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> *Of Nature trusts the mind which builds for aye.*"—WORDSWORTH

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INDEX

Abbe (Prof. Cleveland), the "Rollers" of Ascension and St. Helena, 585
Abel (Sir Frederick, F.R.S.), Smokeless Explosives, 328, 352
Abercromby (Hon. John), a Trip through the Eastern Caucasus, 391
Abercromby (Hon. R.), the Motion of Dust, 406
Abney (Captain W. de W., F.R.S.), Photo-nephograph, 491
Abnormal Shoots of Ivy, W. F. R. Weldon, 464
Aborigine, a Surviving Tasmanian, Hy. Ling Roth, 105
Acetic Acid Solutions, Vapour-pressure of, Raoult and Recoura, 431
Accumulations of Capital in the United Kingdom in 1875–85, Robert Giffen, 211
Achlya, Prof. Marcus M. Hartog, 298
Acoustics: Melde's Vibrating Strings, Rev. W. Sidgreaves, 355; Propagation of Sound, Violle and Vautier, 359; the Testing of Tuning-forks, Dr. Lehmann, 383
Acquired Characters, Palæontological Evidence for the Transmission of, Henry Fairfield Osborn, 227
Acquired Characters and Congenital Variation: the Duke of Argyll, F.R.S., 173, 294, 366; W. T. Thiselton Dyer, F.R.S., 315; F. V. Dickins, 316; Right Rev. Bishop R. Courtenay, 367; Dr. J. Cowper, 368; Herbert Spencer, 414; Prof. E. Ray Lankester, F.R.S., 415. *See also* Panmixia
Actinometric Observations at Kiev, 1888–89, R. Savelief, 359
Acworth (W. M.): Railways of England, 434; Railways of Scotland, 434
Adams (Prof. J. C., F.R.S.), on certain Approximate Formulæ for Calculating the Trajectories of Shot, 258
Adamson (Daniel): Death of, 256; Obituary Notice of, 279
Advancement of Science, Australasian Association for the, Prof. Orme Masson, 441
Africa: H. M. Stanley's Exploration of, 20, 73; Reported Massacre of Dr. Peters's Party, 21; South African Gold-fields, the, G. D. Cocorda, 164; the Land of an African Sultan, Walter B. Harris, 270; East Africa and its Big Game, Captain Sir J. Willoughby, 298; African Monkeys in the West Indies, Dr. P. L. Sclater, F.R.S., 368; Meteorology of the Gold and Slave Coast, Dr. Danckelmann, 479
Agriculture: Sheep Farming in Australia, Prof. Wallace, 113; Practical Observations on Agricultural Grasses and other Pasture Plants, William Wilson, 196; Field Experiments on Wheat in Italy, Prof. Giglioli, 404
Ahrens's Polarizing Binocular Microscope, 93
Aitken (John, F.R.S.), On the Number of Dust Particles in the Atmosphere of Certain Places in Great Britain and on the Continent, with remarks on the relation between the Amount of Dust and Meteorological Phenomena, 382, 394
Aitkens (Sir William), Animal Alkaloids, Second Edition, 161
Aka Expedition of 1883, Colonel Woodthorpe, 86
Algæ, a New Atlas of, Dr. J. Reinke, 127
Algebra: an Elementary Text-book for the Higher Classes of Secondary Schools and for Colleges, Prof. G. Chrystal, 338
Algebraic Equations, Roots of, Prof. A. Cayley, F.R.S., 335
Algeria, Earthquake in, 113
Algol, Satellite of, W. H. S. Monck, 198
Algol, Spectroscopic Observations of, Prof. Vogel, 164, 285
Alpine Chain, a Geological Map of the, Prof. T. G. Bonney, F.R.S., 483
Alpine Expeditions of Dr. Emil Zsigmondy, 291
Aluminium and Nitric Acid, A. Ditte, 599
Amber, Mexican, G. F. Kunz, 372
America: Sir Daniel Wilson on the Recent Toronto Meeting of the American Association for the Advancement of Science, 17; European Weeds in, 18; American Journal of Mathematics, 71, 332, 525; American Resorts, with Notes upon their Climate, Dr. Bushrod W. James, 79; American Journal of Science, 46, 92, 309, 405, 500, 598; American Meteorological Journal, 92, 357, 501; American Meteorological Society, 324; American Ethnological Reports, J. W. Powell, 99; American Philosophical Society, Philadelphia, 136; American Naturalist, 231
Among Cannibals, Carl Lumholtz, 200
Amsterdam, Royal Academy of Sciences, 24, 96, 216, 383, 552, 600
Analytical Tables, Coloured, H. W. Hake, 29
Anatomy: a Glossary of Anatomical, Physiological, and Biological Terms, T. Dunman, 173; a Text-book of Human Anatomy, Prof. Alex. MacAlister, F.R.S., 269
Anchovies on the South Coast of England, J. T. Cunningham, 230
Anderson (Joseph), Sugar losing its Attractions for Lepidoptera, 349
André (Ch.), Jupiter's Satellites, 94
Anemometers, W. H. Dines, 212
Angot (Alfred): Wind-Velocity at Top of Eiffel Tower, 48, 67; the Observations of Temperature on Top of Eiffel Tower, 167; on the Eiffel Tower Observations, 181; Diurnal Range of Barometer, 449
Animal Life, Glimpses of, W. Jones, 409
Animals and Plants, Distribution of, by Ocean Currents, Rev. Paul Camboué, 103
Animals, Effects of Music on, A. E. C. Stearns, 470
Animaux, Les Industries des, F. Houssay, 409
Annuario Meteorologico of the Italian Meteorological Society, 231
Anomalies, Temperature, Dr. R. Spitaler, 303
Anoura, the Metamorphosis of, E. Bataillon, 23
Anthropology: the Malay People, Dr. B. Hagen, 21; the Last Living Aboriginal of Tasmania, 43; Prehistoric Burial-ground discovered in Caucasus by Beyern, 43; Anthropological Institute, 119, 256, 406; Journal of the Anthropological Institute, 594; Inheritance of Acquired Mental Peculiarity, Handtmann, 209; L'Anthropologie, 300; the Veddahs of Ceylon, Dr. Arthur Thomson, 303; Classification of Races, Based on Physical Characters only, M. Denniker, 332; Modern Crania in Montpellier, De Lapouge, 357; the Cephalic Index of Corsican Population, Dr. A. Fallot, 357; the Chin Tribes of North Burma, G. B. Sacchiero, 375; Characteristic Survivals of Celts in Hampshire, T. W. Shore, 406; Charlotte Corday's Skull, Dr. Topinard, 500; Jacques Bertillon on the Identification of Criminals by Measurement, 592
Anthropometry, Cambridge: Dr. John Venn, F.R.S., 450, 560; Francis Galton, F.R.S., 454
Antilles, the Lesser, Owen T. Bulkeley, 268
Antiparallel, the Use of the Word, W. J. James, 10; E. M. Langley, 104

Apex of the Sun's Way, Lewis Boss, 548
Aplin (O. V.), the Birds of Oxfordshire, R. Bowdler Sharpe, 169
Aquaria, the Management of, W. P. Seal, 18
Arc Light, Joseph McGrath, 154
Archæology : Interesting Remains discovered in Hamburg, 21 ; Archæological Congress at Moscow, 283 ; Cambridge Archæological Museum, 324 ; Proposed Archæological Survey of Ceylon, 372 ; Vaphio (Morea) Rock-Sepulchre, S. Reinach, 500 ; Archæology and Ethnology of Easter Island, Walter Hough, 569
Arctic Ice Cap, is Greenland our, S. E. Peal, 58
Arctic (North Pole) Expedition, Dr. Nansen's Plan for, 374
Arctic Voyagers, Cause of Change of Skin-Colour in, Prof. Holmgren, 546
Area of the Land and Depths of the Oceans in Former Periods, T. Mellard Reade, 103
Argentina, Dr. Hermann Burmeister on the Fossil Horses and other Mammals of, 82
Argentine Ornithology, P. L. Sclater, F.R.S., and W. H. Hudson, R. Bowdler Sharpe, 7
Argyll (the Duke of, F.R.S.) : Acquired Characters and Congenital Variation, 173, 294, 366 ; and the Neo-Darwinians, W. T. Thiselton Dyer, F.R.S., 247
Arloing (M.), Diastases Secreted by *Bacillus heminecrobiophilus*, 143
Armenia, the Catastrophe of Kantzorik, F. M. Corpi, 190
Armstrong (Prof. H. E., F.R.S.), Constitution of Tri-derivatives of Naphthalene, 454
Arnaud, Digitaline and Tanghinine, 48
Arrest's (D'), Comet, G. Leveau, 596
Ascension, the "Rollers" of, Prof. Cleveland Abbe, 585
Ascidians and Crabs, Prof. W. A. Herdman, 344
Asia, Central : Colonel Roborovski's Expedition in, 234 ; the Russian Expeditions in, 352
Asia Minor, Prof. Bornmüller's Botanical Tour through, 136
Asiatic Cholera, Bacteria of, Dr. E. Klein, F.R.S., 509
Assaying, Text-book of, C. Beringer and J. J. Beringer, Thomas Gibb, 245
Assmann (Dr.) : Aspiration Thermometers, 239 ; Climatological Considerations about Influenza, 325
Association for Improvement of Geometrical Teaching, 207, 282
Association of Public Sanitary Inspectors, 324
Assyrian Sculptured Group, Explanation of, Dr. E. B. Tylor, F.R.S., 283
Asteroid, a New, 450
Asteroids, Discovery of, Dr. Palisa, 522 ; M. Charlois, 522
Astronomy : Our Astronomical Column, 19, 44, 68, 87, 114, 138, 163, 210, 232, 256, 285, 304, 326, 350, 374, 402, 428, 449, 472, 496, 521, 548, 571, 595 ; Stellar Parallax by means of Photography, Prof. Pritchard, 19 ; Measurements of Double Stars, S. W. Burnham, 19 ; Barnard's Comet, 1888–89, 19 ; Biographical Note on J. C. Houzeau, M. A. Lancaster, 20 ; Karlsruhe Observatory, 20 ; Objects for the Spectroscope, A. Fowler, 20, 44, 68, 87, 114, 138, 163, 183, 210, 232, 256, 285, 304, 326, 350, 374, 402, 428, 449, 472, 496, 521, 548, 571, 595 ; Large Scale Charts of the Constellations, Arthur Cottam, 45 ; Barnard's Comet, II. 1889, March 31, 45 ; the Structure of Jupiter's Belt 3. III., Dr. Terby, 45 ; Hand-book of Descriptive and Practical Astronomy, G. F. Chambers, 49 ; Ancient Chinese Astronomical Instruments, 66 ; the Minimum Sun-spot Period, M. Bruguière, 68 ; Return of Brorsen's Comet, Dr. E. Lamp, 69 ; the Companion of η Pegasi, 69 ; General Bibliography of Astronomy, 69 ; J. C. Houzeau's Vade Mecum, 69 ; a New Comet discovered by Lewis Swift, 69 ; Total Solar Eclipse of 1886, 88 ; Palermo Observatory, 88 ; Variable Star Y Cygni, 88 ; Paramatta Observatory, 88 ; Minor Planet, 282 (Clorinde), 88 ; Comet Davidson (*e* 1889), 88 ; New Variable Star in Hydra, 88 ; Rev. S. J. Perry, F.R.S., on Sun-spots in High Southern Latitudes, 88 ; Origin of Shooting-Stars, 92 ; M. H. Faye on the Orbit of Winnecke's Periodical Comet, 94 ; Jupiter's Satellites, Ch. André, 94 ; Star Distances, Miss A. M. Clerke, 81 ; Sun-spot of June, July, and August 1889, 115 ; Photographic Star Spectra, 115 ; Comet Brooks (*d* 1889, July 6), Dr. Knopf, 115 ; Comet Swift (*f* 1889, November 17), Dr. Zelbr, 115 ; S Cassiopeiæ, Rev. T. E. Espin, 115 ; New Double Stars, Miss A. M. Clerke, 132 ; Brazilian Honours to French Astronomers, 135 ; Photometric Intensity of Coronal Light, 139 ; Corona of January 1, 1889, Prof. Tacchini, 139 ; Minor Planet 12 (Victoria), 139 ; Comet Swift (*f* 1889, November 17), Dr. R. Schorr, 139 ; Periodic Comets, 139 ; the Eclipse Parties, 139 ; Period of U Coronæ, S. C. Chandler, 163 ; Identity of Brooks's Comet (*d* 1889) with Lexell's Comet, S. C. Chandler, 163 ; some Photographic Star Spectra, 163 ; Magnitude and Colour of η Argûs, 164 ; Orbit of Barnard's Comet, 1884 II., 164 ; Spectrum of Algol, 164 ; the Newall Telescope for the University of Cambridge, 166 ; Variable Star in Cluster G.C. 3636, Prof. Pickering, 183 ; Changes in Lunar Craters, Prof. Thury, 183 ; the Satellite of Algol, W. H. S. Monck, 198 ; Recent Observations of Jupiter, W. F. Denning, 206 ; Dr. Peters's Star Catalogue, 210 ; Longitude of Mount Hamilton, 211 ; Comet Borelly (*g* 1889, December 12), 211 ; Comet Brooks (*d* 1889, July 6), 211 ; the Solar Eclipse, 211 ; Identity of Comet Vico (1844) with Brooks's (1889), 233 ; Observations of some Suspected Variables, Rev. John G. Hagen, 233 ; Spectrum of a Metallic Prominence, 233 ; Comet Swift (*f* 1889, November 17), Dr. Zelbr, Dr. Lamp, 233 ; Solar Spots and Prominences, Prof. Tacchini, 233 ; Meteor, Rev. T. W. Morton, 249 ; the Temperature of the Moon, Prof. Langley, 257 ; on the Orbit of Struve 228, J. E. Gore, 257 ; Orbit of Swift's Comet (V. 1880), 257 ; on the Variability of R Vulpeculæ, 257 ; on the Rotation of Mercury, 257 ; the Cluster G.C. 1420, and the Nebula N.G.C. 2237, Dr. Lewis Swift, 285 ; on the Spectrum of ζ Ursæ Majoris, Prof. Pickering, 285 ; Spectroscopic Observations of Algol, Prof. Vogel, 286 ; the Meteorite of Migheï, J. Rutherford Hill, 298 ; Total Eclipse of January 1, 1889, Prof. Holden, 305 ; Orbits of the Companions of Brooks's Comet (1889, V., July 6), 305 ; Greenwich Observatory, 305 ; Star Land, Sir Robert S. Ball, F.R.S., 315 ; Eight Rainbows seen at the same time, Sir William Thomson, F.R.S., 316 ; Dr. Percival Frost, F.R.S., 316 ; Annuaire du Bureau des Longitudes, 1890, 327 ; Annuaire de l'Observatoire Royal de Bruxelles, 1890, 327 ; Royal Astronomical Society, 327 ; Total Solar Eclipse of 1886, Dr. Schuster, F.R.S., 327 ; Solar Halos and Parhelia, 330 ; a Photographic Method for Determining Variability in Stars, Isaac Roberts, 332 ; Earth Tremors from Trains, and their Effects on Astronomical Instruments, H. H. Turner, 344 ; the Nuclei of Great Comet II. of 1882, F. Tisserand, 358 ; Spectrum of the Zodiacal Light, Maxwell Hall, 351 ; Solar and Stellar Motions, Prof. J. R. Eastman, 351 ; Dun Echt Observatory, 351 ; Transit Observations at Melbourne Observatory, 351 ; the Maintaining and Working of the Great Newall Telescope, 357 ; Is the Copernican System of Astronomy True? W. S. Cassedy, 366 ; Progress of Astronomy in 1886, Prof. Winlock, 374 ; Maximum Light Intensity of the Solar Spectrum, Dr. Mengarini, 374 ; Spectrum of Borelly's Comet (*g* 1889), 374 ; Spectra of δ and μ Centauri, 374 ; on the Star System ξ Scorpii, 374 ; the Total Eclipse, Prof. David P. Todd, 379 ; Scenery of the Heavens, by J. E. Gore, 391 ; the Distance of the Stars, Dr. W. H. S. Monck, 392 ; Ephemeris of Brooks's Comet (*d* 1889), 403 ; New Short Period Variable in Ophiuchus, 403 ; Observations of the Magnitude of Iapetus, 403 ; Observations of ζ Ursæ Majoris and β Aurigæ, 403 ; the Movement of Planets, F. Tisserand, 406 ; Total Solar Eclipse of December 22, 1889, M. A. De La Baume Pluvinel, 428 ; Comets and Asteroids discovered in 1889, 428 ; Mass of Saturn, Asaph Hall, 429 ; the Astronomical Observatory of Harvard College, 446 ; the Solar and the Lunar Spectrum, Prof. Langley, 450 ; the Corona of 1889, December 22, W. H. Wesley, 450 ; Nebular Hypothesis, Herbert Spencer, 450 ; Nebula, General Catalogue No. 4795, W. E. Jackson, 450 ; a New Asteroid, 450 ; Hues's Treatise on the Globes (1592), 459 ; Astronomy with an Opera Glass, Garrett P. Serviss, 462 ; Méguéia Meteorite, Prof. Simaschko, 472 ; Velocity of the Propagation of Gravitation, J. Van Hepperger, 472 ; Vatican Observatory, 472 ; Double-Star Observations, S. W. Burnham, 472 ; Sun-spot in High Latitudes, G. Dierckx, 472 ; the Elements of Astronomy, Prof. C. A. Young, 485 ; Death and Obituary Notice of, Prof. C. M. V. Montigny., 479 ; Observatory at Madagascar, 497 ; the Great Comet of 1882, 522 ; Melbourne Star Catalogue, 522 ; Brooks's Comet (*a* 1890), 522 ; Discovery of Asteroids, 522 ; Solar Activity in 1889, 522 ; New Light from Solar Eclipses, William M. Page, William E. Plummer, 529 ; the Apex of the Sun's Way, Lewis Boss, 548 ; Stability of the Rings of Saturn, O. Callandreau, 548 ; Brooks's Comet (*a* 1890), 549 ; Bright Lines in Stellar Spectra, Rev. J. E. Espin, 549 ; the Moon in London, Rev. T. R. R. Stebbing, 586 ; the Effect of Railways on Instruments in Observatories, 592 ;

Mathematical Study of Solar Corona, Prof. F. H. Bigelow, 595; Solar Observations at Rome, Prof. Tacchini, 595; D'Arrest's Comet, G. Leveau, 596; Astronomical Society of France, 596; Observations of Sun-spots made at Lyons Observatory in 1889, by Em. Marchand, 599
Atacama, on the Supposed Enormous Showers of Meteorites in the Desert of, 108
Atlantic, Waterspout in, 470
Atlantic, North, Pilot Chart of, February 1890, 401
Atlantic Ocean, Pilot Chart of the North, 85
Atlas, Facsimile, to the Early History of Cartography, by A. E. Nordenskiöld, 558
Atlas of Algæ, a New, Dr. J. Reinke, 127
Atlas of the World, Library Reference, John Bartholomew, 413
Atmosphere, General Circulation of, Dr. Pernter, 325
Atmospheric Circulation, A. Buchan, 363
Atmospheric Dust, Dr. William Marcet, F.R.S., 358, 473
Atomic Volumes of Elements Present in Iron and their Influence on its Molecular Structure, the Relation between, Prof. W. C. Roberts-Austen, F.R.S., 420
Attention, Psychology of, Th. Ribot, 460
Auger (V.), a New Class of Diacetones, 215
Australia: Australasian Association for the Advancement of Science, 400; Prof. Orme Masson, 441; Decrease of Kangaroos, 43; Exploration of the Musgrave Ranges, 86; Sheep Farming in, Prof. Wallace, 113; the Useful Plants of, J. H. Maiden, 194; Among Canibals, Carl Lumholtz, 200; Tietkens's Explorations in Central, 286; Australia Twice Traversed, Ernest Giles, 341; Report on the Meteorology of Australia, C. L. Wragge, 348; A. J. Campbell's Collections of Bird Skins and Eggs from Western Australia, 593
Austria (H.I.H. the late Prince Rudolph of), Notes on Sport and Ornithology, R. Bowdler Sharpe, 169
Aveling (Rev. F. W.), Light and Heat, 558
Avian Anatomy, Dr. R. W. Shufeldt on, 594
Ayrton (Prof. W. E., F.R.S.), Galvanometers, 310, 381

β-Inosite, Maquenne, 215
Babylonian Metrical System, the, Dr. Lehmann, 167
Bacillus heminecrobiophilus, Diastases Secreted by, Arloing, 143
Backhouse (T. W.), Luminous Clouds, 297
Bacteria: of Asiatic Cholera, Dr. E. Klein, F.R.S., 509; Biology of Anaërobic Bacteria, Dr. Weyl, 359; Luminous and Plastic Food of Phosphorescent Bacteria, Dr. Beyerinck, 552; Bacteriological Laboratory, Poona, 469
Bailey (G. H.), Behaviour of more Stable Oxides at High Temperatures, 502
Baker (T. W.), a Meteor, 418
Bala Volcanic Series of Caernarvonshire and Associated Rocks; being the Sedgwick Prize Essay for 1888, Alfred Harker, 414
Ball (John, F.R.S.), Botanical Bequest, 17
Ball (Sir Robert S., F.R.S.): "Time and Tide, a Romance of the Moon," 30; "Star Land," 315
Ball (V., LL.D., F.R.S.), Tavernier's Travels in India, 313
Ballarat School of Mines, Melbourne, 593
Balloon, Asbestos Hot-air, in India, Successful Use of, Percival Spencer, 325
Ballot (Christoforus Henricus Diedericus Buys), Obituary Notice of, 371
Banana Disease in Fiji, Sea-water Cure for, 19
Bar, New Method of Measuring small Elongations of a, Signor Cardani, 427
Barbados Monkey, the, Colonel H. W. Feilden, 349
Barber (Thos. Walter), the Engineer's Sketch Book, 52
Barclay (H. G.), Bird-preservation in the Farne Islands, 112
Barillot (Ernest), Manuel de l'Analyse des Vins, 510
Barnard (E. E.): Measurements of Double Stars, 19; Comet 1888-89, 20; Comet II. 1889, March 31, 45; Comet *b* 1889, Comet *c* 1889, discovered by, 428
Barnard (James), the Last Living Aboriginal of Tasmania, 43
Barometer, Diurnal Range of, A. Angot, 449
Barrows (W. H.), the Food of Crows, 137
Bartholomew (John), Library Reference Atlas of the World, 413
Barus (Carl), the Molecular Stability of Metals, particularly of Iron and Steel, 369
Bashore (H. B.), [American] Indian Pipe, 303
Basset (A. B., F.R.S.): Extension and Flexure of Cylindrical and Spherical Thin Elastic Shells, 238; on the Effect of Oil on Disturbed Water, 297
Bassot (M.), Difference of Longitude between Paris and Leyden 215
Basutoland, Sir Marshall Clarke on Education in, 86
Bataillon (E.), the Metamorphosis of Anoura, 23
Batoum, Curious Marine Phenomenon at, 426
Bears and Wolves in Bosnia, 325
Bebber (Dr. Van): Loomis on Rainfall of the Earth, 43; Dependence of the Force of Winds upon Surface over which they blow, 372
Beck (C. R.), Crystalline Substances obtained from Fruits of various Species of Citrus, 527
Becker (G. F.), Geology of the Quicksilver Deposits of the Pacific Slope, 532
Beddard (Frank E.), the Pigment of the Touraco and the Tree Porcupine, 152
Bedford College, London, Physical and Chemical Laboratories at, 160, 279
Bee, Wax Organs of, G. Carlet, 407
Beetle Settlement in Disused Gasometer, T. H. Hall, 520
Beevor (C. E., M.D.), Arrangement of Excitable Fibres of Internal Capsules of Bonnet Monkey, 166
Before and After Darwin, Prof. G. J. Romanes, F.R.S., 524
Behal (A.), a New Class of Diacetones, 215
Bellati (Prof. M.), the Absorption of Hydrogen by Iron, 380
Belt, Fighting for the, F. C. Constable, 199
Ben Nevis Observatory Report for January 1890, 348
Benda (Dr.), the Coiled Glands in the Skin, 24
Beneden (P. J. Van), Histoire Naturelle des Cétacés des Mers d'Europe, 223
Benedikt (Dr. R.) and Dr. E. Knecht, Chemistry of the Coal Tar Colours, 8
Bengal, Technical Education in, 65
Benham (W. B.), Earthworms from Pennsylvania, 560
Bennett (Alfred W.): Fossil Rhizocarps, 154; the Revised Terminology in Cryptogamic Botany, 225
Benzoic Acid, New Form of, 594
Berget (Alphonse), Relation between Electric and Thermal Conductivities of Metals, 287
Beringer (C.) and J. J. Beringer, Text-book of Assaying, Thomas Gibb, 245
Berlin: Physiological Society, 23, 95, 119, 288, 359, 407, 479, 504, 528, 599; Berlin Academy of Sciences, Money Grants, 42; Research Grants, 426; Physical Society, 95, 167, 215, 239, 263, 383, 407, 480, 504, 551; the Proposed Berlin International Horticultural Exhibition, 283; Berlin Nachtigall Gesellschaft, 426; Meteorological Society of, 95, 215, 383, 479, 504; Berlin Natural Science Museum, Opening of, 112
"Bermuda Islands," the, Angelo Heilprin, Dr. H. B. Guppy, 193
Bermuda Islands, Proposed Meteorological Station at the, 85
Bernoulli on the St. Petersburg Problem, 165
Bernthsen (A.), a Text-book of Organic Chemistry, 172
Berry (David), Bequest of £100,000 to the University of St. Andrews by, 41
Berthelot (M.): Animal Heat, 119; the Carbon Graphites, 311; Formation of Nitrates in Plants, 311; Berthelot and P. Petit on Animal Heat and the Combustion of Urea, 94
Bertillon (Jacques): Application of Photography to Study of Physical Peculiarities engendered by different Occupations, 230; on the Identification of Criminals by Measurement, 592
Bertrand (J.), Calcul des Probabilités, 6
Bertrand's Refractometer, Prof. S. P. Thompson, 526
Bertrand's Idiocyclophanous Prism, Prof. S. P. Thompson, 574
Berwickshire, the Birds of, Geo. Muirhead, R. Bowdler Sharpe, 169
Besson (M.): Combination of Ammonia and Phosphoretted Hydrogen with Dichloride and Dibromide of Silicon, 359; Combination of Gaseous Phosphoretted Hydrogen with Boron and Silicium Fluorides, 287
Bethnal Green Free Library, Proposed Enlargement of, 349
Betts (Benjamin), a New Logical Machine, 79
Bevan (E. J.): Acetylation of Cellulose, 142; the Constituents of Flax, 143
Beyerinck (Dr.), Luminous and Plastic Food of Phosphorescent Bacteria, 552
Beyern, Prehistoric Burial Ground in Caucasus discovered by, 43
Beynon (Richard), Effect of Oil on Disturbed Water, 205
Bezold (Prof. von), on the Production of Clouds, 95
Bible, the Religion of the Semites, Prof. W. Robertson Smith, 337

