employed to a limited extent. The attempt to do so, nevertheless, has cost an amount of time and labor scarcely repaid by the results.

The works in question are enumerated as nearly as possible, or as seemed convenient to the reader, in a logical sequence, and under those headings to which it was supposed the majority of persons would look for works of the character desired. As to the periodicals, comparatively few could be catalogued, and these mostly (1) the publications of very prominent societies and magazines of a high character, or (2) the publications noticed in the Annuals to which references have been made for notices. All the periodicals have been enumerated under the head of "General Science;" but in the case of those devoted to special branches, references have been made to the places where they are catalogued,

under the heads of the special subjects to which they are dedicated.

Especial attention may be again called to the annual records of progress in the different departments of science. These must be considered as indispensable adjuncts to the student, and no considerable library should be without them. The cost is inconsiderable, and there are very few cases where, in an enforced choice between a new monograph in the department to which one relates and the *Annual Record* itself, preference might not wisely be given to the latter over the former. The neglect to make such provision is, nevertheless, remarkable, and most of the libraries of the country are destitute of these indispensable periodicals, and to many librarians they seem to be even unknown.

As in previous volumes of this *Record*, those journals have been referred to for notices of new works which are most widely circulated in the United States, and therefore available to most readers. They are the following:

(1) The American Journal of Science and Art. Editors and Proprietors: James D. and E. S. Dana, and B. Silliman. Associate Editors [eight]. Third series. Volume XV. [Volume XVI.].—(Whole number, CXV., CXVI.) Nos. 85–90 [Nos. 91–96]. January to June, 1878 [July to December, 1878]. New Haven: J. D. & E. S. Dana. 1878. (8vo. Published monthly. Price, $6 00 per year, with 12 cts. for prepaid postage.)

(2) The American Naturalist, an Illustrated Magazine of Natural History. Edited by A. S. Packard, Jr., and Edward D. Cope. Associate Editors [four]. Volume XII. [Volume XIII.]. Philadelphia: Press of McCalla & Stavely [etc.]. 1878. (8vo. Published monthly; yearly subscription, $4 00.)

(3) Nature: a Weekly Illustrated Journal of Science. Volume XVII. October 1877 to May 1878. [Volume XIX. October 1878 to May 1879.] London and New York: Macmillan and Co. 1878. (4to. Published weekly. Price, sixpence per number.)

(4) The Popular Science Monthly. Conducted by E. L. Youmans. Vol. XII. November, 1877, to April, 1878 [et seq.]. New York: D. Appleton and Company, 549 and 551 Broadway. 1878 [et seq.]. (8vo. Published monthly. Price, $5 per annum.)

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[Nature, XVII., 461–463.]

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