Bibliography of Astronomy, General, 69
Bibliothèque Photographique, P. Moëssard, 224
Biddulph, Lieut.-General Sir Robert, Cyprus, 45
Bidschof (Dr.), Comet Brooks (*a* 1890), 571
Bidwell (Shelford, F.R.S.), Electrification of Steam, 213
Big Game, East Africa and its, Captain Sir John C. Willoughby, 298
Bigelow (Prof. F. H.), Mathematical Study of Solar Corona, 595
Biology: Proposed Lacustrine Station on Lake Plön, 18; Prof. Weismann's Essays, Dr. St. George Mivart, F.R.S., 38; Marine Biology, the Puffin Island Station, 304; Biology of Anaërobic Bacteria, Dr. Weyl, 359; the Botanical Institute and Marine Station at Kiel, 397
Bionomics, "Like to Like," a Fundamental Principle in, Prof. Geo. J. Romanes, F.R.S., 535; John T. Gulick, 535
Bird-preservation in the Farne Islands, H. G. Barclay, 112
Birds of Berwickshire, Geo. Muirhead, R. Bowdler Sharpe, 169
Birds: Count Salvadori on the Birds of New Guinea and the Molucca Islands, 85
Birds, Dr. R. W. Shufeldt on Avian Anatomy, 594
Birds of India, Vol. I., E. W. Oates, 388
Birds in My Garden, W. T. Greene, R. Bowdler Sharpe, 169
Birds of Oxfordshire, O. V. Aplin, R. Bowdler Sharpe, 169
Birds, Sea, the Wanton Destruction of, G. W. Lamplugh, 490
Black Sea: Proposed Scientific Investigation of, 348; the Level of the, 356
Bladder in Fishes, the, Prof. Liebreich, 359
Blanchard (Prof. Raphael): Discovery of Carotine Pigment in Alpine Lake Crustacean, 325; a Colouring-matter from Diaptomus analogous to Carotin, 383
Blanford (Dr., F.R.S.), Presidential Address to the Geological Society, 455
Blind Species, Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of the, A. S. Packard, 507
Blumentritt (Dr. F.), Ethnology of Philippine Islands, 327
Blunfield (R. W.), Alexandrian Garden Pest, 181
Boat, Submarine, Periscope for Navigating, 349
Bodmer (G. R.), Hydraulic Motors, Turbines and Pressure Engines, 27
Bogdanovitch (M.), in Central Asia, 352
Boguski (J. J.), Variations of Electric Resistance of Nitric Peroxide at various Temperatures, 119
Boilers, Marine and Land, T. W. Traill, 486
Boilers, the Evaporative Efficiency of, C. E. Stromeyer, 516
Boisbaudran (Lecoq de), some New Fluorescent Materials, 287
Bollettino of Italian Geographical Society, 164
Bonavia (Dr. E.), the Cultivated Oranges and Lemons of India and Ceylon, C. B. Clarke, F.R.S., 579
Bone and Dentine, the Longevity of Textural Elements, particularly in, John Cleland, 392
Bonn, Earthquake at, 470
Bonney (Prof. T. G., F.R.S.): Crystalline Schists and their Relations to Mesozoic Rocks in Lepontine Alps, 333; a Geological Map of the Alpine Chain, 483
Bonsdorf (A. B.), the Secular Upheaval of the Coasts of Finland, 348
Boole (Mary), a New Logical Machine, 79
Borelly's Comet (*g* 1889, December 12), 211, 374, 429
Borneo (British North), Gold Exploration in, 182
Bort (Teisserenc de), Barometric Gradients, 161
Bosnia: Earthquakes in, 136; Bears and Wolves in, 325
Boss (Lewis), Apex of the Sun's Way, 548
Botany: On a New Application of Photography to the Demonstration of Physiological Processes in Plants, Walter Gardiner, 16; Foreign Botanical Appointments, 17, 136; Russian Botanical Appointments, 42; John Ball Bequest, 17; European Weeds in America, 18; Sea-water Cure for the Banana Disease, 19; some Provençal Tree Hybrids, G. de Saporta, 23; Retarded Germination, 31; the African Oil Palm in Labuan, 42; Street Plants in Manchester, 42; Enumeratio Specierum Varietatumque Generis Dianthus, F. N. Williams, 51; Morphology and Biology of *Oidium albicans*, Linossier and Roux, 72; the Flora of Derbyshire, by the Rev. W. H. Painter, 77; Pinks of Western Europe, by F. N. Williams, 78; Curious Dwarf Japanese Tree, *Thuja obtusa*, 86; Herr Kny, on Trees Growing in an Inverted Position, 86; How Plants maintain themselves in the Struggle for Existence, Prof. Walter Gardiner, 90; the Botanical Gazette, 92; Journal of Botany, 92; Nuova Giornale Botanico Italiano, 92; Cool Cultivation of Tropical, &c., Plants, Thiselton Dyer, 136; Botanical Tour through Asia Minor, Prof. Bornmüller's, 136; Tubercles on Roots of Leguminous Plants, Prof. H. Marshall Ward, F.R.S., 140; the Flora of Suffolk, by Dr. W. M. Hind, 149; Noxious Grass, Lalang, at Singapore, 182; the Useful Plants of Australia, J. H. Maiden, 194; Index of British Plants, Robert Turnbull, 196; Hand-book of Practical Botany for the Botanical Laboratory and Private Student, E. Strasburger, 223; the Revised Terminology in Cryptogamic Botany, Alfred W. Bennett, 225; Flower-Land, an Introduction to Botany, Robert Fisher, 247; the *Coco de Mer*, 256; Malayan Plants in Calcutta Herbarium, 283; the Weather Plant (*Abrus precatorius*), Dr. Francis Oliver, 283; St. Louis, the Shaw Bequest for the Endowment of Botanic Garden at, 324; the Kew Bulletin, 325, 426; Sweet-scented Fern, 349; Das australische Florenelement in Europa, Dr. Constantin Freiherr von Ettingshausen, 365; Effects of Fog on Plants under Glass, 372; *Melilotus alba* (Bokhara Clover) as a Weed in Western States of America, 372; Germination of Castor-oil Plant Seed, J. R. Green, 380; Die Arten der Gattung Ephedra, von Dr. Otto Stapf, 390; the Botanical Institute and Marine Station at Kiel, 397; Hygrometric Club Moss from Mexico, 401; Botanical Gazette, 405; Diseases of Plants, Prof. H. Marshall Ward, F.R.S., 436; the Botanical Laboratory in the Royal Gardens, Peradeniya, Ceylon, 445; Haudleiding tot de Kennis der Flora van Nederlandsch Indie, 461; Abnormal Shoots of Ivy, W. F. R. Weldon, 464; Seeding of Sugar-Cane, D. Morris, 478; True Nature of Callus, Spencer Moore, 478; the Dispersal of Plants, as Illustrated by the Flora of the Keeling Islands, Dr. H. B. Guppy, 492; Salad-plants, H. de Vilmorin, 494; the Native Ebony of St. Helena, Morris, 519; Self-colonization of Coco-nut Palm, W. B. Hemsley, 537; Suggestion for Facilitating the Study of Botany in India, G. Carstensen, 546; Self-colonization of Coco-nut Palm, Captain W. J. L. Wharton, F.R.S., 585; Organization of Fossil Plants of Coal-measures, Prof. Williamson, F.R.S., 572; Botanical Condition of German Ocean, Major Reinhold, 569; a Blue Primrose, 569; Threatened Extinction of Cyclamen in Savoy, 569; How to know Grasses by their Leaves, A. N. M'Alpine, Prof. John Wrightson, 557
Bottomley (J. T., F.R.S.), Four-Figure Mathematical Tables, 510
Bouchard (Ch.), Mechanism of the Local Lesion in Infectious Diseases, 48
Bourdon's Pressure-Gauge: Prof. A. M. Worthington, 296; Prof. A. G. Greenhill, F.R.S., 517
Bournemouth Industrial and Loan Exhibition, Science Exhibits in, 545
Boussingault (M.), Proposed Statue to the late, 207, 348
Boutzoureano (M.), on a New Series of Salts of Selenite, 87
Bower (J. A.), Science of Every-day Life, 78
Boys (C. V., F.R.S.), on the Cavendish Experiment, 155
Brande (Dr.), Taxine, a New Alkaloid from Yew Leaves, &c., 496
Brandis (Sir D., F.R.S.), a Manual of Forestry, William Schlich, 121
Brassart Brothers' New Seismoscopes, 137
Brazil, Dr. Lund's Exploration of the Limestone Caverns of, 26
Brazilian Honours to French Astronomers, 135
Bréal (M.), Fixation of Nitrogen of the Leguminosæ, 23
Breathing, Thought and: R. Barrett Pope, 297; Prof. F. Max Müller, 317; Rev. W. Clement Ley, 317; Mrs. J. C. Murray-Aynsley, 441
Brewery and Malt-House, the Microscope in the, Chas. Geo. Mathews and Francis Edw. Lott, 246
Brezina (A.), Die Meteoritensammlung des k.k. mineralog. Hofkabinetes in Wien, 127
Brezina (A.) and E. Cohen, Die Structur und Zusammensetzung der Meteoreisen erläutert durch photographische Abbildungen geätzter Schnittflächen, 127
Brick Buildings, Magnetism in, R. W. Wilson, 405
Bridge across the Bosphorus, Proposed, 568
Bridge, Chenab, Testing of, 372
Bridge, Testing of the New Forth, 281; Opening of the, 429
Bright Lines in Stellar Spectra, Rev. J. E. Espin, 549
Brinton (Dr. D. G.): Ethnologic Affinity of Ancient Etruscans, 66; Etruscans a Libyan Offshoot, 448; the Cradle of the Semites, 569
British Association, Second Report of the Committee on Teaching Chemistry, 160

British Earthquakes, Record of, Charles Davison, 9; William White, 202
British Guiana, the Journal Timehri, 549
British Journal Photographic Almanac, 1890, 510
British Museum: Reading Room, 199; Electric Light at the, 301; Catalogue of the Fossil Reptilia and Amphibia in the, Richard Lydekker, 534
British Plants, Index of, Robert Turnbull, 196
Brodhun (Dr.), New Contrast-Photometer, 552
Brook and its Banks, the, Rev. J. G. Wood, 53
Brooks (W.): Comet *a* 1889, Comet *d* 1889, discovered by, 428; Comet (*d* 1889, July 6) Dr. Knopf, 115, 211; Brooks's Comet (1889), Identity of Comet Vico (1844) with, 233; Orbits of the Companions of, 305; Brooks's Comet (*a* 1890), 522, 549; Dr. Bidschof, 571
Brorsen's Comet, Return of, Dr. E. Lamp, 69
Brown (Arthur), Mirages, 225
Brown (A. B.), the Steering of Steam-ships, 516
Brown (Prof. Crum), a New Synthesis of Dibasic Organic Acids, 431
Brown (H. T., F.R.S.), Identity of Cerebrose and Galactose, 262
Browne (Montagu), the Vertebrate Animals of Leicestershire and Rutland, 220
Bruce (E. S.), an Optical Feature of Lightning Flashes, 406
Bruguière (M.), Minimum Sun-spot Period, 68
Brush-Turkeys on the Smaller Islands north of Celebes, Dr. A. B. Meyer, 514
Bryan (G. H.), Stability of Rotating Spheroid of Perfect Liquid, 526
Bryce's (Prof. J.) Speech on Presentation of A. R. Wallace for Degree of D.C.L. at Oxford, 112
Buchan (A.), Atmospheric Circulation, 363
Buchan (Dr.), Influenza and Weather, 596
Buffalo in Northern Australia, Increase of, 18
Bulk of Ocean Water, Is the, a Fixed Quantity, A. J. Jukes-Browne, 130
Bulk of Ocean Water, Does the, Increase, T. Mellard Reade, 175; Rev. Osmond Fisher, 197
Bulkeley (Owen T.), the Lesser Antilles, 268
Bulletin de l'Académie Royal de Belgique, 212, 237
Bulletin de la Société d'Anthropologie, 332
Bulletin de la Société Imperiale des Naturalistes de Moscou, 92
Bummelen (Van), Composition of Tobacco-growing Soils in Deli and Java, 384
Burder (Geo. F.), Self-luminous Clouds, 198
Burmah, a Thousand Miles on an Elephant in the Shan States, Holt S. Hallett, 265
Burmeister (Dr. Hermann), on the Fossil Horses and other Mammals of Argentina, 82
Burnham (S. W.): Measurements of Double Stars, 19; Double-Star Observations, 472
Burton (C. V.), a Physical Basis for the Theory of Errors, 47
Burton (F. M.), Chiff-Chaff Singing in September, 298
Burton (Prof. W. K.), Electrical Cloud Phenomena, 10
Buschan (Herr), Prehistoric Textiles, 182
Butter, Cocoa-Nut, 162, 284
Butterflies, Maltese, George Fraser, 199
Buys-Ballot (Prof. C. H. D.), Death of, 324

Caballero (Dr. E.), Remarkable Meteor at Pontevedra, 303
Cælum, New Variable in, Prof. Pickering, 571
Caernarvonshire, Volcanic Rocks of, Alfred Harker, 414
Calculus of Probabilities, J. Bertrand, 6
California, Spread of the Australian Ladybird in, J. R. Dobbins, 161
Callandreau (O.), Stability of the Rings of Saturn, 548
Calorimeter, the Steam, J. Joly, 212
Camboué (Rev. Paul), Distribution of Animals and Plants by Ocean Currents, 103
Cambrian and Silurian, Sedgwick and Murchison, Prof. James D. Dana, 421
Cambridge: University of, Appointment of Examiners, 23; the Mechanical Workshops at, 23; the John Lucas Walker Fund, 23; Election of Fellows at St. John's College, 23; Science and the Indian Civil Service, 25; Physiology at, 41; the Newall Telescope, 166; Archæological Museum, 324; University Natural Science Club *Conversazione*, 371; Anthropometry at, 560; Dr. John Venn, F.R.S., 450; Francis Galton, F.R.S., 454
Campbell (A. J.), Collections of Western Australian Birdskins and Eggs, 593
Canada, Mining and Mineral Statistics of, 87
Canary, Effects of Musical Sounds on a, 593
Cannibals, Among, Carl Lumholtz, 200
Capacity, Specific Inductive, Prof. Oliver J. Lodge, F.R.S., 30
Capital, Accumulations of, in the United Kingdom in 1875–85, Robert Giffen, 211
Capital, the Growth of, Robert Giffen, 553
Carbutt (Mrs. E. H.), Five Months' Fine Weather in Canada, Western United States, and Mexico, 247
Cardani (Signor), New Method of measuring Small Elongations of a Bar, 427
Carinthia, Earthquake in, 284
Carlet (G.), Wax Organs of Bees, 407
Carlier (E. W.), Note on a Probable Nervous Affection observed in an Insect, 197
Carnelley (Prof.): the Relation of Physiological Action to Atomic Weight, 189; Attempt to express Periodic Law of Chemical Elements by Algebraic Formula, 304
Carotine Pigment in Alpine Lake Crustacean, Discovery of, by Prof. Raphael Blanchard, 325, 383
Carruthers (G. T.), Locusts in the Red Sea, 153
Carstensen (G.), Suggestion for Facilitating Study of Botany in India, 546
Cartailhac (Emile), La France Préhistorique, 102
Carter (Brudenell), Vision-Testing for Practical Purposes, 302
Cartography, Facsimile Atlas to the Early History of, A. E. Nordenskiöld, 558
Carus-Wilson (Charles A.): Behaviour of Steel under Mechanical Stress, 213; the Rupture of Steel by Longitudinal Stress, 574
Cashmere, North-West, Dauvergne's Journey in, 165
Cassedy (W. S.), Is the Copernican System of Astronomy True?, 366
Cassiopeiæ, S, Rev. T. E. Espin, 115
Catalogue of the Fossil Reptilia and Amphibia in the British Museum (Natural History), Richard Lydekker, 534
Cattle-poisoning by Ergotized Lolium, 569
Caucasus, Prehistoric Burial Ground in, Beyern, 43
Caucasus, Search and Travel in the, D. W. Freshfield, 351
Caucasus, a Trip through the Eastern, Hon. John Abercromby, 391
Causes of Variation, E. D. Cope on, Prof. E. Ray Lankester, F.R.S., 128
Cave Dwelling in New Zealand, Discovery of, H. O. Forbes 209
Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of the Blind Species, A. S. Packard, 507
Cavendish Experiment, C. V. Boys, F.R.S., on the, 155
Cayley (Prof. A., F.R.S.), Roots of an Algebraic Equation, 335, 359
Celebes Photographs, Dr. A. B. Meyer, 471; Brush-Turkeys on the Smaller Islands north of, Dr. A. B. Meyer, 514
Celts in Hampshire, Characteristic Survivals of, T. W. Shore, 406
Centauri, Spectra of δ and μ, 374
Cetacea, *Rorqual musculus* stranded in Médoc District, 113
Cétacés des Mers d'Europe, Histoire Naturelle des, P. J. Van Beneden, 223
Ceylon: Geodetical Survey of, 86; the Veddahs of, Dr. Arthur Thomson, 303; Asiatic Society, 349; Proposed Archæological Survey of, 372
Chabrié (M.): the Chlorides of Selenium, 284; Gas obtained by Heating Silver Fluoride with Chloroform in Sealed Tube, 521
Chaffinch, the, E. J. Lowe, F.R.S., 394
Challenger Expedition: Report on the Magnetical Results of the Voyage of H.M.S., E. W. Creak, F.R.S., 105; Zoological Results of the, 217; Report on the Scientific Results of the Exploring Voyage of H.M.S., 361; Meteorological Report of the, 443
Chambers (G. F.), Hand-book of Descriptive and Practical Astronomy, 49
Chandler (S. C.): Period of U Coronæ, 163; Identity of Brooks's Comet (*d* 1889) with Lexell's Comet (1770), 163
Characters, Acquired: and Congenital Variation, the Duke of Argyll, F.R.S., 173, 294; Palæontological Evidence for the Transmission of, Henry Fairfield Osborn, 227; Congenital Variation, the Duke of Argyll, F.R.S., 366; Right Rev.

Bishop R. Courtenay, 367; Dr. J. Cowper, 368; Inheritance of, Herbert Spencer, 414; Prof. E. Ray Lankester, F.R.S., 415; Transmission of, Prof. E. Ray Lankester, F.R.S., 486
Charlois (M.), Discovery of Asteroids, 522
Charts of the Constellations, Large Scale, Arthur Cottam, 45
Chatelier (H. Le), Electrical Resistance of Iron Alloys at High Temperatures, 383
Chelmsford, Earthquake at, 256
Chelmsford, Supposed Earthquake at, on January 7, Chas. Davison, 369
Chemistry: Chemistry of the Coal-tar Colours, Dr. R. Benedikt and Dr. E. Knecht, 8; Experiments upon Simultaneous Production of Pure Crystals of Sodium Carbonate and Chlorine Gas from Common Salt, Dr. Hempel, 19; the Microscope as Applied to Physiological Chemistry, Prof. Kossel, 23; Sorbite, Vincent and Delachanal on, 23; Double Nitrites of Ruthenium and Potassium, Joly and Vèzes, 23; Agricultural Chemistry, Fixation of Nitrogen by the Leguminosæ, M. Bréal, 23; Air in the Soil, Th. Schlœsing, fils, 23; the Exhaustion of Soils Cultivated without Manure, and the Value of Organic Matter in Soil, P. P. Dehérain, 119; the Fermentation of Stable Manure, Th. Schlœsing, 143; Composition of Tobacco-growing Soils in Deli and Java, Van Bummelen, 384; Absorption of Atmospheric Ammonia by Soils, H. Schlœsing, 479; Redetermination of Atomic Weight of Palladium, Dr. E. H. Keiser, 44; Nitrosochloride of Pinol, a new Isomer of Camphor, 44; Researches on Digitaline and Tanghinine, Arnaud, 48; Phenyl-thiophene, A. Renard, 48; the Composition of the Chemical Elements, A. M. Stapley, 56; New Mode of Preparing Manganese, Dr. Glatzel, 67; Laboratory at Stalybridge Mechanics' Institute, 85; a Case of Chemical Equilibrium, W. H. Pendlebury, 104; a New Method of Preparing Fluorine, M. Moissan, 117; Perfected Mode of Preparation of Fluorine, Henri Moissan, 138; the Anhydrous Platinous Fluoride, H. Moissan, 119; Introduction to Chemical Science, R. P. Williams and B. P. Lascelles, 128; Chemical Society, 142, 191, 262, 335, 468, 502, 519; Isolation of Tetrahydrate of Sulphuric Acid existing in Solution, S. U. Pickering, 142; Magnetic Rotation of Nitric Acid, &c., Dr. W. H. Perkin, F.R.S., 142; Phosphorus Oxyfluoride, Method of making, Thorpe and Hambly, 142; Acetylation of Cellulose, Cross and Bevan, 142; Action of Light on Moist Oxygen, Dr. A. Richardson, 142; α-β-Dibenzoylstyrolene and Zinin's Lepiden Derivatives, Japp and Klingemann, 142; Oxyamidosulphonates and their Conversion into Hyponitrites, Divers and Haga, 143; Constituents of Flax, Cross and Bevan, 143; a Text-book of Organic Chemistry, A. Bernthsen, 172; Synoptical Tables of Organic and Inorganic Chemistry, Clement J. Leaper, 510; Compounds of Phenanthraquinone with Metallic Salts, Japp and Turner, 191; β-Inosite, Maquenne, 215; a New Class of Diacetones, Behal and Auger, 215; Examination of Mighei (June 9, 1889) Meteorite, Stanislas Meunier, 232; Frangulin, Thorpe and Robinson, 262; Arabinon, C. O. Sullivan, F.R.S., 262; the Identity of Cerebrose and Galactose, Brown and Morris, 262; Action of Chloroform and Alcoholic Potash on Hydrazines, Dr. S. Ruhemann, 263; Refracting Powers of Simple Salts in Solution, E. Doumer, 263; the Chlorides of Selenium, Chabrié, 284; Combinations of Gaseous Phosphoretted Hydrogen with Boron and Silicium Fluorides, Besson, 287; the Story of Chemistry, Harold Picton, F.R.S., 292; the Chemistry of Photography, R. Meldola, F.R.S., 293; Attempt to express Periodic Law of Elements by Algebraic Formula, Prof. Carnelley, 304; the Physical and Chemical Characteristics of Meteorites as throwing Light upon their Past History, J. Norman Lockyer, F.R.S., 305; the Carbon Graphites, Berthelot and Petit, 311; Formation of Nitrates in Plants, Berthelot, 311; Refracting Power of Double Salts in Solution, E. Doumer, 312; New Method of Synthesizing Indigo, Dr. Flimm, 326; New Method of Estimating Oxygen Dissolved in Water, Dr. Thresh, 335; Phosphorus Trifluoride, M. Moissan, 349; Combinations of Ammonia and Phosphuretted Hydrogen with Dichloride and Dibromide of Silicon, Besson, 359; Report on the Scientific Results of the Exploring Voyage of H.M.S. *Challenger*, 361; Two Gaseous Fluorides of Carbon, Moissan, 373; the Absorption of Hydrogen by Iron, Bellati and Lussana, 380; New Estimates of Molecular Distance, Dr. Peddie, 382; a Dictionary of Applied Chemistry by Prof. T. E. Thorpe, F.R.S., Vol. I., Sir H. E. Roscoe, M.P., F.R.S., 387; New Compounds of Hydroxylamine with Metallic Chlorides, Crisner, 401; Diethyline Diamine, Dr. J. Sieber, 428; Analysis of Carcote (Chili) Meteorite, Drs. Will and Pinnow, 428; Prof. Crum Brown on a New Synthesis of Dibasic Organic Acids, 431; the Vapour-pressure of Acetic Acid Solutions, Raoult and Recoura, 431; Volumetric Estimation of Copper, Etard and Lebeau, 431; Crystalline Allotropic Forms of Sulphur, Dr. Muthmann, 449; Nitrous Anhydride and Nitric Peroxide, Prof. Ramsay, F.R.S., 454; Constitution of Tri-derivatives of Naphthalene, Armstrong and Wynne, 454; Estimation of Free Halogens and Iodides in presence of Chlorine and Bromine, P. Lebeau, 479; a New Alkaloid (Taxine) from Leaves, &c., of Yew Tree, Drs. Hilger and Brande, 496; Behaviour of more Stable Oxides at High Temperatures, Dr. G. H. Bailey and W. B. Hopkins, 502; Influence of Different Oxides on Decomposition of Potassium Chlorate, Fowler and Grant, 502; Ammonium Hypochlorite, Cross and Bevan, 502; the Production of Ozone by Flames, J. T. Cundall, 502; Action of Sulphuric Acid on Aluminium, A. Ditte, 503; the α Dextro- and Lævo-rotatory Borneol Camphorates, A. Haller, 503; Isolation of Fluoroform, M. Meslans, 521; Gas obtained by heating Silver Fluoride with Chloroform in Sealed Tube, M. Chabrié, 521; the Glow of Phosphorus, Prof. T. E. Thorpe, F.R.S., 523; Apparatus for Distilling Mercury in Vacuum, Prof. Dunstan, 526; Theory of Osmotic Pressure, Prof. S. U. Pickering, 526; Crystalline Substances obtained from Fruits of various Species of Citrus, Prof. W. A. Tilden, F.R.S., and C. R. Beck, 527; Studies on Isomeric Change, IV.; Halogen Derivatives of Quinone, A. R. Ling, 527; Hydrazine, Drs. Curtius and Jay, 547; Crystals of Lime, H. A. Miers, 560; a Nitrosoplatinichloride, M. Vèzes, 576; Glycollic Nitrile and Direct Synthesis of Glycollic Acid, Louis Henry, 576; Nessler's Ammonia Test as a Micro-Chemical Reagent for Tannin, Spencer Moore, 585; New Form of Benzoic Acid, 594
Chenab Bridge, Testing of, 372
Chiff-Chaff Singing in September, F. M. Burton, 298; Rev. W. Clement Ley, 317
Chin Tribes, North Burma, the, G. B. Sacchiero, 375
China, Flora of, 46
China, Increasing Coldness of Climate in, 570
China, Scientific Education in, the Question of Language, 162
Chinese Astronomical Instruments, Ancient, 66
Chloroform, the Hyderabad Commission, 154, 289
Cholera, Bacteria of Asiatic, Dr. E. Klein, F.R.S., 509
Cholera Epidemics, the Suspected Connection between Influenza and, Dr. Smolenski, 282
Chree (C.), Effects of Pressure on Magnetization of Cobalt, 237
Chrystal (Prof. G.), Algebra, an Elementary Text-book for the Higher Classes of Secondary Schools and for Colleges, II., 338
Cicadidæ, Oriental, W. L. Distant's Monograph on, 161
Cingalese Manuscripts, Ancient, 349
City and Guilds of London Institute, 160
City of Paris, the Accident to the Engines of, 592
Civil Service Examinations, the Future Indian, 265
Civilization, Early Egyptian, W. M. Flinders-Petrie, 109
Clarke (Sir Marshall) on Education in Basutoland, 86
Cleland (John), the Longevity of Textural Elements, particularly in Dentine and Bone, 392
Clerke (Miss A. M.): Star Distances, 81; New Double Stars, 132
Climate, Dr. Bushrod W. James on American Resorts, with Notes on their, 79
Climate in China, Increasing Coldness of, 570
Clorinde, New Minor Planet, 88
Cloud Phenomena, Electrical, Prof. W. K. Burton, 10
Clouds: Prof. von Bezold on the Production of, 95; Luminous Night, Evan McLennan, 131; Self-luminous Clouds, Geo. F. Burder, 198; C. E. Stromeyer, 225; T. W. Backhouse, 297; Joseph John Murphy, 298; Robert B. White, 369; Photographs of Luminous, O. Jesse, 592
Clover, Bokhara, as a Weed in Western States of America, 372
Clupea harengus, some Stages in Development of Brain of, E. W. L. Holt, 525
Cluster G.C. 3636, Variable Star in, Prof. Pickering, 183
Cluster G.C. 1420 and the Nebula N.G.C. 2237, Dr. Lewis Swift, 285
Coal-tar Colours, Chemistry of the, Dr. R. Benedikt and Dr. E. Knecht, 8
Coal: Discovery of, in Kent, 400; Prof. W. Boyd Dawkins,

F.R.S., 418; Spontaneous Combustion of, in Ships, Prof. V. Lewes, 517; Organization of Fossil Plants of Coal-measures, Prof. W. C. Williamson, F.R.S., 572
Coasts of Finland, the Secular Upheaval of, 348
Cobalt, Effects of Pressure on Magnetization of, C. Chree, 237
Cockburn (J.), a Brilliant Meteor, 81
Cockerell (T. D. A.): Galls, 344, 559; a Greenish Meteor, 369; some Notes on Dr. A. R. Wallace's "Darwinism," 393
Coco de Mer, the, 256
Coco-nut Palm, Self-fertilization of, W. B. Hemsley, F.R.S., 537; Captain W. J. L. Wharton, F.R.S., 585
Cocoa-nut Butter, 162, 284
Cocorda (G. D.), the South African Gold-fields, 164
Code, Technical Education in the New Education, 505
Coldstream (William), Illustrations of some of the Grasses of the Southern Punjab, being Photo-lithographs of some of the Principal Grasses found at Hissar, 533
Coleman (A. P.), Glories, 154
Collins (F. Howard): an Epitome of the Synthetic Philosophy, 340; Heredity and the Effects of Use and Disuse, 559
Colomb (Admiral), Rule of the Road at Sea, 515
Coloration, Protective, of Eggs, Dr. Alfred R. Wallace, 53; Rev. Fred F. Grensted, 53; E. B. Titchener, 129
Colour-blind Engine Drivers, 325
Colour-blindness in the Mercantile Marine, 494
Colour-blindness, the Committee on, 568
Coloured Analytical Tables, H. W. Hake, 29
Colouring-matter, a New Green Vegetable, C. Michie Smith, 573
Colours, Chemistry of the Coal-tar, Dr. R. Benedikt and Dr. E. Knecht, 8
Combustion, Spontaneous, in Coal Ships, Prof. V. Lewes, 517
Comets: Barnard's Comet, 1888-89, 20; Barnard's Comet, II. 1889, March 31, 45; Comet Borelly (*g* 1889, December 12), 211; Spectrum of, 374; Brooks's (*d* 1889, July 6), Dr. Knopf, 115, 211; Identity of Brooks's Comet (*d* 1889) with Lexell's (1770), S. C. Chandler, 163; Orbit of Barnard's Comet (1884, II.), 164; a New Comet, 164; Identity of Comet Vico (1844) with Brooks's (1889), 233; Ephemeris of Brooks's Comet (*d* 1889), 403; Orbits of the Companions of, 305; Comets and Asteroids discovered in 1889—Comet *a* 1889, W. Brooks, 428; Comet *b* 1889, E. E. Barnard, 428; Comet *c* 1889, E. E. Barnard, 428; Comet *d* 1889, W. Brooks, 428; Comet *e* 1889, Davidson, 429; Comet *f* 1889, Lewis Swift, 429; Comet *g* 1889, M. Borelly, 429; Brooks's Comet (*a* 1890) 522, 549; Dr. Bidschof, 571; Return of Brorsen's Comet, Dr. E. Lamp, 69; Comet Davidson (*e* 1889), 88; D'Arrest's Comet, G. Leveau, 596; a New Comet (*f* 1889, November 17) discovered by Lewis Swift, 69; Dr. Zelbr, 115, 233; Dr. R. Schorr, 139; Dr. Lamp, 233; Orbit of Swift's Comet (V. 1880), 257; Nuclei of Great Comet (II. 1882), F. Tisserand, 358, 522; Periodic Comets, 139; the Orbit of Winnecke's Periodical Comet, M. H. Faye, 94
Compass on Board, the, 412
Conductivity in Flints, a Natural Evidence of High Thermal, Prof. A. S. Herschel, F.R.S., 175
Congenital Variation, Acquired Characters and: the Duke of Argyll, F.R.S., 173, 294, 366; W. T. Thiselton Dyer, F.R.S., 315; F. V. Dickins, 316; Right Rev. Bishop R. Courtenay, 367; Dr. J. Cowper, 368; Herbert Spencer, 414; Prof. E. Ray Lankester, F.R.S., 415
Congress, Moscow Archæological, 283
Conroy (Sir John), Luminous and Non-Luminous Radiation of Gas-Flame, 357
Constable (F. C.), Fighting for the Belt, 199
Constellations, Large Scale Charts of the, Arthur Cottam, 45
Continents and Oceans, the Permanence of, Joseph John Murphy, 175
Cook (Charles S.), Spectrum of Aqueous Vapour, 598
Cooke (M. C.), Toilers in the Sea, 409
Cope (Prof. E. D.): Lamarck *versus* Weismann, 79; on the Causes of Variation, Prof. E. Ray Lankester, F.R.S., 128
Copenhagen, the Lund Museum in the University of, 26
Copernican System of Astronomy, is it True? W. S. Cassedy, 366
Copper, the Spectrum of Subchloride of, Prof. A. S. Herschel, F.R.S., 513
Copper, Volumetric Estimation of, Etard and Lebeau, 431
Coral Reefs, Examination of the Structure of, Angelo Heilprin, Dr. H. B. Guppy, 193
Coral Reefs of the Java Sea and its Vicinity, Dr. H. B. Guppy, 300
Coral Reefs in Recent Seas, Dr. John Murray, 167
Corday's (Charlotte) Skull, Dr. Topinard, 500
Cormorant, Pallas's, 373
Cornish (Thos.), the Old English Black Rat in Cornwall, 161
Corona of January 1, 1889, Prof. Tacchini, 139
Corona of 1889, December 22, W. H. Wesley, 450
Coronal Light, Photometric Intensity of, Prof. Thorpe, 139
Corpi (F. M.), the Catastrophe of Kantzorik, Armenia, 190
Corsican Population, Cephalic Index of, Dr. A. Fallot, 357
Cory (Dr. Robert), History and Pathology of Vaccination, E. M. Crookshank, 486
Cosson (M.), Death of, 230
Costa Rica, Meteorology of, Boletin Trimestral of San José Observatory, 427
Cotes (E. C.), Locusts in India, 403
Cottam (Arthur) Large Scale Charts of the Constellations, 45
Courtenay (Right Rev. Bishop R.), Acquired Characters and Congenital Variation, 367
Cowper (Dr. J.), Acquired Characters and Congenital Variation, 368
Crabs, Foreign Substances attached to: Francis P. Pascoe, 176; F. Ernest Weiss, 272; Alfred O. Walker, 296; Captain David Wilson-Barker, 297; Dr. R. von Lendenfeld, 317; Prof. W. A. Herdman, 344; Walter Garstang, 417, 490, 538; Ernest W. L. Holt, 463, 515, 586
Cradle of the Aryans, the, Gerald H. Rendall, 128
Craig (Thomas), a Treatise on Linear Differential Equations, 508
Craters, Changes in Lunar, Prof. Thury, 183
Creak (E. W., F.R.S.), Report on the Magnetical Results of the Voyage of H.M.S. *Challenger*, 105
Creation and Physical Structure of the Earth, J. T. Harrison, 151
Criminals, Identification of, by Measurement, Jacques Bertillon, 592
Crismer (M.), New Compound of Hydroxylamine with Metallic Chlorides, 401
Croft (W. B.), Electrical Figures, 132
Croll (Dr. James, F.R.S.), Former Glacial Periods, 441
Crookshank (E. M.), History and Pathology of Vaccination, Dr. Robert Cory, 486
Cross (C. J.), Acetylation of Cellulose, 142; the Constituents of Flax, 193
Crosthwaite (R. J.), Wanton Destruction of Forests in India, 210
Crows, the Food of, W. B. Barrows, 137
Crustaceans, Discovery by Prof. Giard of Micro-organism conferring Phosphorescence on, 137
Cryptogamic Botany, the Revised Terminology in, Alfred W. Bennett, 225
Crystal Palace, International Exhibition of Mining and Metallurgy, 592
Crystals of Lime, H. A. Miers, 515
Cundall (J. T.), Production of Ozone by Flames, 502
Cunningham (J. T.), Anchovies on South Coast of England, 230
Curtius (Dr.), Hydrazine, 547
Cyclamen in Savoy, Threatened Extinction of, 569
Cygni, Y, Variable Star, 88
Cyprus, Lieut.-General Sir Robert Biddulph, 45

Daffodils, Double Varieties of, 593
Daily Graphic, the, 66
Dalmatia, Earthquakes in, 136
Dana (Prof. James D.), Sedgwick and Murchison, Cambrian and Silurian, 421
Danckelmann (Dr. von): Meteorology of Gold and Slave Coast, 479; Climate of German Togoland, 545
Danish Expedition to East Coast of Greenland, the Proposed, 545
Darwin (Prof. G. H., F.R.S.), Microseismic Vibration of the Earth's Crust, 248
Darwin, Before and After, Prof. G. J. Romanes, F.R.S., 524
Darwin's and Lamarck's Theories as to Transmission of Acquired Characters, Prof. E. R. Lankester, F.R.S., 486
Darwin's Voyage of a Naturalist, New Edition, 495
Darwinian Theory, and Acquired Characters and Congenital Variation, 368; Herbert Spencer, 414; Prof. E. Ray Lankester, F.R.S., 415

Darwinian Theory and Evolution, Rev. John T. Gulick, 309
Darwinians, Neo-, the Duke of Argyll and the, W. T. Thiselton Dyer, F.R.S., 247
Darwinism: Prof. E. Ray Lankester, F.R.S., 9; Prof. Geo. J. Romanes, F.R.S., 59; some Notes on Dr. A. R. Wallace's, by T. D. A. Cockerell, 393; and Panmixia, Prof. Geo. J. Romanes, F.R.S., 437
Daubrée (M.), Analogy of South African Diamantiferous Matrix to Meteorites, 263
Dauvergne's Journey in North-West Cashmere, 165
Davidson's Comet (*e* 1889), 429
Davis (John), a Life of, Clements R. Markham, F.R.S., 52
Davison (Chas.), Supposed Earthquake at Chelmsford on January 7, 369
Dawkins (Prof. W. Boyd, F.R.S.), Discovery of Coal near Dover, 418
Dawson (Sir J. W., F.R.S.): Fossil Rhizocarps, 10; Certain Devonian Plants from Scotland, 537
Day (Francis), Fishes, 101
Deformation of an Elastic Shell, Prof. Horace Lamb, F.R.S., 549
Dehérain (P. P.), the Exhaustion of Soils cultivated without Manure, and Value of Organic Matter in Soil, 119
Delachanal, Vincent and, Sorbite, 23
Demography and Hygiene, Congress on, 401
Denniker (M.), Classification of Races, based on Physical Characters only, 332
Denning (W. F.), Recent Observations of Jupiter, 206
Dentine and Bone, the Longevity of Textural Elements, particularly in, John Cleland, 392
Dentition, a Milk, in Orycteropus, O. Thomas, 309
Derbyshire, the Flora of, by the Rev. W. H. Painter, 77
Descartes and his School, Prof. Kuno Fisher, 171
Desert of Atacama, on the Supposed Enormous Showers of Meteorites in the, 108
Deslandres (H.): Fundamental Common Property of Two Kinds of Spectra, Lines and Bands; Distinct Characteristics of each of the Classes; Periodic Variations to Three Parameters, 576
Deslongchamps (M. Eugène), Death and Obituary Notice of, 207
Deutschen Seewarte: Annual Report of, 85; Meteorological Observations, 231
Dewar's (D.) Weather and Tidal Forecasts for 1890, 546
Diamine (Diethyline), Dr. J. Sieber, 428
Diamonds, the Formation of, M. Daubrée, 263
Dianthus, Enumeratio Specierum Varietatumque Generis, F. N. Williams, 51
Dianthus, Notes on the Pinks of Western Europe, by F. N. Williams, 78
Dibasic Organic Acids, a New Synthesis of, Prof. Crum Brown, 431
Dickins (F. V.), Acquired Characters and Congenital Variation, 316
Dickinson (W. L.), Local Paralysis of Peripheral Ganglia and Connection of Nerve-fibres with them, 118
Dierckx (G.), Sun-spot in High Latitudes, 472
Differential Equations, a Treatise on Linear, Thomas Craig, 508
Differential Equations, a Treatise on Ordinary and Partial, Prof. W. W. Johnson, 270
Digestions, a Comparative Study of Natural and Artificial, A. S. Lea, 430
Dines (W. H.), Anemometers, 212
Diseases of Plants, Prof. H. Marshall Ward, F.R.S., 436
Diseases, Tropical, the Relation of the Soil to, A. Ernest Roberts, 31
Distant (W. L.), Monograph on Oriental *Cicadidæ*, 161
Disturbed Water, on the Effect of Oil on, A. B. Basset, F.R.S., 297
Ditte (A.), Action of Sulphuric Acid on Aluminium, 503
Divers (Dr. E., F.R.S.), Oxyamido-sulphonates and their Conversion into Hyponitrites, 143
Dobbins (J. R.), Spread of the Australian Ladybird in California, 161
Dog, the, M. de Mortillet, 332
Dogs and Music, 372
Double-star Observations: S. W. Burnham, 19, 472; E. E. Barnard, 19
Double Stars, New, Miss A. M. Clerke, 132
Doumer (E.), Refracting Powers of Simple Salts in Solution, 263
Doumer (E.), Refracting Powers of Double Salts in Solution, 312
Dover, Discovery of Coal near, Prof. W. Boyd Dawkins, F.R.S., 418
Dreams, Dr. Julius Nelson, 546
Du Chaillu (Paul B.), the Viking Age, 173
Duchayla's Proof, Prof. J. D. Everett, F.R.S., 198
Dumont (M.), Natality of Paimpol, 332
Dun Echt Observatory, 351
Dundee Technical Education Association, 113
Dunman (T.), a Glossary of Anatomical, Physiological, and Biological Terms, 173
Dunn (J.), a Remarkable Meteor, 560
Dunstan (Prof.), Apparatus for distilling mercury *in vacuo*, 526
Dust, Atmospheric, Dr. Marcet, 358, 473
Dust, the Motion of, Hon. Ralph Abercromby, 406
Dust Particles, the Number of, in the Atmosphere of certain Places in Great Britain and the Continent, with Remarks on the Relation between the Amount of Dust and Meteorological Phenomena, John Aitken, F.R.S., 394
Dutch East Indies, Science in, 547
Dutch India, Flora of, 461
Dwight (Jonathan, Jun.), Birds that have struck the Statue of Liberty in New York Harbour, 181
Dyer (W. T. Thiselton, F.R.S.): the Duke of Argyll and the Neo-Darwinians, 247; Acquired Characters and Congenital Variation, 315
Dynamics, Elementary, of Particles and Solids, W. M. Hicks, F.R.S., 534

Earl (A. G.), Elements of Laboratory Work, 461
Earth and its Story, edited by Dr. Robert Brown, 341
Earth, on the Creation and Physical Structure of the, J. T. Harrison, 151
Earth's Crust, Microseismic Vibration of the, Prof. G. H. Darwin, F.R.S., 248
Earth-currents and the Occurrence of Gold, Geo. Sutherland, 464
Earth-tremors from Trains, H. H. Turner, 344
Earthquakes: Record of British Earthquakes, Charles Davison, 9; at St. Louis, 18; Earthquake of July 28, 1889, at Kiushiu, J. Wada, 23; Relation of certain Magnetic Perturbations to Earthquakes, M. Mascart, 23; the Earthquake of Tokio, April 18, 1889, Prof. Cargill G. Knott, 32; Earthquakes in Algeria and Servia, 113; in Italy, Dalmatia, Bosnia, and Herzegovina, 136, 181; at Granada, 161; British Earthquakes, William White, 202; Earthquakes in Turkestan, 230; the Earthquake of July 12 at Lake Issyk-kul, 230; Earthquakes at Chelmsford and in Perthshire, 256; Chas. Davison, 369; in Carinthia, 284; at Rome and in Portugal, 401; at Bonn and Malaga, 470; at Trieste, 519; in the United States, 569; in the Tyrol, 569
Earthworms from Pennsylvania, W. B. Benham, 560
Easter Island, Archæology and Ethnology of, Walter Hough, 569
Eastman (Prof. J. R.), on Solar and Stellar Motions, 351, 392
Eclipses: Eclipse Parties, 139; Total Solar, of 1886, Rev. S. J. Perry, F.R.S., 88; H. H. Turner, 88; Dr. Schuster, F.R.S., 327; Total Eclipse of December 22, 1889, 229; M. A. De La Baume Pluvinel, 428; Total Eclipse of January 1, 1889, Prof. Holden, 305
Eder (Dr. J. M.), La Photographie à la Lumière du Magnésium, 584
Edinburgh International Exhibition, 85
Edinburgh Royal Society, 167, 214, 335, 358, 382, 431, 478, 575
Edison Phonograph, Use of, in Preserving American Indian Languages, J. W. Fewkes, 560
Education: Physiology of Education, Mary Putnam Jacobi, 28; Lord Salisbury on Free Education, 84; Education in Basutoland, Sir Marshall Clarke on, 86; Scientific Education in China, the Question of Language, 162; the Need for Vital Improvements in English Education, Sir Lyon Playfair, 180: Association for Improvement of Geometrical Teaching, 207; Polytechnics for London, 242; Necessity of a School for Modern Oriental Studies, Prof. Max Müller, 255; the New Codes, English and Scotch, 385; Land Grants to Educational Institutions in U.S.A., 448; the Revised Instructions to Inspectors of Elementary Education, 577; Mathematical Teaching at Sorbonne, Prof. Ch. Hermite, 597; Technical Education in New South Wales and Bengal, 66; Conference at

Manchester on Technical Education, 84; Dundee Technical Education Association, 113; the City Guilds and Technical Education, Sir H. E. Roscoe, M.P., F.R.S., 160; on the Future of our Technical Education, Sir Henry E. Roscoe, M.P., F.R.S., 183; Technical Education in Elementary Schools, 356; Technical Education in Central India, 470; a South London Polytechnic, 481; Technical Education Bill, Sir H. E. Roscoe, 493; Technical Education in the Code, 505
Eggs, Protective Coloration of, E. B. Titchener, 129; Dr. Alfred R. Wallace, 53; Rev. Fred. F. Grensted, 53
Egypt, Vandalism in, 447
Egyptian Civilization, Early, W. M. Flinders Petrie, 109
Eissler (M.), a Hand-book of Modern Explosives, 224
Elastic After-Strain, on a Certain Theory of, Prof. ¡Horace Lamb, F.R.S., 463
Elastic Shell, Deformation of an, Prof. Horace Lamb, F.R.S., 549
Elastical Researches of Barré de Saint-Venant, Prof. A. G. Greenhill, F.R.S., 458
Electricity: Modern Views of Electricity, Dr. Oliver J. Lodge, F.R.S., 5, 80; Electrical Cloud Phenomena, Prof. W. K. Burton, 10; New Method of Measuring Differences of Potential of Contact, Prof. Righi, 18; Institution of Electrical Engineers, 21; Magnetism and Electricity, Andrew Jamieson, 30; Specific Inductive Capacity, Prof. Oliver J. Lodge, F.R.S., 30; Siegsfeld's Electric Thermometer, 43; a Method of driving Tuning-Forks Electrically, W. G. Gregory, 47; a New Electric Radiation Meter, W. G. Gregory, 47; Electrifications due to Contact of Gases and Liquids, J. Enright, 47; Proceedings of the National Electric Light Association at its Ninth Convention, 50; Electric Light at the British Museum, 301; the National Electric Light Association, 302; Magnetism and Electricity, Arthur W. Poyser, 52; a Proposed Gilbert Club, 84; the Edinburgh International Exhibition, 85; Variations of Electric Resistance of Nitric Peroxide at Various Temperatures, J. J. Boguski, 119; Electrical Figures, W. B. Croft, 132; the Arc Light, Joseph McGrath, 154; Effect of Repeated Heating and Cooling on Electrical Coefficient of Annealed Iron, Herbert Tomlinson, F.R.S., 166; Electrification due to Contact of Gases with Liquids, Enright, 166; Electrification of a Steam Jet, Shelford Bidwell, F.R.S., 213; Development of Electricity and Heat in Dilute Electrolytic Solutions, Prof. Planck, 215; the Peltier Effect and Contact E.M.F., Prof. Oliver J. Lodge, F.R.S., 224; Electric Currents in Skin from Mental Excitation, Herr Tarchenoff, 232; Electrical Negative Variation of Heart accompanying Pulse, Dr. Aug. Waller, 288; Electric Splashes, Dr. S. P. Thompson, 309; on Galvanometers, Ayrton, Mather, and Simpson, 310, 381; Electrostatic Stress, Sir W. Thomson, F.R.S., 358; Easy Lecture Experiment in Electric Resonance, Prof. Oliver J. Lodge, F.R.S., 368; Determination of Coefficient of Dynamic and Electromotor Produce, P. Guzzi, 380; Electrical Resistance of Iron Alloys at High Temperatures, H. Le Chatelier, 383; Electrical Resistance, Measurement of, Dr. Feussner, 407; Electrical Oscillations in Rarefied Air, M. James Moser, 431; Magnetism and Electricity, Prof. Jamieson, 461; Electrical Radiation from Conducting Spheres, an Electric Eye and a Suggestion Regarding Vision, Prof. Oliver J. Lodge, F.R.S., 462; Use of Bolometer for Observing Electrical Radiations of Hertz, Dr. Rubens, 504; Short Lectures to Electrical Artisans, J. A. Fleming, 561; Absolute Measurements in Electricity and Magnetism, Andrew Gray, 561; Electricity in Modern Life, G. W. de Tunzelmann, 561; Samples of Current, Electrical Literature, 561; Shape of Movable Coils used in, Electrical Measuring Instruments, T. Mather, 574; Prof. Stricker's New Electrical Lantern, 593
Elementary Physics, M. R. Wright, 78
Elementary Schools, Technical Education in, 356
Elephant Sketeton, Large Indian, 66
Ellis (Thos. S.), the Human Foot, 365
Ellis (Wm.), Relative Prevalence of North-East and South-West Winds, 586
Emerson (P. H.), Naturalistic Photography, 366
Encyclopædie der Wissenschaften, 87
Engine Drivers, Colour-blind, 325
Engineer's Sketch-book, Thomas Walter Barber, 52
Engineers, Institution of Electrical, 21
Engines, Compound Locomotives, 331
England, Railways of, W. M. Acworth, 434
Enright (J.), Electrification due to Contact of Gases and Liquids, 47, 166
Entomology: the Metamorphosis of Anoura, E. Bataillon, 23; Entomological Society, 93, 191, 382, 503, 575; Presidential Address by Lord Walsingham, 334; Entomologist's Monthly Magazine, New Series, 161; Spread of the Australian Ladybird in California, J. R. Dobbins, 161; Extraordinary Abundance of *Agrotis spina* in New South Wales in October, A. S. Olliff, 161; Alexandria Garden Pest, R. W. Blunfield, 181; Temperature Experiments on Lepidoptera, F. Merrifield, 191; the Gizzard in Scolopendridæ, Victor Willem, 237; Sugar Losing its Attractions for Lepidoptera, Joseph Anderson, 349; Sugar-cane Pests at St. Vincent, 372; Wax Organs of the Bee, G. Carlet, 407; Beetle-settlement in Disused Gasometers, T. H. Hall, 520; Introduction into California of Australian Natural Enemies of the Fluted Scale (*Icerya purchasi*), 569
Ephedra die Arten der Gattung, von Dr. Otto Stapf, 390
Epidemic of Influenza, 145
Equation, Roots of Algebraic, Prof. A. Cayley, 359
Equations, a Treatise on Linear Differential, Thomas Craig, 508
Equilibrium, a Case of Chemical, W. H. Pendlebury, 104
Ergot, Cattle-poisoning by, 569
Eschenhagen (Dr.), Potsdam Magnetic Observatory, 479
Espin (Rev. T. E.): S Cassiopeiæ, 115; Bright Lines in Stellar Spectra, 549
Estuary, the Mersey, Effects of Training Walls in, L. F. V Harcourt, 380
Estuary, the Thames, Captain Tizard, R.N., 539
Etheridge (R., Jun.), the Murrumbidgee Limestone, 67
Ethnology: the Leyden Ethnographical Collection, 180; Ethnography of Venezuela, Pre-Columbian, Dr. Marcano, 332; Ethnologic Affinity of Ancient Etruscans, Dr. Brinton, 66, 448; Sixth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution, 1884–85, J. W. Powell, 99; Ethnology of the Philippine Islands, Dr. F. Blumentritt, 327; German Contributions to Ethnology, 433; Archæology and Ethnology of Easter Island, Walter Hough, 569; Internationale Archiv für Ethnographie, 594
Eton, Science at, Lieut.-General Tennant, F.R.S., 587
Etruscans, Ethnologic Affinity of Ancient, 66, 448
Ettingshausen (Dr. Constantin Freiherr von), Das Australische Florenelement in Europa, 365
Euclid, the Study of, 80
Everett (Prof. J. D., F.R.S.): Duchayla's Proof, 198; Traité d'Optique, M. E. Mascart, 224
Every-day Life, Science of, J. A. Bower, 78
Evolution and the Darwinian Theory, Rev. John T. Gulick, 309
Evolution of Sex: M. S. Pembrey, 199; Dr. A. B. Meyer, 272; Prof. Patrick Geddes and Arthur Thomson, 531
Ewart (Prof. J. C.): Sardines in Moray Firth, 282; Cranial Nerves of Torpedo, 477; Development of Ciliary Ganglion, 501
Exact Thermometry: Herbert Tomlinson, F.R.S., 198; Dr. Sydney Young, 271
Exhibition illustrating Application of Photography and Meteorology, Proposed, 301
Exhibition, Bournemouth Industrial and Loan, Science Exhibits in, 545
Exhibition of Mining and Metallurgy, Proposed International, 447
Exhibition, Paris: English Men of Science decorated, 17; French Native Colonists in, 427
Exhibition, the Proposed Berlin International Horticultural, 283
Explosives, a Hand-book of Modern, M. Eissler, 224
Explosives, Smokeless, Sir Frederick Abel, F.R.S., 328, 352
Exton (Dr. H.), Geology of Witwatersrand Gold-fields, 190
Eye, the, Cortical Visual Areas, Prof. Munk, 407

Fall of Miner down a 100-Metre Shaft without being Killed, M. Reumeaux, 471
Fallot (Dr. A.), Cephalic Index of Corsican Population, 357
Farne Islands, Bird-Preservation in the, H. G. Barclay, 112
Fauna of British India, including Ceylon and Burmah, 101
Fauna of Mergui and its Archipelago, 556
Faye (M. H.), the Orbit of Winnecke's Periodical Comet, 94
Feilden (Col. H. W.), the Barbados Monkey, 349
Fermentation, the Micro-organisms of, practically considered, Alfred Jörgensen, Prof. Percy F. Frankland, 339

Fern, Sweet-scented, 349
Ferrel (William), a Popular Treatise on the Winds, 124
Feussner (Dr.), Measurement of Electrical Resistance, 407
Fewkes (J. W.), Use of Edison Phonograph in Preserving American Indian Languages, 560
Fichte (Johann Gottlieb), the Popular Works of, 294
Field Experiments on Wheat in Italy, Prof. Giglioli, 404
Field laid down to Permanent Grass, Sir J. B. Lawes, F.R.S., 229
Fievez (Ch.), Death and Obituary Notice of, 400
Fighting for the Belt, F. C. Constable, 199
Fiji, Sea-water Cure for Banana Disease in, 19
Finland, the Secular Upheaval of Coasts of, 348
Fire-damp, Explosions in Mines in Relation to Cosmic and Meteorological Conditions, Dr. Wagner, 504
Fischer-Sigwart (Herr), Snake and Fish, 162
Fisher (Prof. Kuno), History of Modern Philosophy, Descartes and his School, 171
Fisher (Rev. Osmond): on the Physics of the Sub-Oceanic Crust, A. J. Jukes-Browne, 54; Does the Bulk of Ocean Water Increase, 197
Fisher (Robert), Flower-Land, an Introduction to Botany, 247
Fisheries, Foreign, Administration of, Prof. W. C. McIntosh, F.R.S., 497
Fishery Industries of the United States, George Brown Goode, 178
Fishes: the Habits of the Salmon, Major John P. Traherne, 74; Dr. René du Bois Reymond on the Striated Muscles of Tench, 95; Prof. Fritsch on the Sensory Organs of the Skin of Fishes, 95; Fishes, Francis Day, 101; the Bladder in Fishes, Prof. Liebreich, 359
Fitzgerald (Captain C. C. P., R.N.), Leak-stopping in Steel Ships, 516
Fitzgerald (Prof. Geo. Fras.), Multiple Resonance obtained in Hertz's Vibrators, 295
Five Months' Fine Weather in Canada, Western U.S., and Mexico, Mrs. E. H. Carbutt, 247
Fleming (J. A.), Short Lectures to Electrical Artisans, 561
Fletcher (Thos.), Coal Gas as a Fuel, 471
Flimm (Dr.), New Method of Synthesizing Indigo, 326
Flint Remains in Kolaba District, W. E. Sinclair, 114
Flints, a Natural Evidence of High Thermal Conductibility in, Prof. A. S. Herschel, F.R.S., 175
Flora of China, 46
Flora of Derbyshire, Rev. W. H. Painter, 77
Flora of Keeling Islands, W. B. Hemsley, F.R.S., 492
Flora of the Malayan Peninsula, Materials for a, Dr. George King, F.R.S., 437
Flora of Suffolk, Dr. W. M. Hind, 149
Flow of Water in Rivers and other Channels, a General Formula for the Uniform, E. Ganguillet and W. R. Kutter, 411
Flower (Prof. W. H., F.R.S.): Who Discovered the Teeth in Ornithorhynchus?, 30, 151; Suggestions for the Formation and Arrangement of a Museum of Natural History in Connection with a Public School, 177
Flower-Land, an Introduction to Botany, Robert Fisher, 247
Fluorine: a New Method of Preparing, Henri Moissan, 117, 138; Colour and Spectrum of, Henri Moissan, 214
Fluoroform, Isolation of, M. Meslans, 521
Fog, Effects of, on Plants under Glass, 372
Folk-Lore, Customs of the Akas, 86
Foot, the Human, Thos. S. Ellis, 365
Foot-Pounds, 298; Prof. A. G. Greenhill, F.R.S., 317
Forbes (H. O.), Discovery of Maori Cave-dwellings, 209
Forces, Proof of the Parallelogram of, W. E. Johnson, 153; Prof. A. G. Greenhill, F.R.S., 298
Forecasting, Weather, 278
Foreign Substances Attached to Crabs: Francis P. Pascoe, 176; F. Ernest Weiss, 272; Alfred O. Walker, 296; Captain David Wilson-Barker, 297; Dr. R. von Lendenfeld, 317; Prof. W. A. Herdman, 344; Walter Garstang, 417, 490, 538; Ernest W. L. Holt, 463, 515, 586
Foreshadowing of the Periodic Law, a First, P. J. Hartog, 186
Forest Surveys of India, 140
Forestry in India, Dr. Schlich, 470
Forestry in Singapore, Noxious Grass, Lalang, 182
Forestry, Major-General Michael, 348
Forestry, a Manual of, William Schlich, Sir D. Brandis, F.R.S., 121
Forestry, Punjab Forest Administration Report, 520
Forests in India, Wanton Destruction of, R. J. Crosthwaite, 210
Fort William Meteorological Observatory, 518
Forth Bridge: Testing of the New, 281; Opening of the, 429
Fossil Plants of Coal-Measures, Organization of, Prof. W. C. Williamson, F.R.S., 593
Fossil Rhizocarps: Sir J. Wm. Dawson, F.R.S., 10; Alfred W. Bennett, 154
Fowler (A.): Karlsruhe Observatory, 20; Objects for the Spectroscope, 20, 44, 68, 87, 114, 138, 163, 183, 210, 232, 256, 285, 304, 326, 350, 374, 402, 428, 449, 472, 496, 521, 548, 571, 595; Note on the Zodiacal Light, 402
Fowler (G. J.), Influence of Different Oxides on Decomposition of Potassium Chlorides, 502
France: Travels in, Arthur Young, 294; La France Préhistorique, Emile Cartailhac, 102; Brazilian Honours to French Astronomers, 135; French Meteorological Society, 161; French Scientific Missions under the Old Monarchy, Dr. Hamy, 427
Frankland (Prof. Percy F.), the Micro-Organisms of Fermentation practically considered, Alfred Jörgensen, 339
Fraser (George), Maltese Butterflies, 199
Free Education, Lord Salisbury on, 84
Freshfield (Douglas W.), Search and Travel in the Caucasus, 351
Fritsch (Prof.): on the Sensory Organs of the Skin of Fishes, 95; Anatomy of *Torpedo marmorata*, 263
Frost (Dr. Percival, F.R.S.), Eight Rainbows seen at the same Time, 316
Future of our Technical Education, on the, Sir Henry Roscoe, M.P., F.R.S., 183
Future Indian Civil Service Examinations, 265

Gairdner (W. T.), the Physician as Naturalist, 436
Galls: Prof. G. J. Romanes, F.R.S., on, 80, 174, 369; R. McLachlan, F.R.S., 131; D. Wetterhan, 131; W. Ainslie Hollis, 131, 272; Dr. St. George Mivart, F.R.S., 174; T. D. A. Cockerell, 344, 559
Galton (Francis, F.R.S.), Cambridge Anthropometry, 454
Galvanometers: Ayrton, Mather, and Sumpner, 310, 381; Reflecting, Geometrical Construction of Direct-reading Scales for, A. P. Trotter, 478
Ganguillet (E.) and W. R. Kutter, a General Formula for the Uniform Flow of Water in Rivers and other Channels, 411
Garden, the Birds in my, W. T. Greene, R. Bowdler-Sharpe, 169
Gardiner (Prof. Walter): on a New Application of Photography to the Demonstration of Physiological Processes in Plants, 16; how Plants maintain themselves in the Struggle for Existence, 90
Gardner (J. Starkie), Physics of the Sub-oceanic Crust, 103
Garrett (T. A.) and W. Lucas, Wimshurst Machine and Hertz's Vibrator, 515
Garstang (Walter), Foreign Substances attached to Crabs, 417, 490, 538
Gas-flame, Luminous and Non-luminous Radiation of, Sir John Conroy, 357
Gas Measurement, Improved Apparatus for, Prof. Lunge, 471
Gauge, Bourdon's Pressure, Prof. A. G. Greenhill, F.R.S., 517
Gauthier-Villars (H.), Eder's Photographie à la Lumière du Magnésium, translated by, 584
Geddes (Prof. Patrick) and Arthur Thomson, Evolution of Sex, 531
Geodesy: a Bibliography of, J. Howard Gore, 9; the Measurement of the Peruvian Arc, E. D. Preston, 309; Geodetic Surveys of India, 140
Geography: Geographical Notes, 20, 45, 164, 234, 286, 327, 351, 374, 403, 472, 571; Geographical Results of Stanley's Expedition, 20, 73, 111; the North Coast of New Guinea, Admiral von Schleinitz, 21; Reported Massacre of Dr. Peters's Party, 21; Cyprus, Lt.-General Sir Robert Biddulph, 45; Physics of the Sub-oceanic Crust, Rev. Osmond Fisher, A. J. Jukes-Browne, 53; Teacher's Manual of Geography, J. W. Redway, 78; Exploration of the Musgrave Ranges, Australia, 86; Death of Major P. E. Warburton, 164; Death of Cardinal Massaja, 164; the Ascent of Kilimanjaro, Meyer and Purtscheller, 164; the South African Gold-fields, G. D. Cocorda, 164; Arrival of Captain Trivier at Mozambique, 165; M. Thoroddsen's Explorations in Iceland, 165; Dauvergne's Journey in N.W. Cashmere, 165; Geography in Russia, Baron Kaulbars, 208; Colonel Roborovski's Expedition in Central Asia, 234; Prof. Kuekenthal's Researches in

King Charles Land, 234 ; a Thousand Miles on an Elephant in the Shan States, Holt S. Hallett, 265 ; the Lesser Antilles, by Owen T. Bulkeley, 268 ; Tietkens's Explorations in Central Australia, 286 ; Tavernier's Travels in India, translated by V. Ball, F.R.S., 313 ; Area of Austro-Hungarian Empire, Dr. Penck, 325 ; Discovery of Pass from Nia to Tibet by Colonel Pevtsoff and M. Roborovsky, 327 ; Search and Travel in the Caucacus, Douglas W. Freshfield, 351 ; the Russian Expeditions in Central Asia, 352 ; Dr. Nansen's Plan for a North Polar Expedition, 374 ; Sir Wm. McGregor's Explorations in New Guinea, 374 ; a Trip through the Eastern Caucasus, by the Hon. John Abercromby, 391 ; Further Explorations of Solomon Islands, C. M. Woodford, 403 ; proposed Danish Exploration of Greenland, 403 ; Geographical Society of Vienna, 403 ; Bartholomew's Library Reference Atlas of the World, 413 ; Hues's Treatise on the Globes (1592), 459 ; Limits of Ever-frozen Soil in Siberia, Yatchevsky, 472 ; Diminution in Population of Iceland, 473 ; Climate of German Togoland, Dr. von Danckelmann, 545 ; Facsimile Atlas to the Early History of Cartography, by A. E. Nordenskiöld, 558 ; Dr. Hans Meyer's Ascent of Kilima-Njaro, 572 ; Modigliani's Exploration of Nias Island, Prof. Giglioli, 587 ; a Naturalist among the Head-hunters, C. M. Woodford, 582
Geology : Indian Geological Survey, Death of E. J. Jones, 41 ; Geological Survey of India, 140 ; Formation of the Earth's Crust, Le Conte, 46 ; Chemical and Physical Studies in the Metamorphism of Rocks, Rev. A. Irving, 49 ; the Murrumbidgee Limestone, R. Etheridge, Jun., 67 ; an Elementary Text-book of, by W. Jerome Harrison, Prof. A. H. Green, F.R.S., 75 ; Dr. Hermann Burmeister on the Fossil Horses and other Mammals of Argentina, 82 ; Geological Society, 94, 190, 238, 310, 333, 382, 502, 527, 550 ; Medals awarded by the Geological Society, 301 ; Presidential Address at the Geological Society, Dr. Blanford, F.R.S., 455 ; Physics of the Sub-oceanic Crust, J. Starkie Gardner, 103 ; Geological Excursion to the Active and Extinct Volcanoes of Southern Italy, 133 ; Dr. W. Hind on the Geology of Suffolk, 149 ; on the Creation and Physical Structure of the Earth, by J. T. Harrison, 151 ; Glaciation of Valleys in Kashmir Himalayas, Captain Stiffe, 190 ; Geology of Witwatersrand Gold-fields, Dr. H. Exton, 190 ; the South American Pampas Formation, Herr Roth, 231 ; Occurrence of *Girvanella* Genus, and on Oolitic Structure, E. Wethered, 238 ; Relation of Pebbly Sands of Suffolk to those of Norfolk, Parts II. and III., Prof. Joseph Prestwich, F.R.S., 238, 502 ; H. S. Williams on the Devonian System, 309 ; some British Jurassic Fish Remains, A. S. Woodward, 310 ; the Pebidian Volcanic Series of St. David, Prof. C. L. Morgan, 311 ; Terraced Hill Slopes of the Midlands, E. A. Walford, 325 ; Crystalline Schists and their Relations to Mesozoic Rocks in Lepontine Alps, Prof. T. G. Bonney, F.R.S., 333 ; Geological Mechanism, by J. Spottiswoode Wilson, 390 ; Sedgwick and Murchison, Cambrian and Silurian, Prof. James D. Dana, 421 ; Former Glacial Periods, Dr. James Croll, F.R.S., 441 ; Mica in Mourne Mountain Granite Geodes, Prof. Sollas, F.R.S., 469 ; Geologische Uebersichtskarte der Alpen, Dr. Franz Noë's, Prof. T. G. Bonney, F.R.S., 483 ; a Geological Map of the Alpine Chain, Prof. T. G. Bonney, F.R.S., 483 ; a Deep Channel of Drift in the Valley of the Cam, Essex, W. Whitaker, 527 ; Geology of the Quicksilver Deposits of the Pacific Slope, G. F. Becker, 532 ; certain Devonian Plants from Scotland, Sir J. W. Dawson, F.R.S., 537 ; Composite Spherulites in Obsidian from Hot Springs near Little Lake, California, Frank Rutley, 551 ; Magnetic Surveys of Special Districts in the British Isles, Profs. A. W. Rucker, F.R.S., and T. E. Thorpe, F.R.S., 598
Geometry : How not to Teach Geometry, Herbert J. Woodall, 60 ; Geometrical Teaching, 80 ; Association for the Improvement of Geometrical Teaching, 207 ; Oxford "Pass" Geometry, 467
Geophilus maritimus, Edward Parfitt, 153
German Chemical Society, 468
German Contributions to Ethnology, 433
Germany, Zoogeography, Wolves, &c., in, Dr. Lampert, 182
Germination, Retarded, 31
Gernez (D.), Malic Acid and its Compounds, 94
Giard (Prof.), Discovery of Micro-organism conferring Phosphorescence on Crustaceans, 137
Gibb (Thomas), Text-book of Assaying, C. Beringer and J. J. Beringer, 245
Giffen (Robert) : Accumulations of Capital in the United Kingdom in 1875–85, 211 ; the Growth of Capital, 553
Giglioli (Prof.) : Field Experiments on Wheat in Italy, 404 ; Modigliani's Exploration of Nias Island, 587
Gilbert Club, Proposed, 84, 112
Giles (Ernest), Australia Twice Traversed, 341
Gill (Dr.), Minor Planet (12), Victoria, 139
Girard (Jules), Recherches sur les Tremblements de Terre, 583
Glacial Periods, Former, Dr. James Croll, F.R.S., 441
Glaciation of Valleys in the Kashmir Himalayas, Captain Stiffe, 190
Glaisher (J. W. L., F.R.S.), the Method of Quarter Squares, 9
Glatzel (Dr.), New Mode of Preparing Manganese, 67
Glimpses of Animal Life, W. Jones, 409
Globes, Hues's Treatise on the (1592), 459
Globular and other Forms of Lightning, Reuben Phillips, 58
Glories, A. P. Coleman, 154
Glossary of Anatomical, Physiological, and Biological Terms, T. Dunman, 173
Glow of Phosphorus, Prof. T. E. Thorpe, F.R.S., 523
Gold, Earth-currents and the Occurrence of, Geo. Sutherland, 464
Gold Exploration in British North Borneo, 182
Gold in Suspension, Fungoid Growths in, 96
Goldscheider (Dr.), Sensitiveness of Articular Surfaces of Joints, 528
Goode (George Brown), Fishery Industries of the United States, 178
Gore (J. E.), Scenery of the Heavens, 391
Göttingen Royal Society of Sciences, 600
Graham (Robert H.), Newton in Perspective, 439
Granada, Earthquake at, 161
Grant (J.), Influence of Different Oxides on Decomposition of Potassium Chlorides, 502
Grass, a Field laid down to Permanent, Sir J. B. Lawes, F.R.S., 229
Grasses, How to Know, by their Leaves, A. N. M'Alpine, Prof. John Wrightson, 557
Grasses of the Southern Punjab, Illustrations of some of the, being Photo-lithographs of some of the Principal Grasses found at Hissar, William Coldstream, 533
Gravitation : the Constant of, C. V. Boys, F.R.S., 155 ; Resonance Method of measuring Constant of, J. Joly, 256
Gravitation, Velocity of the Propagation of, J. Van Hepperger, 472
Gray (Andrew), Absolute Measurements in Electricity and Magnetism, 561
Gray (Dr. Asa), Scientific Papers of, W. Botting Hemsley, F.R.S., 221
Greatheed (W.), Influenza, 270
Greely (General), Bibliography of Meteorology, 303
Green Vegetable Colouring-matter, a New, C. Michie Smith, 573
Green (Prof. A. H., F.R.S.) : an Elementary Text-book of Geology, W. Jerome Harrison, 75
Green (J. R.), Germination of Castor-oil Plant Seed, 380
Greene (W. T.), the Birds in my Garden, R. Bowdler Sharpe, 169
Greenhill (Prof. A. G., F.R.S.) : the Parallelogram of Forces, 298 ; Foot-pounds, 317 ; the Life and Work of G. A. Hirn, 323 ; the Elastical Researches of Barré de Saint-Venant, 458 ; Bourdon's Pressure Gauge, 517
Greenish Meteor, a, T. D. A. Cockerell, 369
Greenland, is it our Arctic Ice Cap?, S. E. Peal, 58
Greenland, the Proposed Danish Expedition to the East Coast of, 403, 545
Greenwich Observatory, 305 ; Meteorological Observations for 1887 at, 570
Gregory (W. G.) : a New Electric Radiation Meter, 47 ; a Method of Driving Tuning-forks Electrically, 47
Grensted (Rev. Fred. F.), Protective Coloration of Eggs, 53
Griffiths (Dr. A. B.), Manures and their Uses, 222, 272
Grombchevsky (Colonel), in Central Asia, 352
Ground-movements, Periodic, Plantamour, 373
Groves (Chas. E., F.R.S.), Systems of "Russian Transliteration," 534
Growth of Capital, Robert Giffen, 553
Guillaume (Ch. Ed.), Traité pratique de la Thermométrie de précision, Dr. Edmund J. Mills, F.R.S., 100
Guillemard (Dr. F. H. H.), a Naturalist in North Celebes, Sydney Hickson, 457

Gulia (Dr.), Death and Obituary Notice of, 302
Gulick (Rev. John T.): Evolution and the Darwinian Theory, 309; "Like to Like," a Fundamental Principle in Bionomics, 536
Gull (Sir William), Death of, 324
Guppy (Dr. H. B.): a Contribution to the Physical History and Zoology of the Somers Archipelago, with an Examination of the Structure of Coral Reefs, Angelo Heilprin, 193; Coral Reefs of the Java Sea and its Vicinity, 300; the Dispersal of Plants, as Illustrated by the Flora of the Keeling Islands, 492
Gurney (Henry Palin), Science and the India Civil Service Examinations, 53
Guzzi (P.), Determination of Coefficient of Dynamic and Electromotor Produce, 380

Haga (T.), Oxyamidosulphonates and their Conversion into Hyponitrites, 143
Hagen (Dr. B.), the Malay Peoples, 21
Hagen (Rev. John G.), Observations of some Suspected Variables, 233
Hailstones: Remarkable, at Philadelphia, Prof. E. J. Houston, 43; Remarkable, G. J. Symons, F.R.S., 134
Hailstorms in Northern India, S. A. Hill, 236
Hake (H. W.), Coloured Analytical Tables, 29
Hall (Asaph), Mass of Saturn, 429
Hall (Maxwell), on the Spectrum of the Zodiacal Light, 351, 402
Hall (T. H.), Beetle Settlement in Disused Gasometers, 520
Haller (A.), the α Dextro- and Lævo-rotatory Borneol Camphorates, 503
Hallett (Holt S.), a Thousand Miles on an Elephant in the Shan States, 265
Halos, Solar, and Parhelia, J. Lovell, 560
Hamburg: Interesting Remains Discovered in, 21; Groundwater Variations and the Typhus Epidemic, 570
Hampshire, Characteristic Survivals of Celts in, T. W. Shore, 406
Hamy (Dr.), French Scientific Missions under Old Monarchy, 427
Handtmann (Pastor), Inheritance of Acquired Mental Peculiarity, 209
Harcourt (L. F. V.), Effects of Training Walls in Mersey Estuary, 380
Hardening and Tempering of Steel, Prof. W. C. Roberts-Austen, F.R.S., on the, 11, 32
Harding (Chas.): Weather in January, 425; on the Cold in March 1890, 598
Harker (Alfred), the Bala Volcanic Series of Caernarvonshire and Associated Rocks, being the Sedgwick Prize Essay for 1888, 414
Harris (P. A.), Brilliant Meteors, 105
Harris (Walter B.), the Land of an African Sultan, 270
Harrison (J. T.), on the Creation and Physical Structure of the Earth, 151
Harrison (W. Jerome), an Elementary Text-book of Geology, Prof. A. H. Green, F.R.S., 75
Hartog (Prof. Marcus M.), Achlya, 298
Hartog (P. J.), a First Foreshadowing of the Periodic Law, 186
Harvard College, the Astronomical Observatory of, 446
Harvey (Augustus), Influenza, 270
Hauck (Dr. F.), Death of, 256
Hawes (F. B.), Carbon Deposit in Blake Telephone Transmitter, 477
Haycraft (Dr. J. B.), Voluntary Muscular Contraction, 495
Haze, the Causes and Character of, Hon. F. A. R. Russell, 60
Hazen (Prof. H. A.), Use of "Sling" Thermometer in Prediction of Frosts, 501
Head-hunters, a Naturalist among the, C. W. Woodford, 582
Health, Hygiene or Public, Louis C. Parkes, 290
Heat, Animal, M. Berthelot, 119
Heat and Light, Rev. F. W. Aveling, 558
Heavens, Scenery of the, J. E. Gore, 391
Hebert (M.), Funeral of, 545
Heilprin (Angelo), a Contribution to the Physical History and Zoology of the Somers Archipelago, with an Examination of the Structure of the Coral Reefs, Dr. H. B. Guppy, 193
Helmholtz (Prof.), on the Production of Waves, 95
Helsingfors University, 400
Hempel (Dr.), Experiments upon Simultaneous Production of Pure Crystals of Sodium Carbonate and Chlorine from Common Salt 16
Hemsley (W. Botting, F.R.S.): Scientific Papers of Dr. Asa Gray, 221; Flora of Keeling Islands, 492; Self-Colonization of Coco-Nut Palm, 537
Henry (Louis), Glycollic Nitrile and direct Synthesis of Glycollic Acid, 576
Henry (Paul and Prosper), Suppression of Halos in Photographic Plates, 576
Hepperger (J. Van), Velocity of the Propagation of Gravitation, 472
Herdman (Prof. W. A.): Les Animaux et les Végétaux Lumineux, Henri Gadeau de Kerville, 293; Foreign Substances attached to Crabs, 344
Heredity and Effects of Use and Disuse, F. H. Collins, 559
Heredity, Theory of, Prof. A. Weismann, 317, 373, 439
Hermite (Prof. Ch.), Mathematical Teaching at Sorbonne, 597
Herring, the Zuyder Zee, Dr. Hoek, 216
Herschel (Prof. A. S., F.R.S.): a Natural Evidence of High Thermal Conductivity in Flints, 175; the Spectrum of Subchloride of Copper, 513
Hertz's Vibrator, Wimshurst Machine and, T. A. Garrett and W. Lucas, 515
Hertz's Vibrators, Multiple Resonance obtained in, Prof. Geo. Fras. Fitzgerald, 295; Fred T. Trouton, 295
Herzegovina, Earthquakes in, 136
Hess (Carl), the Eye of the Mole, 373
Heymans (Dr.), Myelin, 528
Hicks (W. M., F.R.S.), Elementary Dynamics of Particles and Solids, 534
Hickson (Sydney J.), a Naturalist in North Celebes, Dr. F. H. H. Guillemard, 457
High Latitudes, Sun-spot in, G. Dierckx, 472
Hilger (Dr.), Taxine, a New Alkaloid from Yew Leaves, &c., 496
Hill (J. Rutherford), the Meteorite of Mighei, 298
Hill (S. A.), Hailstorms in Northern India, 236
Himalayas, Glaciation of Valleys in Kashmir, Captain Stiffe, 190
Hind (Dr. W. M.,), the Flora of Suffolk, 149
Hind (Dr. Wheelton), on the Geology of Suffolk, 149
Hiorns (Arthur H.), Iron and Steel Manufacture, 159
Hirn (Gustave Adolphe): Death of, 281; the Life and Work of, Prof. A. G. Greenhill, F.R.S., 323
Hissar, Illustrations of some of the Grasses of the Southern Punjab, being Photographs of some of the Principal Grasses found at, William Coldstream, 533
History of Modern Philosophy, Descartes and his School, Prof. Kuno Fisher, 171
Holden (Prof.), Total Eclipse of January 1, 1889, 305
Hollis (W. Ainslie), Galls, 131, 274
Holmgren (Prof.), Cause of Change of Skin-colour in Arctic Voyagers, 546
Holt (Ernest W. L.): Foreign Substances attached to Crabs, 463, 515, 586; some Stages in Development of Brain of *Clupea harengus*, 525
Hopkins (George M.), Experimental Science, 102
Hopkins (W. B.), Behaviour of more Stable Oxides at High Temperatures, 502
Hopkinson (Dr. J., F.R.S.): Magnetism, 249, 273; Physical Properties of Nickel Steel, 332
Horny Sponges, Robert von Lendenfeld, 146
Horses, Fossil, of Argentina, Dr. Hermann Burmeister, 82
Horsley (Victor, F.R.S.), Arrangement of Excitable Fibres of Internal Capsules of Bonnet Monkey, 166
Horticultural Exhibition, the Proposed Berlin International, 283
Horticulture, the Cultivated Oranges and Lemons of India and Ceylon, Dr. E. Bonavia, C. B. Clarke, F.R.S., 579
Hough (Walter), Archæology and Ethnology of Easter Island, 569
Houssay (F.), Les Industries des Animaux, 409
Houston (Prof. E. J.), Remarkable Hailstones at Philadelphia, 43
Houzeau (J. C.): Biographical Note on, A. Lancaster, 20, 69; Vade Mecum, 69
Hudson (Dr. C. T., F.R.S.), on some Needless Difficulties in the Study of Natural History, 375
Hudson (W. H.), Argentine Ornithology, R. Bowdler Sharpe, 7
Hues's (Robert), Treatise on the Globes (1592), 459
Hughes (Mrs. Watts), Voice Figures, 42
Hulme (F. Edward), Wayside Sketches, 270
Human Anatomy, a Text-book of, Prof. Alex. Macalister, F.R.S., 269
Human Foot, the, Thos. S. Ellis, 365

Hume (Allan O.), the Nests and Eggs of Indian Birds, Vol. I., 388
Humphry (Geo. M., M.D., F.R.S.), Old Age, 484
Hyderabad Chloroform Commission, 154, 289
Hydra, New Variable Star in, 88
Hydraulic Motors, Turbines and Pressure Engines, G. R. Bodmer, 27
Hydrazine, Drs. Curtius and Jay, 547
Hydrobromic Acid, the Preparation of, A. Recoura, 599
Hydrophobia, the New Muzzling Regulation, 241
Hydrostatics, Stability of Rotating Spheroid of Perfect Liquid, E. H. Bryan, 526
Hydroxylamine with Metallic Chlorides, New Compounds of, Crismer, 401
Hygiene and Demography, Congress on, 401
Hygiene of French Native Colonists in Paris, 427
Hygiene or Public Health, Louis C. Parkes, 290
Hypnotic Subjects and the Eye, 94
Hypothesis, Nebular, Herbert Spencer, 450

Iapetus, Observations of the Magnitude of, 403
Ice Forms, Peculiar, Prof. J. G. MacGregor, 463
Iceland: Diminution in Population of, 473; M. Thoroddsen's Explorations in, 165
Ichthyology: the Spiracle Gill of Selachians, Dr. Virchow, 119; the Zuyder Zee Herring, Dr. Hoek, 216; Anchovies on South Coast of England, J. T. Cunningham, 230; Drumming Fish (*Balistes aculeatus*), 263; Anatomy of *Torpedo marmorata*, Prof. Fritsch, 264; Sardines in Moray Firth, Prof. Ewart, 282; the Bladder in Fishes, Prof. Liebreich, 359; Cranial Nerves of Torpedo, Dr. J. C. Ewart, 477; Marine Fisheries Society of Great Grimsby, 520; some Stages in Development of Brain of *Clupea harengus*, E. W. L. Holt, 525
Identity of Comet Vico (1844) with Brooks's (1889), 233
Idylls of the Field, Francis A. Knight, 79
Im Hochgebirge, Wanderungen von Dr. Emil Zsigmondy, 291
Images, Visualized, Produced by Music, Geo. E. Newton, 417
Index of British Plants, Robert Turnbull, 196
Index Generum Avium, F. H. Waterhouse, R. Bowdler Sharpe, 169
Index: a Suggested Subject-index to the Royal Society's Catalogue of Scientific Papers, 342, 391
Index of the Papers of the London Mathematical Society, 594
India: Science and the Indian Civil Service Examinations, 25, 265; Henry Palin Gurney, 53; Indian Geological Survey, Death of Mr. E. J. Jones, 41; Recent Indian Surveys, 139, 230; Fauna of British India, including Ceylon and Burma, 101; Wanton Destruction of Forests in India, R. J. Crosthwaite, 210; Dr. Schlich, 470; Northern, Hailstorms in India, S. A. Hill, 236; Olive Cultivation in India, 303; Travels in India, Jean Baptiste Tavernier, 313; the Birds of India, E. W. Oates, 388; the Nests and Eggs of Indian Birds, Allan O. Hume, 388; Locusts in India, E. C. Cotes, 403, 491; Technical Education in Central, 470; Suggestion for Facilitating the Study of Botany in, G. Carstensen, 546; Provincial Index of Minerals of, Dr. W. King, 546; Native Indian Scientific Literature, 569; the Cultivated Oranges and Lemons of India and Ceylon, Dr. E. Bonavia and C. B. Clarke, F.R.S., 579; Catalogue of the Library of Indian Museum, 594
Indian, American, Languages, Use of Edison Phonograph in Preserving, J. W. Fewkes, 560
Indian, American, Pipe, H. B. Bashore, 303
Indigo, New Method of Synthesizing, Dr. Flimm, 326
Inductive Capacity, Specific: W. A. Rudge, 10; Prof. Oliver J. Lodge, F.R.S., 30
Influenza: the Epidemic of, 145; W. Greatheed, 270; Augustus Harvey, 270; the Suspected Connection between Influenza and Cholera Epidemics, Dr. Smolenski, 282; Climatological Considerations about Influenza, Dr. Assmann, 325; Children's Growth in Weight checked by Influenza, 471; Supposed Chinese Source of Russian Influenza, 593; Influenza and Weather, Mitchell and Buchan, 596
Inheritance of Acquired Characters: the Duke of Argyll, F.R.S., 173, 294, 366; W. T. Thiselton Dyer, F.R.S., 315; F. V. Dickins, 316; Right Rev. Bishop R. Courtenay, 367; Dr. J. Cowper, 368; Herbert Spencer, 414; Prof. E. Ray Lankester, F.R.S., 415. *See also* Panmixia
Inheritance of Acquired Mental Peculiarity, Handtmann, 209
Inherited Characters and Panmixia, Prof. Geo. J. Romanes, F.R.S., 437
Insect, Note on a Probable Nervous Affection observed in an, E. W. Carlier, 197
Institution of Civil Engineers, 229
Institution of Electrical Engineers, 21
Institution of Mechanical Engineers, 331; Anniversary Meeting, 591
Institution of Naval Architects, 494, 515
Internationales Archiv für Ethnographie, 209, 372
Iron and Steel Institute, Visit to America of, 469
Iron and Steel Manufacture, Arthur H. Hiorns, 150
Iron and Steel, Molecular Stability of Metals, particularly of, Carl Barus, 369
Iron, the Relation between Atomic Volumes of Elements present in, and their Influence on its Molecular Structure, Prof. W. C. Roberts-Austen, F.R.S., 420
Iron, the Villari Critical Points in Nickel and, Herbert Tomlinson, F.R.S., 574
Irving (Rev. A.), Chemical and Physical Studies in the Metamorphism of Rocks, 49
Isefiord, Denmark, Zoological Floating Station at, 569
Italy, Southern, Geological Excursion to the Active and Extinct Volcanoes of, 133
Italy: Earthquake in, 136; Activity of Queccia de Salsa, 181
Ivy, Abnormal Shoots of, W. F. R. Weldon, 464
Izvestia of the Russian Geographical Society, 352

Jackson (W. E.), Nebula, General Catalogue No. 4795, 450
Jacobi (Mary Putnam), Physiological Notes on Primary Education and the Study of Language, 28
James (Dr. Bushrod W.), American Resorts, with Notes upon their Climate, 79
James (W. J.), the Use of the Word Antiparallel, 10
Jamieson (Prof.), Magnetism and Electricity, 461
January, Weather in, Chas. Harding, 425
Japan: Cyclone of September 11-12, 1889, in, M. Wada, 208; Great Volcanic Eruption in, 400; Meteorology in 1887, M. Wada, 400; Japanese Dwarf Tree (*Thuja obtusa*), 86
Japp (Prof. F. R., F.R.S.): α-β-Dibenzoylstyrolene and Zinin's Lepiden Derivatives, 142; Compounds of Phenanthraquinone with Metallic Salts, 191
Jastrow (Prof.), the Cradle of the Semites, 569
Java Sea, Coral Reefs of the, and its Vicinity, Dr. H. B. Guppy, 300
Jay (Dr.), Hydrazine, 547
Jenkins (Prof. P.), the Strength of Ships, 515
Jerusalem, Troglodytic Remains in, Herr Schick, 284
Jesse (O.), Photographs of Luminous Night Clouds, 592
Johns Hopkins University, 448
Johnson (W. E.), Proof of the Parallelogram of Forces, 153
Johnson (Prof. W. W.), a Treatise on Ordinary and Partial Differential Equations, 270
Johnston (Miss E. J.), the Relation of Physiological Action to Atomic Weight, 189
Johnston (R. M.), Variability of Tasmanian *Unio*, 303
Joly (A.), Double Nitrites of Ruthenium and Potassium, 23
Joly (J.): the Steam Calorimeter, 212; Resonance Method of Measuring Constants of Gravitation, 256
Jones (E. J.), Death of, 41
Jones (W.), Glimpses of Animal Life, 409
Jörgensen (Alfred), the Micro-organisms of Fermentation practically considered, Prof. Percy F. Frankland, 339
Joule (Prof. J. P.), Proposed Memorial to, 89, 160, 281
Journal of Botany, 405
Jukes-Browne (A. J.): Physics of the Sub-oceanic Crust, 53; Is the Bulk of Ocean Water a Fixed Quantity?, 130
Jungfrau Railway, Proposed, Herr Trautweiler, 303
Jupiter, Recent Observations of, W. F. Denning, 206
Jupiter's Belt 3, III., the Structure of, Dr. Terby, 45
Jupiter's Satellites, Ch. André, 94

Kane (Sir Robert, F.R.S.): Death of, 371; Obituary Notice of, 398
Kangaroos, Decrease of, 43
Karlsruhe Observatory, A. Fowler, 20
Kater Pendulum, Shuckburgh Scale, O. H. Tittmann, 538
Katzenstein (Dr.), Experiments on Influence of Bodily Labour on Metabolism of Man, 479
Kaulbars (Baron), Geography in Russia, 208
Keeling Islands, Flora of, Dr. H. B. Guppy, W. B. Hemsley, F.R.S., 492

Keiser (Dr. E. H.), Redetermination of Atomic Weight of Palladium, 44
Kent, Discovery of Coal in, 400
Kerville (Henri Gadeau de), Les Animaux et les Végétaux Lumineux, Prof. W. A. Herdman, 293
Kew Bulletin, 42, 136, 283, 325, 448, 569
Kew Observatory Report, 208
Key to the Royal Society Catalogue, James C. McConnel, 342, 391, 418
Khŭrbet 'Ajlân, Excavations at, 592
Kiel, the Botanical Institute and Marine Station at, 397
Kiev, Actinometric Observations (1888–89) at, R. Savelief, 359
Kilima-Njaro, the Ascent of, Dr. Hans Meyer and Purtscheller, 164, 572
King Charles Land, Prof. Kuekenthal's Researches in, 234
King (Dr. George, F.R.S.), Materials for a Flora of the Malayan Peninsula, 437
King (Dr. W.), Provincial Index of Minerals of India, 546
Kirby (W. F.), Systems of "Russian Transliteration," 534
Kirschbaum (Madame Rosa), First Lady Physician admitted to Medical Practice in Austria, 509
Klein (Dr. E., F.R.S.), the Bacteria of Asiatic Cholera, 509
Klingemann (Dr. F.), α-β-Dibenzoyltyrolene and Zinin's Lepiden Derivatives, 142
Knight (Francis A.), Idylls of the Field, 79
Knopf (Dr.), Comet Brooks (*d* 1889, July 6), 115
Knott (Prof. Cargill G.), the Earthquake of Tokio, April 18, 1889, 32
Kny (Herr), on Trees Growing in an Inverted Position, 86
Kolaba District, Flint Remains in, W. E. Sinclair, 114
Kossel (Prof.), Microscope as applied to Physiological Chemistry, 23
Krakatão, the Period of the Long Sea-waves of, James C. McConnel, 392
Kremser (Dr.), Frequency of Mist, 215
Kubary (J. S.), Ethnographische Beiträge zur Kenntniss des Karolinen Archipels, 433
Küchenmeister (Dr. Gottlob Friederich H.), Death of, 592
Kuekenthal's (Prof.), Researches in King Charles Land, 234
Kunz (G. F.), Mexican Amber, 372
Kutter (W. R.) and E. Ganguillet, a General Formula for the Uniform Flow of Water in Rivers and other Channels, 411

Laboratories of Bedford College, London, 279
Laboratory, Botanical, in the Royal Gardens, Peradeniya, Ceylon, 445
Laboratory, New Marine, at St.-Wast-la-Hougue, 160
Laboratory, the Poona Bacteriological, 469
Laboratory Work, Elements of, A. G. Earl, 461
Labuan, the African Oil Palm in, 42
Laccadive Islands, Rat-plague in, 303
Ladybird, Australian, in California, Spread of the, J. R. Dobbins, 161
Lagrange (Dr. Fernand), Physiology of Bodily Exercise, 485
Lake-dwelling near Milan, Discovery of, 67
Lalang, Noxious Grass at Singapore, 182
Lamarck *versus* Weismann, Prof. E. D. Cope, 79
Lamarck's and Darwin's Theories as to Transmission of Acquired Characters, Prof. E. R. Lankester, F.R.S., 486
Lamb (Prof. Horace, F.R.S.): on a Certain Theory of Elastic After-strain, 463; on the Deformation of an Elastic Shell, 549
Lamp (Dr. E.): Return of Brorsen's Comet, 69; Comet Swift (*f* 1889, November 17), 233
Lampert (Dr.), Zoogeography, Wolves, &c., in Germany, 182
Lamplugh (G. W.), the Wanton Destruction of Sea-birds, 490
Lancaster (M. A.), Biographical Note on, J. C. Houzeau, 20
Land, Area of the, and Depths of the Oceans in Former Periods, T. Mellard Reade, 103
Langley (E. M.), the Use of the Word Antiparallel, 104
Langley (J. N., F.R.S.), Local Paralysis of Peripheral Ganglia and Connection of Nerve-Fibres with them, 118
Langley (Prof.), the Solar and the Lunar Spectrum, 450
Language, Study of Physiological Notes on Primary Education and the, Mary Putnam Jacobi, 28
Languages, American Indian, Use of Edison Phonograph in Preserving, J. W. Fewkes, 560
Lankester (Prof. E. Ray, F.R.S.): Darwinism, 9; E. D. Cope on the Causes of Variation, 128; the Inheritance of Acquired Characters, 415; Transmission of Acquired Characters and Panmixia, 486; Panmixia, 558
Lapouge (M. de), Modern Crania in Montpellier, 357
Larden (W.), Mirage in the South American Pampas, 69
Lascelles (B. P.) and R. P. Williams, Introduction to Chemical Science, 128
Latitude, Redetermination of, in Tokio, Watanabe, 427
Latter (Prof. Oswald H.), Who Discovered the Teeth in Ornithorhynchus?, 130, 174
Law, Science and, 399
Lawes (Sir J. B., F.R.S.), a Field laid down to Permanent Grass, 229
Lea (A. S.), a Comparative Study of Natural and Artificial Digestions, 430
Leak-stopping in Steel Ships, Captain C. C. P. Fitzgerald, R.N., 516
Lean (Wm. Scarnell), a Brilliant Meteor, 60
Leaper (Clement J.), Synoptical Tables of Organic and Inorganic Chemistry, 510
Least Squares, Theory of, a Formula in the, D. Wetterhan, 394
Lebeau (P.): Volumetric Estimation of Copper, 431; Estimation of Free Halogen and Iodides in Presence of Chlorine and Bromine, 479
Le Conte, Formation of the Earth's Crust, 46
Lefroy (Sir John H., F.R.S.), Death and Obituary Notice of, 568
Lehmann (Dr.): the Babylonian Metrical System, 167; the Testing of Tuning-forks, 383
Leicester Museum Grounds, on a Mite of the Genus *Tetranychus* found Infesting Lime Trees in the, F. R. Rowley, 31
Leicestershire and Rutland, the Vertebrate Animals of, Montagu Browne, 220
Lendenfeld (Dr. Robert von): a Monograph of the Horny Sponges, 146; Physiology of Sponges, 570; Foreign Substances attached to Crabs, 317
Lepidoptera, Sugar losing its Attractions for, Joseph Anderson, 349
Lepidoptera, Temperature Experiments on, F. Merrifield, 191
Lesquereux (Prof.), Death of, 135
Lesser Antilles, the, Owen T. Bulkeley, 268
Leumann (Prof.), Influence of Blood-Circulation and Breathing on Mind-Life, 209
Leveau (G.), D'Arrest's Comet, 596
Lewes (Prof. V.), the Ignition of Coal Cargoes, 517
Lewis (Prof. H. C.), the late, Wm. Upham, 256
Ley (Rev. W. Clement): Thought and Breathing, 317; Chiff-Chaff singing in September, 317
Leyden Ethnographical Collection, the, 180
Libraries, Free, the Manchester, 181
Library, Bethnal Green Free, Proposed Enlargement of, 349
Library, Proposed Free, at Whitechapel, 161
Library Reference Atlas of the World, John Bartholomew, 413
Liebreich (Prof.), the Bladder in Fishes, 359
Life, Animal, Glimpses of, W. Jones, 409
Light, Coronal, Photometric Intensity of, Prof. Thorpe, 139
Light and Heat, Rev. F. W. Aveling, 558
Light, New, from Solar Eclipses, William M. Page, William E. Plummer, 529
Light-Waves, Measurement by, A. A. Michelson, 405
Lightning, Effects of, 10
Lightning, Globular and other Forms of, Reuben Phillips, 58
Like to Like, a Fundamental Principle in Bionomics, Prof. Geo. J. Romanes, F.R.S., 535; John T. Gulick, 535
Lime, Crystals of, H. A. Miers, 515, 560
Lime Trees in Leicester Museum Grounds, on a Mite of the Genus *Tetranychus* found Infesting, F. R. Rowley, 31
Linear Differential Equations, a Treatise on, Thomas Craig, 508
Ling (A. R.), Studies on Isomeric Change, IV., Halogen Derivatives of Quinone, 527
Linnean Society, 143, 191, 239, 334, 405, 431, 478, 527, 599
Linnean Society of New South Wales, 161, 284
Linossier (G.), Morphology and Biology of *Oidium albicans*, 72
Liquid Surfaces, Tension of Recently-formed, Lord Rayleigh, 566
Liquids, Determination, by Measurement of Ripples, of Surface Tensions of, Prof. C. Michie Smith, 575
Lissa (Baron de), the Pioneer Plants of British North Borneo, 494
Liverpool Literary and Philosophical Society, 471
Liverpool Physical Society, 135
Lizard of South-West United States, *Heloderma suspectum*, the Poisonous, Craniology of, R. W. Shufeldt, 181

Lobley (J. Logan), Mount Vesuvius, 195
Lockyer (J. Norman, F.R.S.): the Physical and Chemical Characteristics of Meteorites as throwing Light upon their Past History, 305; on the Zodiacal Light, 402
Locomotive, the Latest Express Compound, 448
Locusts in India, E. C. Cotes, 403, 491
Locusts in the Red Sea, G. T. Carruthers, 153
Lodge (Prof. Dr. Oliver J., F.R.S.): Modern Views of Electricity, 5, 80; Specific Inductive Capacity, 30; the Peltier Effect and Contact E.M.F., 224; Easy Lecture Experiment in Electric Resonance, 368; Electrical Radiation from Conducting Spheres, an Electric Eye and a Suggestion regarding Vision, 462
Loewig (Dr. K. J.), Death of, 545
Logical Machine, a New, Mary Boole, 79
London Geological Field Class, 519
London Mathematical Society, 594
London, the Moon in, Rev. T. R. R. Stebbing, 586
London Polytechnic, a South, 481
London, Polytechnics for, 242
London University, the Proposed Reconstitution of, 282, 348
Longitude of Mount Hamilton, 211
Longitude between Paris and Leyden, Difference of, Bassot, 215
Longitudes, Annuaire du Bureau des, 327
Loochoo Islands, Proposed Meteorological Observatory in, 401
Loomis on Rainfall of Earth, Dr. van Bebber, 43
Lott (Francis Edw.) and Chas. Geo. Mathews, the Microscope in the Brewery and Malt-house, 246
Lovell (J.), Solar Halos and Parhelia, 560
Lowe (E. J., F.R.S.), the Chaffinch, 394
Lucas (W.) and T. A. Garrett, Wimshurst Machine and Hertz's Vibrator, 515
Ludwigshafen, Antediluvian Remains Discovered at, 520
Lumholtz (Carl), Among Cannibals, 200
Luminous Clouds: T. W. Backhouse, 297; Joseph John Murphy, 298
Luminous Night Clouds, Evan McLennan, 131
Luminous Organisms, Henri Gadeau de Kerville, Prof. W. A. Herdman, 293
Lummer (Dr.), Abbe's Apparatus for Testing Transparent Films with Plane Parallel Surfaces, 552
Lunar Craters, Changes in, Prof. Thury, 183
Lund Museum in the University of Copenhagen, 26
Lunge (Prof.), Improved Apparatus for Gas Measurements, 471
Lupton (Sydney), the St. Petersburg Problem, 165
Lussana (S.), the Absorption of Hydrogen by Iron, 380
Lydekker (Richard), Catalogue of the Fossil Reptilia and Amphibia in the British Museum (Natural History), 534
Lynn (W. T.), Obituary Notice of Lorenzo Respighi, 254

Macalister (Prof. Alex., F.R.S.), a Text-book of Human Anatomy, 269
M'Alpine (A. N.), How to know Grasses by their Leaves, Prof. John Wrightson, 557
McConnel (James C.): the Period of the Long Sea-Waves of Krakatão, 392; Key to the Royal Society Catalogue, 342, 391, 418
McGrath (Joseph), the Arc Light, 154
MacGregor (Prof. J. G.), Peculiar Ice Forms, 463
McGregor (Sir W.), Explorations in New Guinea, 374
McIntosh (Prof. W. C., F.R.S.), the Administration of Foreign Fisheries, 497
McLachlan (R., F.R.S.), Galls, 131
McLennan (Evan), Luminous Night Clouds, 131
Macmahon (Major P. A., R.A.): a New Theory of Symmetric Functions, II., 71; Symmetrical Functions of Roots of Systems of Equations, 380
McNab (Dr. William Ramsay): Death of, 112; Obituary Notice of, 159; Proposed Memorial to, 347
Madagascar, Astronomical Observatory at, 497
Magnetic Observatory, Potsdam, Dr. Eschenhagen, 479
Magnetic Surveys of Special Districts in the British Isles, Profs. A. W. Rücker, F.R.S., and T. E. Thorpe, F.R.S., 598
Magnetical Results of the Voyage of H.M.S. *Challenger*, Report on the, Commander E. W. Creak, F.R.S., 105, 363,
Magnetism in Brick Buildings, R. W. Willson, 405
Magnetism, Dr. J. Hopkinson, F.R.S., 249, 273
Magnetism and Electricity, Arthur W. Poyser, 52
Magnetism and Electricity, Prof. Andrew Jamieson, 30, 461
Magnetism, a Proposed Gilbert Club, 84
Magnetization of Cobalt, Effects of Pressure on, C. Chree, 237
Maiden (J. H.), the Useful Plants of Australia, 194
Malaga, Earthquake at, 470
Malay Peoples, the, Dr. B. Hagen, 21
Malayan Peninsula, Materials for a Flora of the, Dr. Geo. King, F.R.S., 437
Malic Acid and its Compounds, D. Gernez, 94
Maltese Butterflies, George Fraser, 199
Mammalian Molars, Primitive Types of, 465
Mammoth Skeleton in Russia, Discovery of, 448
Manchester Conference on the Technical Instruction Act, 97
Manchester Field Naturalists' Society, 593
Manchester Free Libraries, the, 181
Manchester Literary and Philosophical Society, 373; Annual Report of, 137
Manchester, Proposed Planting of Evergreen Shrubs in, 401
Manchester, Street Plants in, 42
Manganese, New Mode of Preparing, Dr. Glatzel, 67
Manure, Stable, the Fermentation of, Th. Schlœsing, 143
Manures and their Uses, Dr. A. B. Griffiths, 222, 272
Manuscripts, Ancient Cingalese, 349
Manx Geological Society, 208
Maori Cave-dwelling, Discovery of, H. O. Forbes, 209
Maps: Facsimile Atlas to the Early History of Cartography, A. E. Nordenskiöld, 558
Maquenne (M.), β-Inosite, 215
Marcet (Dr.), Atmospheric Dust, 358, 473
Marchand (Em.), Observations on Sun-spots made at Lyons Observatory in 1889, 599
Marine Fisheries Society of Great Grimsby, 520
Marine Laboratory, New, at St.-Wast-la-Hougue, 160
Marine Millipede, a, 104; Edward Parfitt, 153; R. I. Pocock, 176
Marine Phenomenon at Batoum, Curious, 426
Marine Station at Kiel, 397
Marine Survey of India, 140
Markham (Clements R., F.R.S.), a Life of John Davis, 52
Marlborough College Natural History Society, 545
Marriott (William), Royal Meteorological Society's Exhibition, 491
Mascart (M.), Relation of certain Magnetic Perturbations to Earthquakes, 23
Mascart (M. E.), Traité d'Optique, J. D. Everett, 224
Mass of Saturn, Asaph Hall, 429
Massaja (Cardinal G.), Death and Obituary Notice of, 164
Masson (Prof. Orme), Australasian Association for the Advancement of Science, 441
Matabele Land and the Victoria Falls, Frank Oates, R. Bowdler Sharpe, 169
Mathematics: Calcul des Probabilités, J. Bertrand, 6; the Method of Quarter Squares, J. W. L. Glaisher, F.R.S., 9; the Use of the Word Antiparallel, W. J. James, 10; a Physical Basis for the Theory of Errors, C. V. Burton, 47; a New Theory of Symmetric Functions (II.), Major MacMahon, 71; a New Logical Machine, Mary Boole, 79; Geometrical Teaching, 80; Mathematical Society, 94, 214, 287, 503, 575, 594; W. E. Johnson on the Proof of the Parallelogram of Forces, 153; the St. Petersburg Problem, Sydney Lupton, 165; Glissette of Hyperbola, Prof. Tait, 214; the Extension and Flexure of Cylindrical and Spherical Thin Elastic Shells, A. B. Basset, F.R.S., 238; a Treatise on Ordinary and Partial Differential Equations, Prof. W. W. Johnson, 270; the Parallelogram of Forces, Prof. A. G. Greenhill, F.R.S., 298; Roots of an Algebraic Equation, Prof. A. Cayley, F.R.S., 335, 359; B. A. Muirhead on Ten and Tenth Notation, 344; Determination of Regulated Harmonic Surfaces, L. Raffy, 359; Symmetrical Functions of Roots of Systems of Equations, Major P. A. MacMahon, R.A., 380; Unit of Length of Sir G. Shuckburgh's Standard Scale, General J. T. Walker, R.E., F.R.S., 381; the Exponential Function, Stieltjes, 382; a Formula in the Theory of Least Squares, D. Wetterhan, 394; Newton in Perspective, Robert H. Graham, 439; the Elastical Researches of Barré de Saint-Venant, Prof. A. G. Greenhill, F.R.S., 458; on a Certain Theory of Elastic After-Strain, Prof. Horace Lamb, F.R.S., 463; Oxford "Pass" Geometry, 467; a Treatise on Linear Differential Equations, Thos. Craig, 508; Four-Figure Mathematical Tables, J. T. Bottomley, F.R.S., 510; Equations aux derivées partielles de la Physique Mathématique, Poincaré, 525; the Shuckburgh Scale and Kater Pendulum,

O. H. Tittmann, 538; Deformation of an Elastic Shell, Prof. Horace Lamb, F.R.S., 549; Index of the Papers of the London Mathematical Society, 594; Mathematical Teaching at Sorbonne, Prof. Ch. Hermite, 597
Mather (T.): Galvanometers, 310, 381; Shape of Movable Coils used in Electrical Measuring Instruments, 574
Mathews (Chas. Geo.) and Francis Edw. Lott, the Microscope in the Brewery and Malt-house, 246
Maximum Light-Intensity of the Solar Spectrum, Dr. Mengarini, 374
Mechanical Engineers, Institution of, 331
Mechanics, the Behaviour of Twisted Strips, Prof. J. Perry, F.R.S., 47
Mechanics, Parallel Motion suitable for Recording Instruments, A. P. Trotter, 478
Mediterranean Sea, Greatest Depths in, 86
Méguéia Meteorite, the, Prof. Simaschko, 472
Melbourne Observatory: Transit Observations at, 351; Star Catalogue, 522
Melbourne, the Ballarat School of Mines, 593
Melicerta ringens, Dr. C. T. Hudson, F.R.S., on, 377
Melde's Vibrating Strings, Rev. W. Sidgreaves, 355
Meldola (R., F.R.S.), the Chemistry of Photography, 293
Mengarini (Dr.), Maximum Light-Intensity of the Solar Spectrum, 374
Merchant Service, Colour-Blindness in the, 494
Mercury, on the Rotation of, Signor Schiaparelli, 257
Mercury *in vacuo*, Apparatus for Distilling, Prof. Dunstan, 526
Mergui and its Archipelago, Fauna of, 556
Meriam (Dr.), Pheasant Culture on Pacific Coast, 137
Merriam (Dr. C. Hart): Who discovered the Teeth in the Ornithorhynchus?, 11; Prof. W. H. Flower, F.R.S., 151
Merrifield (F.), Temperature Experiments on Lepidoptera, 191
Mersey Estuary, Effects of Training Walls in, L. F. V. Harcourt, 380
Meslans (M.), Isolation of Fluoroform, 521
Metallic Prominence, Spectrum of a, 233
Metallurgy: on the Hardening and Tempering of Steel, Prof. W. C. Roberts-Austen, F.R.S., 11, 32; Iron and Steel Manufacture, by Arthur H. Hiorns, 150; Physical Properties of Nickel Steel, Dr. J. Hopkinson, F.R.S., 332; the Rupture of Steel by Longitudinal Stress, C. A. Carus-Wilson, 574; the Villari Critical Point in Nickel and Iron, Herbert Tomlinson, F.R.S., 574; International Exhibition of Metallurgy and Mining at the Crystal Palace, 592
Metals: Molecular Stability of, particularly of Iron and Steel, Carl Barus, 369; Relation between Electric and Thermal Conductivities of, Alph. Berget, 387
Metamorphism of Rocks, Chemical and Physical Studies in the, Rev. A. Irving, 49
Meteorology: Electrical Cloud Phenomena, Prof. W. K. Burton, 10; Quarterly Weather Report for 1880, 18; Loomis on the Rainfall of the Earth, Dr. van Bebber, 43; Remarkable Hailstones at Philadelphia, Prof. E. J. Houston, 43; the Causes and Character of Haze, Hon. F. A. R. Russell, 60; Dr. Bushrod W. James's American Resorts, with Notes on their Climate, 79; Proposed Meteorological Station at the Bermuda Islands, 85; Annual Report of the Deutsche Seewarte, 85; Berlin Meteorological Society, 96; Deutsche Seewarte Observations, 231; Pilot Chart of the North Atlantic Ocean, 85, 161, 401; Rainfall of Germany during 1876–85, Dr. H. Meyer, 85; American Meteorological Journal, 92; Thunderstorms in England and Wales, 93; Prof. von Bezold on the Production of Clouds, 95; Meteorological Society, *see* Royal; Meteorology of New South Wales, H. C. Russell, 113; Meteorology of the Straits Settlements, 114; a Popular Treatise on the Winds, William Ferrel, 124; Luminous Night Clouds, Evan McLennan, 131; Meteorology of Suffolk, 149; Barometric Gradients, Teisserenc de Bort, 161; the Observations of Temperature on top of Eiffel Tower, Alfred Angot, 167, 181; Meteorological Institute of Roumania, 181; Cyclone of September 11–12, 1889, in Japan, M. Wada, 208; Meteorological Institute of the Netherlands, 208; Anemometers, W. H. Dines, 212; Frequency of Mist, Dr. Kremser, 215; Self-luminous Clouds, C. E. Stromeyer, 225; Remarkable Electrical Phenomena seen at the Säntis Observatory, 231; Meteorology in the United States, 231; Meteorology of Mexico for Twelve Years ending 1888, 256; Rainbow due to Sunlight reflected from the Sea, Sir William Thomson, F.R.S., 271; William Scouller, 271; Exact Thermometry, Dr. Sydney Young, 271; Weather Forecasting, 278; Meteorology of the North Atlantic for December 1889, 284; Luminous Clouds, T. W. Backhouse, 297; Joseph John Murphy, 298; Proposed Exhibition illustrating Application of Photography to Meteorology, 301; Temperature "Anomalies," 303; Bibliography of Meteorology, General Greely, 303; Report on the Meteorology of Australia, C. L. Wragge, 348; the Ben Nevis Observatory Report for January 1890, 348; Atmospheric Dust, Dr. Marcet, 358; Atmospheric Circulation, A. Buchan, 363; Shining Night Clouds, Robert B. White, 369; Dependence of Force of Winds upon Surface over which they blow, Dr. van Bebber, 372; Behaviour of Water in Soil, Dr. Wagner, 383; Sun-spots in 1889, Prof. Spörer, 383; on the Number of Dust Particles in the Atmosphere of Certain Places in Great Britain and on the Continent, with Remarks on the Relation between the Amount of Dust and Meteorological Phenomena, John Aitken, F.R.S., 382, 394; Meteorology in Japan, 1887, M. Wada, 400; Proposed Meteorological Observatory in Loochoo Islands, 401; the Motion of Dust, Hon. Ralph Abercromby, 406; an Optical Feature of Lightning Flashes, 406; Weather in January, Chas. Harding, 425; Meteorology of Central America, Boletin Trimestral of San José (Costa Rica) Observatory, 427; Meteorological Report of the *Challenger* Expedition, 443; Diurnal Range of Barometer, A. Angot, 449; Waterspout in Atlantic, 470; Preponderance of North-East Wind during past Five Years, C. L. Prince, 470; Meteorology of the Gold and Slave Coast, Dr. Danckelmann, 479; Royal Meteorological Society's Exhibition, William Marriott, 491; Captain Abney's Photo-Nephograph, 491; Pickering's Pole-star Recorder, 491; Photo-Nephograph, Captain Abney's, 491; Report of the Meteorological Council for Year ending March 31, 1889, 495; Use of "Sling" Thermometer in Prediction of Frosts, Prof. H. A. Hazen, 501; Photography in Relation to Meteorological Work, G. M. Whipple, 503; Fire-damp Explosions in Mines in Relationship to Cosmic and Meteorological Conditions, 504; Meteorological Observatory at Fort William, 518; D. Dewar's Weather and Tidal Forecasts for 1890, 546; Variability of Temperature of British Isles (1859–83), R. H. Scott, F.R.S., 550; Solar Halos and Parhelia, J. Lovell, 560; New Way of giving Information as to Weather on Coasts, 568; Meteorological Observations for 1887 at Greenwich Observatory, 570: Increase of Coldness in China, 570; U.S.A. Signal Service Monthly Weather Review for January 1890, 570; Relative Prevalence of North-East and South-West Winds, William Ellis, 586; Influenza and Weather, Mitchell and Buchan, 596; C. Harding on the Cold in March 1890, 598
Meteors: a Brilliant, Paul A. Cobbold, 32; Remarkable Meteor at Pontevedra, Dr. E. Caballero, 303; a Brilliant Meteor, Wm. Scarnell Lean, 60; a Brilliant, J. Cockburn, 81; Brilliant Meteors, P. A. Harris, 105; R. H. Tiddeman, 105; Rev. T. W. Morton, 249; a Greenish Meteor, T. D. A. Cockerell, 369; a Meteor, T. W. Baker, 418; a Remarkable Meteor, J. Dunn, 560; Meteorites of Mexico, M. Daubrée, 71; on the Supposed Enormous Showers of Meteorites in the Desert of Atacama, 108; Die Mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen, G. Tschermak, 127; Die Structur und Zusammensetzung der Meteoreisen erläutert durch photographische Abbildungen Geätzter Schnittflächen, A. Brezina und E. Cohen, 127; Die Meteoritensammlung des k.k. Mineralog. Hofkabinetes in Wien, A. Brezina, 127; Examination of the Mighei, of June 9, 1889, Stanislas Meunier, 232; J. Rutherford Hill, 298; Prof. Simaschko, 472; Analogy of South African Diamantiferous Matrix to Meteorites, M. Daubrée, 263; the Physical and Chemical Characteristics of Meteorites, as throwing Light upon their Past History, J. Norman Lockyer, F.R.S., 305
Metric System of Weights and Measures, Thuillier and Waterhouse's Conversion Tables, 66
Metrical System, the Babylonian, Dr. Lehmann, 167
Meunier (Stanislas), Examination of Mighei (June 9, 1889) Meteorite, 232
Mexican Amber, G. F. Kunz, 372
Mexico for Twelve Years ending 1888, Meteorology of, 256
Mexico, Hygrometric Club Moss from Mexico, 401
Mexico, the Eruption of the Volcano Popocatepetl, 592
Meyer (Dr. A. B.): Evolution of Sex, 272; Celebes Photographs, 471; Brush-Turkeys on the Smaller Islands north of Celebes, 514
Meyer (Dr. H.), Rainfall of Germany 1876–85, 85

Meyer (Dr. Hans), the Ascent of Kilimanjaro, 164, 572
Meyrick (E.): Osteolepidæ, 342; Dr. J. A. H. Murray, 343
Mica in Mourne Mountain Granite Geodes, Prof. Sollas, F.R.S., 469
Michael (Major-General), Forestry, 348
Michelson (A. A.), Measurement by Light-Waves, 405
Micro-organism conferring Phosphorence on Crustaceans, Discovery by Prof. Giard of, 137
Micro-organisms of Fermentation practically considered, Alfred Jörgensen, Prof. Percy F. Frankland, 339
Microscopy: the Microscope as applied to Physiological Chemistry, Prof. Kossel, 23; Royal Microscopical Society, 93; Ahrens's Polarizing Binocular Microscope, 93; Formation of Scottish and Italian Microscopical Societies, 180; the Microscope in the Brewery and Malt-house, Chas. Geo. Mathews and Francis Edw. Lott, 246; Tercentenary of the Invention of the Compound Microscope, 256; Zeiss's New Apochromatic Objective Microscope, 494; Microseismic Vibration of the Earth's Crust, Prof. G. H. Darwin, F.R.S., 248
Middlesex Natural History and Scientific Society, 138
Miers (H. A.), Crystals of Lime, 515, 560
Mighei, the Meteorite of, Stanilas Meunier, 232; J. Rutherford Hill, 298
Milan, Discovery of Lake-Dwelling near, 67
Millipede, a Marine, 104; Edward Parfitt, 153; R. I. Pocock, 176
Mills (Dr. Edmund J., F.R.S.), Traité pratique de la Thermométrie de précision, Ch. Ed. Guillaume, 100; Exact Thermometry, 227, 538
Mills (John) and Barker North, Introductory Lessons in Quantitative Analysis, 197
Miner, Fall of a, without being killed, down a 100-metre Shaft, M. Reumeaux, 471
Mineralogy: Mineralogical Magazine, 67; Statistics of Mineralogy in Canada, 87; Great Find of Rare Minerals of Yttrium and Thorium Groups in Texas, 162; Provincial Index of the Minerals of India, Dr. W. King, 546; Mines at Bendigo, Victoria, Report of School of, 209; Mining and Metallurgy, Proposed International Exhibition of, 447; Mining and Metallurgy, International Exhibition of, at the Crystal Palace, 592
Minimum Sun-spot Period, M. Bruguière, 68
Minor Planet (12), Victoria, Dr. Gill, 139
Minor Planets, Clorinde, 88
Mint, Royal, the New Assistant Secretary at, T. Rose Kirke, 493
Mirage in the South American Pampas, W. Larden, 69
Mirages, Arthur E. Brown, 225
Missouri Botanical Garden, 209
Mist, Frequency of, Dr. Kremser, 215
Mitchell (Sir Arthur), Influenza and the Weather, 596
Mite of the Genus *Tetranychus* found infesting Lime Trees in the Leicester Museum Grounds, on the, F. R. Rowley, 31
Mivart (Dr. St. George, F.R.S.), Prof. Weismann's Essays, 38; Galls, 174
Modern Views of Electricity, 102
Modigliani's Exploration of Nias Island, Prof. Giglioli, 587
Moebius (Prof.), Drumming Fish (*Balistes aculeatus*), 263
Moissan (Henri): a New Method of Preparing Fluorine, 117; the Anhydrous Platinous Fluorine, 119; Perfected Mode of Preparing Fluorine, 138; Colour and Spectrum of Fluorine, 214; Phosphorus Trifluoride, 349; Two Gaseous Fluorides of Carbon, 373
Mole, the Eye of the, Carl Hess, 373
Molecular Stability of Metals, particularly of Iron and Steel, Carl Barus, 369
Molecular Structure, the Relation between Atomic Volumes of Elements present in Iron, and their Influence on its, Prof. W. C. Roberts-Austen, F.R.S., 420
Molucca Islands, Count Salvadori on the Birds of, 85
Monck (Dr. W. H. S.): Satellite of Algol, 198; the Distances of the Stars, 392
Monkey, the Barbados, Colonel H. W. Feilden, 349
Monkey, Bonnet, Arrangement of Excitable Fibres of Internal Capsule of, Beevor and Horsley, 166
Monkeys, African, in the West Indies, Dr. P. L. Sclater, F.R.S., 368
Montigny (Prof. C. M. V.), Death and Obituary Notice of, 497
Montpellier University, Proposed Commemoration of Founding of, 447
Montsouris Observatory, the Effect of Railways on Instruments in, 592
Moon in London, the, Rev. T. R. R. Stebbing, 586
Moore (John Murray), New Zealand for the Emigrant, Invalid, and Tourist, 342
Moore (Spencer): True Nature of Callus, 478; Nessler's Ammonia Test as a Micro-chemical Reagent for Tannin, 583
Morea, Rock-sepulchre at Vaphio, S. Reinach, 500
Morgan (Prof. C. Ll.), the Pebidian Volcanic Series of St. David's, 311
Morley Memorial College and the Royal Victoria Hall, 343
Morocco, Travels in, Walter B. Harris, 270
Morris (D.): Seeding of Sugar-cane, 478; the Native Ebony of St. Helena, 519
Morris (Dr. G. H.), Identity of Cerebrose and Galactose, 262
Mortillet (M. de), the Dog, 332
Morton (Rev. T. W.), Meteor, 249
Moscow Archæological Congress, 283
Moser (James), Electrical Oscillations in Rarefied Air, 431
Moss (F. J.), Through Atolls and Islands in the Great South Sea, 151
Moss, Hygrometric Club, from Mexico, 401
Mount Hamilton, Longitude of, 211
Mount Vesuvius, J. Logan Lobley, 195
Mouse-Hunt, a Kind of Weasel, E. B. Titchener, 394
Mozambique, Arrival of Captain Trivier at, 165
Muirhead (B. A.), Ten and Tenth Notation, 344
Muirhead (Geo.), the Birds of Berwickshire, R. Bowdler Sharpe, 169
Müller (Prof. Max): Necessity of a School for Modern Oriental Studies, 255; Thought and Breathing, 317
Multiple Resonance obtained in Hertz's Vibrators, Prof. Geo. Fras. Fitzgerald, 295; Fred T. Trouton, 295
Munk (Dr.): Absorption of Fats and Fatty Acids in Absence of Bile in Intestine, 119; the Cortical Visual Areas, 407; Fat the only Food leaving Intestines by Lacteals, 504
Munro's Wind-measuring Instruments, 492
Murchison, Sedgwick and, Cambrian and Silurian, Prof. James D. Dana, 421
Murphy (Joseph John): the Permanence of Continents and Oceans, 175; Luminous Clouds, 298
Murray (Dr. John), Coral Reefs in Recent Seas, 167
Murray-Aynsley (Mrs. J. C.), Thought and Breathing, 441
Museums: Opening of the Berlin National Science, 112; Suggestions for the Formation and Arrangement of a Museum of Natural History in Connection with a Public School, Prof. W. H. Flower, F.R.S., 177; Cambridge Archæological, 324; Annual Meeting of Museums Association, 591
Music on Animals, Effect of, R. E. C. Stearns, 470
Music, Dogs and, 372
Music, Visualized Images produced by, Geo. E. Newton, 417
Musical Sounds, the Effect of, on Animals, R. E. C. Stearns, 593
Muthmann (Dr.), Crystalline Allotropic Forms of Sulphur, 449
Muzzling Regulations, the New, 241

Nansen's (Dr.) Plan for North Pole Expedition, 374
Naphthalene, Constitution of Tri-derivatives of, Armstrong and Wynne, 454
Natality of Paimpol, M. Dumont, 332
National Union of Teachers, 545
Native Colonists, French, in Paris, 427
Natural Evidence of High Thermal Conductivity in Flints, Prof. A. S. Herschel, F.R.S., 175
Natural History: Suggestions for the Formation and Arrangement of a Museum of Natural History in connection with a Public School, Prof. W. H. Flower, F.R.S., 177; Catalogue of the Fossil Reptilia and Amphibia in the British Museum, Richard Lydekker, 534; on some Needless Difficulties in the Study of Natural History, Dr. C. T. Hudson, F.R.S., 375; Glimpses of Animal Life, W. Jones, 409; Toilers in the Sea, M. C. Cooke, 409; Les Industries des Animaux, F. Houssay, 409; Natural Selection, Lamarck *versus* Weismann, Prof. E. D. Cope, 79; Prof. G. J. Romanes, F.R.S., on the Formation of Galls, 80; Naturalist in North Celebes, Sydney J. Hickson, Dr. F. H. H. Guillemard, 457; the Physician as Naturalist, W. T. Gairdner, 436; Naturalistic Photography, P. H. Emerson, 366
NATURE, Progress of, during Twenty Years, 1
Navigation, der Kompass an Bord, Dr. Neumayer, 412

Nebula N.G.C. 2237, the Cluster G.C. 1420 and, Dr. Lewis Swift, 285
Nebula, General Catalogue No. 4795, W. E. Jackson, 450
Nebular Hypothesis, Herbert Spencer, 450
Neo-Darwinians, Duke of Argyll and the, W. T. Thiselton-Dyer, F.R.S., 247
Nessler's Ammonia Test as a Micro-chemical Reagent for Tannin, Spencer Moore, 585
Nervous Affection observed in an Insect, Note on a Probable, E. W. Carlier, 197
Netanson (Ladislas), the Characteristic Temperatures, Pressures, and Volumes of Bodies, 167
Neumayer (Dr.), der Kompass an Bord, 412
Neumayr (Prof.), Death of, 324
New Light from Solar Eclipses, William M. Page, William E. Plummer, 529
New Guinea, Kaiser Wilhelmsland, the North Coast of, Admiral von Schleinitz, 21
New Guinea and the Molucca Islands, Count Salvadori on the Birds of, 85
New Guinea, Sir Wm. McGregor's Explorations in, 374
New South Wales: Technical Education in, 66; Royal Society of, 96; Meteorology of, H. C. Russell, 113
New Zealand, Discovery of Cave-Dwelling in, H. O. Forbes, 209
New Zealand for the Emigrant, Invalid, and Tourist, John Murray Moore, 342
Newall Telescope for the University of Cambridge, 166; the Maintaining and Working of the, 357
Newcastle Learned Societies' Annual Gathering, 519
Newton (Geo. E.), Visualized Images produced by Music, 417
Newton in Perspective, Robert H. Graham, 439
Nias Island, Modigliani's Exploration of, Prof. Giglioli, 587
Nickel and Iron, the Villari Critical Points in, Herbert Tomlinson, F.R.S., 574
Night-Clouds, Luminous: Evan McLennan, 131; Photographs of, O. Jesse, 592
Nitrogen in Soils, Sources of, Prof. John Wrightson, 286
Niven (W. D., F.R.S.), on certain Approximate Formulæ for Calculating the Trajectories of Shot, Prof. J. C. Adams, 258
Noe's (Dr. Franz) Geologische Uebersichtskarte der Alpen, Prof. T. G. Bonney, F.R.S., 483
Nordenskiöld (A. E.), Facsimile Atlas to the Early History of Cartography, 558
Norfolk and Norwich Naturalists' Society, 519
North America, Cave Fauna of, with Remarks on the Anatomy of the Brain and Origin of the Blind Species, A. S. Packard, 507
North (Barker) and John Mills, Introductory Lessons in Quantitative Analysis, 197
North Celebes, a Naturalist in, Sydney J. Hickson, Dr. F. H. H. Guillemard, 457
Northwich, Subsidence at, 230
Nuovo Giornale Botanico Italiano, 405

Oates (E. W.), Ornithology of India, Vol. I., 388
Oates (Frank), Matabele Land and the Victoria Falls, R. Bowdler Sharpe, 169
Objects for the Spectroscope, A. Fowler, 20, 44, 68, 87, 114, 138, 163, 183, 210, 232, 257, 285, 304, 326, 350, 374, 402, 428, 449, 472, 521, 548, 571, 595
Observatories: Karlsruhe Observatory, A. Fowler, 20; Palermo, 88; Paramatta, 88; Greenwich, 305; Dun Echt, 351; Melbourne, 351; Astronomical Observatory of Harvard College, 446; Vatican, 472; Madagascar, 497; the Effect of Railways on Instruments in, 592
Observatory: Proposed Meteorological, in Loochoo Islands, 401; Fort William Meteorological, 518
Ocean Currents, Distribution of Animals and Plants by, Rev. Paul Camboué, 103
Ocean, German, Botanical Condition of, Major Reinhold, 569
Ocean Water, is the Bulk of, a Fixed Quantity, A. J. Jukes-Browne, 130; T. Mellard Reade, 175; Rev. O. Fisher, 197
Oceans, Area of the Land and Depths of the, in Former Periods, T. Mellard Reade, 103
Oceans, the Permanence of Continents and, Joseph John Murphy, 175
Odontology: Who Discovered the Teeth in Ornithorhynchus? Dr. C. Hart Merriam, 11, 151; Prof. W. H. Flower, F.R.S., 30, 151; Prof. Oswald H. Latter, 30, 174
Oil on Disturbed Water, Effect of, Richard Beynon, 205; A. B. Basset, F.R.S., 297
Old Age, Dr. Geo. M. Humphry, F.R.S., 484
Olfactometer, Dr. Zwardemaaker, 349
Olive Cultivation in India, 303
Oliver (Dr. Francis), the Weather Plant (*Abrus precatorius*), 283
Olliff (A. S.), Extraordinary Abundance of Noctuid Moth (*Agrotis spina*) in New South Wales in October, 161
Oölogy: the Nests and Eggs of Indian Birds, by Allan O. Hume, Vol. I., 388; A. J. Campbell's Collection of Eggs in Western Australia, 593. *See also* Eggs
Opera Glass, Astronomy with an, Garrett P. Serviss, 462
Ophiuchus, New Short Period Variable in, 403
Opossum in Tasmania, Destruction of, 304
Optics: Geometrical, Notes on (II.), Prof. S. P. Thompson, 213; Traité d'Optique, M. E. Mascart, Prof. J. D. Everett, F.R.S., 224; Vision-Testing for Practical Purposes, Brudenell Carter, 302; Measurement by Light-Waves, A. A. Michelson, 405: Abbe's Apparatus for Testing Transparent Films with Plane Parallel Surfaces, Dr. Lummer, 552
Oranges and Lemons of India and Ceylon, the Cultivated, Dr. E. Bonavia, C. B. Clarke, F.R.S., 579
Orbit of Swift's Comet (V. 1880), 257
Orbits of the Companions of Brooks's Comet (1889 V., July 6), 305
Ornithology: Argentine Ornithology, P. L. Sclater, F.R.S., and W. H. Hudson, R. Bowdler Sharpe, 7; Count Salvadori on the Birds of New Guinea and the Molucca Islands, 85; Pheasant-Culture on the Pacific Coast, Dr. Meriam, 137; the Food of Crows, W. B. Barrows, 137; Notes on Sport and Ornithology, H.I.H. the late Prince Rudolph of Austria, 169; Matabele Land and the Victoria Falls, Frank Oates, 169; Index Generum Avium, F. H. Waterhouse, 169; Birds of Oxfordshire, O. V. Aplin, 169; the Birds of Berwickshire, Geo. Muirhead, 169; the Birds in my Garden, W. T. Greene, R. Bowdler Sharpe, 169; Birds that have struck the Statue of Liberty in New York Harbour, Jonathan Dwight, Junior, 181; Chiff-Chaff Singing in September, 298; Rev. W. Clement Ley, 317; Pallas's Cormorant, 373; Oates's Ornithology of India, Vol. I., R. Bowdler Sharpe, 388; the Nests and Eggs of Indian Birds, by Allan O. Hume, Vol. I., edited by E. W. Oates, R. Bowdler Sharpe, 388; the Chaffinch, E. J. Lowe, F.R.S., 394; A. J. Campbell's Collections of Western Australian Bird-Skins and Eggs, 593; Effects of Music on a Canary, 593; Dr. R. W. Shufeldt on Avian Anatomy, 594
Ornithorhynchus, Who discovered the Teeth in the, Dr. C. Hart Merriam, 11, 151; Prof. W. H. Flower, F.R.S., 30, 151; Prof. Oswald H. Latter, 30, 174
Orycteropus, a Milk Dentition in, O. Thomas, 309
Osborn (H. Leslie), a Preservative for Animal Tissues, 199
Osborn (Henry Fairfield), Palæontological Evidence for the Transmission of Acquired Characters, 227
Osteolepidæ, 271, 342; E. Meyrick, 342
O'Sullivan (C., F.R.S.), Arabinon, 262
Oudemans (Prof. J. A. C.) on Star Distances, 81
Oxford "Pass" Geometry, 467
Oxfordshire, the Birds of, O. V. Aplin, R. Bowdler Sharpe, 169
Ozone, Production by Flames of, J. T. Cundall, 502

Pacific Coast, Pheasant Culture on, Dr. Meriam, 137
Pacific, Notes on a Recent Volcanic Island in the, Captain W. J. L. Wharton, F.R.S., 276
Pacific Slope, Geology of the Quicksilver Deposits of the, G. F. Becker, 532
Packard (A. S.), Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of the Blind Species, 507
Page (William M.), New Light from Solar Eclipses, William E. Plummer, 529
Paimpol, Natality of, M. Dumont, 332
Painter (Rev. W. H.), the Flora of Derbyshire, 77
Palæontology: Fossil Rhizocarps, 10, 154; Gigantic Fossil Elephant's Tusk discovered in Italy, 66; Dr. H. Burmeister on the Fossil Horses and other Mammals of Argentina, 82; Palæontological Evidence for the Transmission of Acquired Characters, Henry Fairfield Osborn, 227; Primitive Types of Mammalian Molars, 465; Antediluvian Remains discovered at Ludwigshafen, 520
Palermo Observatory, 88

Palestine Exploration Fund, 284 ; Excavation of Khürbet 'Ajlân, 592
Palisa (Dr.), Discovery of Asteroids, 522
Palladium, Redetermination of Atomic Weight of, Dr. E. H. Keiser, 44
Palm in Labuan, the African Oil, 42
Palmieri (Prof.), Vesuvius in 1889, 18
Pampas, Mirage in the South American, W. Larden, 69
Pampas Formation, the South American, Herr Roth, 231
Panmixia: Palæontological Evidence for the Transmission of Acquired Characters, Henry Fairfield Osborn, 227 ; Acquired Characters and Congenital Variations, the Duke of Argyll, F.R.S., 173, 294, 366 ; Acquired Characters and Congenital Variations, W. T. Thiselton-Dyer, F.R.S., 315 ; F. V. Dickins, 316 ; Prof. E. Ray Lankester, F.R.S., 415, 486, 558 ; Acquired Characters and Congenital Variations, Right Rev. Bishop R. Courtenay, 367 ; Dr. J. Cowper, 368 ; Herbert Spencer, 414 ; Prof. Geo. J. Romanes, F.R.S., 437, 511, 584 ; Herbert Spencer, 511 ; R. Haig Thomas, 585
Parallelogram of Forces, Proof of the, W. E. Johnson, 153 ; Prof. A. G. Greenhill, F.R.S., 298
Paramatta Observatory, 88
Parfitt (Edward), a Marine Millipede, 153
Parhelia and Solar Halos, 330 ; J. Lovell, 560
Parinaud (H.), Strabismus, 72
Paris Academy of Sciences, 23, 48, 71, 94, 119, 143, 167, 214, 263, 287, 311, 335, 358, 382, 406, 431, 455, 479, 503, 528, 551, 575, 599 ; Prizes, 239
Paris, the Effect of Railways on Instruments in the Observatory at Montsouris, 592
Paris Exhibition, English Men of Science decorated at, 17
Paris, Foreign Students in, 520
Paris from the Hygienic Point of View, French Native Colonists in, 427
Parkes (Louis C.), Hygiene or Public Health, 290
Particles and Solids, Elementary Dynamics of, W. M. Hicks, F.R.S., 534
Pascoe (Francis P.), Foreign Substances attached to Crabs, 176
Pasteur Institute, 66
Pasture Plants, Practical Observations on Agricultural Grasses and other, William Wilson, 196
Peal (S. E.), Is Greenland our Arctic Ice Cap?, 58
Peculiar Ice Forms, Prof. J. G. MacGregor, 463
Peddie (Dr.), New Estimates of Molecular Distance, 382
Pegasi (η), the Companion of, 69
Pelew Islands, 433
Peltier, Effect and Contact E.M.F., Prof. Oliver J. Lodge, F.R.S., 224
Pembrey (M. S.), the Evolution of Sex, 199
Penck (Dr.), Area of Austro-Hungarian Empire, 325
Pendlebury (W. H.), a Case of Chemical Equilibrium, 104
Pendulum (Kater), Shuckburgh Scale and, O. H. Tittman, 538
Pennyslvania, Earthworms from, W. B. Benham, 560
Peradeniya, Ceylon, Botanical Laboratory in the Royal Gardens, 445
Periodic Comets, 139
Periodic Law, a First Foreshadowing of the, P. G. Hartog, 186
Periscope for Navigating Submarine Boat, 349
Perkin (Dr. W. H., F.R.S.), Magnetic Rotation of Nitric Acid, &c., 142
Permanence of Continents and Oceans, Joseph John Murphy, 175
Permanent Grass, a Field laid down to, Sir J. B. Lawes, F.R.S., 229
Pernter (Dr.), General Circulation of Atmosphere, 325
Perry (Prof., F.R.S.), the Behaviour of Twisted Strips, 47
Perry (Rev. S. J., F.R.S.): Sun-spots in High Southern Latitudes, 88 ; Total Solar Eclipse of 1886, 88 ; Obituary Notice of, 279 ; Last Days of, Father Strickland, S.J., 301
Perspective, Newton in, Robert H. Graham, 439
Perthshire, Earthquake in, 256
Peruvian Arc, the Measurement of, E. D. Preston, 309
Peters (Dr.), Reported Massacre of, 21
Peters (Dr.), Star Catalogue, 210
Petit (P.), the Carbon Graphites, 311
Petrie (W. M. Flinders), Early Egyptian Civilization, 109
Pevtsoff (Colonel), Discovery of New Pass from Nia to Tibet by, 327
Pheasant-Culture on Pacific Coast, Dr. Meriam, 137
Phenanthraquinone with Metallic Salts, Compounds of, Japp and Turner, 191
Philadelphia, American Philosophical Society, 136
Philippine Islands, Ethnology of the, Dr. F. Blumentritt, 327
Phillips (Reuben), Globular and other Forms of Lightning, 58
Philology, a Uniform System of Russian Transliteration, 396 ; Chas. E. Groves, F.R.S., 534 ; W. F. Kirby, 535
Philosophical Institute of Canterbury, N.Z., 209
Philosophy, Synthetic, F. Howard Collins, 340
Phonograph, the Edison, Use in Preserving American Indian Languages, J. W. Fewkes, 560
Phosphorus, Glow of, Prof. T. E. Thorpe, F.R.S., 523
Phosphorus Trifluoride, M. Moissan, 349
Photography: on a New Application of Photography to the Demonstration of Certain Physiological Processes in Plants, Walter Gardiner, 16 ; Stellar Parallax by Means of Photography, Prof. Pritchard, F.R.S., 19 ; Photography of the Red End of Spectrum, Colonel J. Waterhouse, 67 ; Photographic Star Spectra, 115 ; Die mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen, G. Tschermak, 127 ; Die Structur und Zusammensetzung der Meteoreisen erläutert durch photographische Abbildungen geätzter Schnittflächen, A. Brezina and E. Cohen, 127 ; the Photographic Society, 208 ; Bibliothèque Photographique, P. Moëssard, 224 ; Application of Photography to the Study of Physical Peculiarities engendered by Different Occupations, M. Bertillon, 230 ; the Chemistry of Photography, R. Meldola, F.R.S., 293 ; Proposed Exhibition Illustrating the Application to Meteorology of Photography, 301 ; French Works on Photography, 326 ; Year-book of Photography, 1890, 326 ; Naturalistic Photography, P. H. Emerson, 366 ; the Camera Club, 494 ; Photographs of North Celebes, Dr. A. B. Meyer, 471 ; Photographing in Natural Colours, Verescz's Discovery as to, 469 ; Photography in Relation to Meteorological Work, G. M. Whipple, 503 ; British Journal Photographic Almanac, 1890, 510 ; Suppression of Halos in Photographic Plates, Paul and Prosper Henry, 576 ; La Photographie à la Lumière du Magnésium, Dr. J. M. Eder, translated by H. Gauthier-Villars, 584 ; Photographic Quarterly, 594
Photo-lithographs of some of the Principal Grasses found at Hissar, being Illustrations of some of the Grasses of the Southern Punjab, William Coldstream, 533
Photometer, New Contrast, Dr. Brodhun, 552
Photometer, a New Wedge, E. J. Spitta, 287
Photometric Intensity of Coronal Light, Prof. Thorpe, F.R.S., 139
Phthisis, Pulmonary, Dr. Weigert's Treatment of, Prof. Visconti, 380
Physician admitted to Medical Practice in Austria, First Lady, 569
Physician as Naturalist, W. T. Gairdner, 436
Physics: Specific Inductive Capacity, W. A. Rudge, 10 ; Physical Society, 47, 166, 213, 309, 381, 477, 526, 574 ; Physics of the Sub-oceanic Crust, Rev. Osmond Fisher, A. J. Jukes-Browne, 53 ; J. Starkie Gardner, 103 ; Elementary Physics, by M. R. Wright, 78 ; Physical Society of Berlin, 95 ; the Characteristic Temperatures, Pressures, and Volumes of Bodies, Ladislas Netanson, 167 ; the Relation of Physiological Action to Atomic Weights, Miss Johnston and Prof. Carnelley, 189 ; Behaviour of Steel under Mechanical Stress, C. H. Carus-Wilson, 213 ; Resonance Method of Measuring Constant of Gravitation, J. Joly, 256 ; Physical and Chemical Characteristics of Meteorites as throwing Light upon their Past History, J. Norman Lockyer, F.R.S., 305 ; Physics and Chemistry of the *Challenger* Expedition, 361 ; Physical Properties of Water, Prof. P. G. Tait, 416 ; Prof. Arthur W. Rücker, F.R.S., 416 ; Tension of Recently Formed Liquid Surfaces, Lord Rayleigh, 566
Physiology: on a New Application of Photography to the Demonstration of Physiological Processes in Plants, Walter Gardiner, 16 ; the Coiled Glands in the Skin, Dr. Benda, 24 ; Iron in the Animal Organism, Dr. Schneider, 24 ; Physiological Notes on Primary Education and the Study of Language, Mary Putnam Jacobi, 28 ; Physiology at the University of Cambridge, 41 ; Mechanism of Local Lesion in Infectious Diseases, Ch. Bouchard, 48 ; Local Paralysis of Peripheral Ganglia and Connection of Nerve-fibres with them, Langley and Dickinson, 118 ; on the Absorption of Fats and Fatty Acids in the Absence of Bile in the Intestine, Dr. J. Munk, 119 ; on Diastases secreted by *Bacillus heminecrobiophilus*, M. Arloing, 143 ; the Influence of Blood-Circulation and Breath-

ing on Mind-Life, Prof. Leumann, 209; Electrical Negative Variation of Heart accompanying Pulse, Dr. Aug. Waller, 288; Outlying Nerve-Cells in Mammalian Spinal Cord, C. S. Sherrington, 388; the Cortical Visual Areas, Dr. J. Munk, 407; Influence of Bodily Labour on Metabolism of Man, Dr. Katzenstein's Experiments, 479; Physiology of Bodily Exercise, Dr. Fernand Lagrange, 485; Voluntary Muscular Contraction, Dr. Haycraft, 495; Development of Ciliary Ganglion, Dr. J. C. Ewart, 501; Fat the only Food leaving Intestines by Lacteals, Dr. J. Munk, 504; Myelin, Dr. Heymans, 528; Sensitiveness of Articular Surfaces of Joints, Dr. Goldscheider, 528; Physiology of Sponges, Dr. Lendenfeld, 570
Pickering (Prof. E. C.), Variable Star in Cluster G.C. 3636, 183; on the Spectrum of ζ Ursæ Majoris, 285; on ζ Ursæ Majoris and β Aurigæ, 403; Pole-Star Recorder, 491; New Variable in Cælum, 571
Pickering (Prof. S. U.), Isolation of Tetrahydrate of Sulphuric Acid existing in Solution, 142; Theory of Osmotic Pressure, 526
Picton (Harold, F.R.S.), the Story of Chemistry, 292
Pietra Papale, La, Dr. P. L. Sclater, F.R.S., 31
Pigment, Carotine, in Alpine Lake Crustacean, Discovery by Prof. Raphael Blanchard of, 325
Pigment of the Touraco and the Tree Porcupine, Frank E. Beddard, 152
Pilot Chart of North Atlantic, 284
Pinks of Western Europe, F. N. Williams, 78
Pinnow (Dr.), Analysis of Carcote (Chili) Meteorite, 428
Pinol, Nitrosochloride of, a New Isomer of Camphor, 44
Pipe, Interesting American Indian, H. B. Bashore, 303
Pisciculture: Change in Character of Salmon Acclimatized in Tasmania, 43; the Habits of the Salmon, Major John P. Traherne, 74
Planck (Prof.), Development of Electricity and Heat in Dilute Electrolytic Solutions, 215
Planet, Minor (12), Victoria, Dr. Gill, 139
Planets, the Movement of, F. Tisserand, 406
Plantamour (M.), Periodic Ground-movements, 373
Plants, Diseases of, Prof. H. Marshall Ward, F.R.S., 436
Plants, Fossil, of Coal-Measures, Organization of, Prof. W. C. Williamson, F.R.S., 573
Plants, on a New Application of Photography to the Demonstration of certain Physiological Processes in, Walter Gardiner, 16
Plants, Prof. Walter Gardiner on how they maintain themselves in the Struggle for Existence, 90
Platt (Margaret) and the Chemical Laboratory at Stalybridge Mechanics' Institute, 85
Playfair (Sir Lyon, F.R.S.), the Need for Vital Improvements in English Education, 180
Plummer (William E.), New Light from Solar Eclipses, William M. Page, 529
Pluvinel (M. A. De La Baume), Total Solar Eclipse of December 22, 1889, 428
Pocock (R. I.), a Marine Millipede, 176
Poincaré (M.), Équations aux Derivées Partielles de la Physique Mathématique, 525
Politics, Elements of Historical and Practical, Woodrow Wilson, 196
Polynesia, Through Atolls and Islands in the Great South Sea, F. T. Moss, 151
Polytechnic, a South London, 481
Polytechnics for London, 242
Pontevedra, Remarkable Meteor at, Dr. E. Caballero, 303
Poona Bacteriological Laboratory, 469
Pope (R. Barrett), Thought and Breathing, 297
Popocatepetl, the Eruption of the Volcano, 592
Porcupine, Tree, the Pigment of the, Frank E. Beddard, 152
Portugal, Earthquake in, 401
Potsdam Magnetic Observatory, Dr. Eschenhagen, 479
Powell (J. W.), Sixth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution, 1884–85, 99
Prehistoric Textiles, Herr Buschan, 182
Preservative, a, for Animal Tissues, H. Leslie Osborn, 199
Pressure-Gauge, Bourdon's: Prof. A. M. Worthington, 296; Prof. A. G. Greenhill, F.R.S., 517
Preston (E. D.), Measurement of the Peruvian Arc, 309
Prestwich (Prof. Joseph, F.R.S.): Relation of Westleton Beds of Suffolk and Norfolk, 238; Relation of "Pebbly Sands" of Suffolk to those of Norfolk, Part iii., 502
Primitive Types of Mammalian Molars, 465
Primrose, a Blue, 569
Prince (C. L.), Preponderance of North-East Winds during Past Five Years, 470
Pringsheim (Dr. E.), Kirchoff's Law and Gaseous Radiation, 480
Prism, Bertrand's Idiocyclophanous, Prof. S. P. Thompson, 574
Pritchard (Prof., F.R.S.), Stellar Parallax by Means of Photography, 19
Probabilities, Calculus of, J. Bertrand, 6
Proceedings of the Royal Society of Edinburgh, 114
Prominences, Solar Spots and, Prof. Tacchini, 233
Propagation of Gravitation, Velocity of the, J. Van Hepperger, 472
Protective Coloration of Eggs: Dr. Alfred R. Wallace, 53; Rev. Fred. F. Grensted, 53; E. B. Titchener, 129
Prussia, Wapiti Acclimatized in, 546
Przewalsky's (N. M.) Zoological Discoveries, 468
Psychology of Attention, Th. Ribot, 460
Psychology: the Society for Psychical Research, 17
Public School, Suggestions for the Formation and Arrangement of a Museum of Natural History in connection with a, Prof. W. H. Flower, F.R.S., 177
Puffin Island Marine Biological Station, 304
Pulsion Mechanical Telephone, 65
Punjab Forest Administration Report, 520
Purtscheller (Prof.), the Ascent of Kilimanjaro, 164

Quantitative Analysis, Introductory Lessons in, John Mills and Barker North, 197
Quarter Squares, the Method of, J. W. L. Glaisher, F.R.S., 9
Quarterly Journal of Microscopical Science, 549
Quenstedt (Prof. von), Death and Obituary Notice of, 400
Quesneville (Dr.), Death of, 84
Quicksilver Deposits of the Pacific Slope, Geology of the, G. F. Becker, 532

Radiation by Gas-Flame, Luminous and Non-Luminous, Sir John Conroy, 357
Raffy (L.), Determination of Regulated Harmonic Surfaces, 359
Railway, North-Eastern: the Latest Express Compound Locomotive, 448
Railway, Proposed Jungfrau, Herr Trautweiler, 303
Railways, the Effect of, on Instruments in Observatories, 592
Railways of England and Scotland, W. M. Acworth, 434
Rainbow due to Sunlight Reflected from the Sea, Sir W. Thomson, F.R.S., 271; W. Scouller, 271
Rainbows, Eight, seen at the same time, Sir William Thomson, F.R.S., 316; Dr. Percival Frost, F.R.S., 316
Rainfall in America, 92
Rainfall of the Earth, by late Prof. Loomis, Dr. van Bebber, 43
Rainfall of Germany 1876-85, Dr. H. Meyer, 85
Ramsay (Prof. William, F.R.S.): Compounds of Selenium, 343; Nitrous Anhydride and Nitric Peroxide, 454
Raoult (F. M.), Vapour-pressure of Acetic Acid Solutions, 431
Rat, the Old English Black, in Cornwall, Thos. Cornish, 161
Rat Plague in Laccadive Islands, 303
Raven, the Anatomy of the, Dr. R. W. Shufeldt, 594
Rayleigh (Lord, F.R.S.), Tension of Recently Formed Liquid Surfaces, 566
Reade (T. Mellard): Does the Bulk of Ocean Water Increase? 175; Area of the Land and Depths of the Oceans in Former Periods, 103
Reading Room, British Museum, Ventilation of, 199
Recoura (A.), Vapour-pressure of Acetic Acid Solutions, 431
Red Sea, Locusts in the, G. T. Carruthers, 153
Redway (J. W.), Teacher's Manual of Geography, 78
Refractometer, Bertrand's, Dr. S. P. Thompson, 526
Reinach (S.), Rock-Sepulchre at Vaphio, Morea, 500
Reinhold (Major), Botanical Condition of German Ocean, 569
Reinke (Dr. J.): a New Atlas of Algæ, 127; the Botanical Institute and Marine Station at Kiel, 397
Religion of the Semites, Lectures on the, Prof. W. Robertson Smith, 337
Renard (Prof. A.): Phenyl-Thiophene, 48; Rock-Specimens collected on Oceanic Islands, 363

Rendiconti del Reale Istituto Lombardo, 212, 380
Resonance, Electric, Easy Lecture Experiment in, Prof. Oliver J. Lodge, F.R.S., 368
Respighi (Prof. Lorenzo): Death of, 160; Obituary Notice of, W. T. Lynn, 254
Reumeaux (M.), Fall of Miner down 100-metre Shaft without being killed, 471
Review, New Russian Natural Science, 409

REVIEWS and OUR BOOK SHELF:—
  Modern Views of Electricity, Prof. Oliver J. Lodge, F.R.S., 5
  Calcul des Probabilités, J. Bertrand, 6
  Argentine Ornithology, P. L. Sclater, F.R S., and W. H. Hudson, R. Bowdler Sharpe, 7
  Chemistry of the Coal-Tar Colours, Dr. R. Benedikt, 8
  Bibliography of Geodesy, J. Howard Gore, 9
  Lund Museum in the University of Copenhagen, 26
  Hydraulic Motors, Turbines and Pressure Engines, G. R. Bodmer, 27
  Physiological Notes on Primary Education and the Study of Language, Mary Putnam Jacobi, 28
  Steam-Engine Design, Jay M. Whitham, 29
  Coloured Analytical Tables, H. W. Hake, 29
  Story of a Tinder-Box, Chas. M. Tidy, 30
  Magnetism and Electricity, Andrew Jamieson, 30
  Time and Tide, a Romance of the Moon, Sir Robert S. Ball, F.R.S., 30
  Chemical and Physical Studies in the Metamorphism of Rocks, based on the Thesis written for the D.Sc. Degree in the University of London, 1888, Rev. A. Irving, 49
  Hand-book of Descriptive and Practical Astronomy, G. F. Chambers, 49
  Proceedings of the National Electric Light Association at its Ninth Convention, 1889, 50
  Enumeratio Specierum Varietatumque Generis Dianthus, F. N. Williams, 51
  Magnetism and Electricity, Arthur W. Poyser, 52
  Engineer's Sketch-Book, Thos. Walter Barber, 52
  Life of John Davis, Clements R. Markham, 53
  Brook and its Banks, Rev. J. G. Wood, 53
  The Zoo, Rev. J. G. Wood, 53
  The Habits of the Salmon, by Major John P. Traherne, 74
  An Elementary Text-book of Geology, by W. Jerome Harrison, 75
  A Contribution to the Flora of Derbyshire, by the Rev. W. H. Painter, 77
  Science of Every-day Life, by J. A. Bower, 78
  Elementary Physics, by M. R. Wright, 78
  Teacher's Manual of Geography, by J. W. Redway, 78
  Notes on Pinks of Western Europe, by F. N. Williams, 78
  American Resorts, with Notes upon their Climate, B. W. James, 79
  Idylls of the Field, by Francis A. Knight, 79
  Sixth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution, 1884–85, 99
  Traité pratique de la Thermométrie de Précision, Ch. Ed. Guillaume, Dr. Edmund J. Mills, F.R.S., 100
  Fauna of British India, including Ceylon and Burma, 101
  La France Préhistorique, Emile Cartailhac, 102
  Experimental Science, Geo. M. Hopkins, 102
  A Manual of Forestry, William Schlich, Sir D. Brandis, F.R.S., 121
  A Popular Treatise on the Winds, William Ferrel, 124
  Atlas deutscher Meeresalgen, Dr. J. Reinke, 127
  Die mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen, G. Tschermak, 127
  Die Structur und Zusammensetzung der Meteoreisen erläutert durch photographische Abbildungen geätzter Schnittflächen, A. Brezina and E. Cohen, 127
  Die Meteoritensammlung des k.k. mineralog. Hofkabinetes in Wien, A. Brezina, 127
  Introduction to Chemical Science, R. P. Williams and B. P. Lascelles, 128
  The Cradle of the Aryans, Gerald H. Rendall, 128
  A Monograph of the Horny Sponges, by Robert von Lendenfeld, 146
  The Flora of Suffolk, by Dr. W. M. Hind, 149
  Iron and Steel Manufacture, by Arthur H. Hiorns, 150
  On the Creation and Physical Structure of the Earth, by J. T. Harrison, 151
  Through Atolls and Islands in the Great South Sea, by F. J. Moss, 151
  Notes on Sport and Ornithology, H.I.H. the late Crown Prince Rudolph of Austria, 169
  Matabele Land and the Victoria Falls, Frank Oates, 169
  Index Generum Avium, F. W. Waterhouse, 169
  The Birds of Oxfordshire, O. V. Aplin, 169
  The Birds of Berwickshire, Geo. Muirhead, 169
  The Birds in My Garden, W. T. Greene, 169
  The Viking Age, Paul B. Du Chaillu, 173
  A Glossary of Anatomical, Physiological, and Biological Terms, T. Dunman, 173
  A Contribution to the Physical History and Zoology of the Somers Archipelago, with an Examination of the Structure of Coral Reefs, Angelo Heilprin, Dr. H. B. Guppy, 193
  The Useful Plants of Australia, J. H. Maiden, 194
  Mount Vesuvius, J. Logan Lobley, 195
  Index of British Plants, Robert Turnbull, 196
  Practical Observations on Agricultural Grasses and other Pasture Plants, William Wilson, 196
  The State, Elements of Historical and Practical Politics, Woodrow Wilson, 196
  Introductory Lessons in Quantitative Analysis, John Mills and Barker North, 197
  Report on the Scientific Results of the Voyage of H.M.S. *Challenger* during the Years 1873–76, under the Command of Captain George S. Nares, F.R.S., and the late Captain Frank T. Thomson, 217
  Vertebrate Animals of Leicestershire and Rutland, Montagu Browne, 220
  Scientific Papers of Asa Gray, W. Botting Hemsley, F.R.S., 221
  Manures and their Uses, Dr. A. B. Griffiths, 222
  Histoire Naturelle des Cétacés des Mers d'Europe, P. J. Van Beneden, 223
  Hand-book of Practical Botany for the Botanical Laboratory and Private Student, E. Strasburger, 223
  Traité d'Optique, M. E. Mascart, J. D. Everett, 224
  Bibliothèque Photographique, P. Möessard, 224
  Hand-book of Modern Explosives, M. Eissler, 224
  Text-book of Assaying, C. Beringer and J. J. Beringer, Thomas Gibb, 245
  The Microscope in the Brewery and Malt-house, Chas. Geo. Mathews and Francis Edw. Lott, 246
  Flower-Land, an Introduction to Botany, Robert Fisher, 247
  Five Months' Fine Weather in Canada, Western U.S., and Mexico, Mrs. E. H. Carbutt, 247
  A Thousand Miles on an Elephant in the Shan States, Holt S. Hallett, 265
  The Lesser Antilles, Owen J. Bulkeley, 268
  A Text-book of Human Anatomy, Prof. Alex. Macalister, F.R.S., 269
  A Treatise on Ordinary and Partial Differential Equations, W. W. Johnson, 270
  The Land of an African Sultan, Travels in Morocco, 1887–88–89, W. B. Harris, 270
  Wayside Sketches, F. Edward Hulme, 270
  Hygiene, or Public Health, Louis C. Parkes, 290
  Im Hochgebirge, Wanderungen von Dr. Emil Zsigmondy, 291
  The Story of Chemistry, Harold Picton, F.R.S., 292
  Les Animaux et les Végétaux Lumineux, Henri Gadeau de Kerville, W. A. Herdman, 293
  Chemistry of Photography, R. Meldola, F.R.S., 293
  The Popular Works of Johann Gottlieb Fichte, 294
  Travels in France, Arthur Young, 294
  East Africa and its Big Game, Captain Sir John C. Willoughby, 298
  Einiges über die Enstehung der Korallenriffe in der Javasee und Branntweinsbai, und über neue Korallenbildung bei Krakatau, Dr. C. Ph. Sluiter, 303
  Lectures on the Religion of the Semites, the Fundamental Institutions, W. Robertson Smith, 337
  Algebra: an Elementary Text-book for the Higher Classes of Secondary Schools and for Colleges, G. Chrystal, 338
  The Micro-organisms of Fermentation practically considered, Alfred Jörgensen, Prof. Percy F. Frankland, 339
  An Epitome of the Synthetic Philosophy, F. Howard Collins, 340
  The Earth and its Story, edited by Dr. Robert Broun, 341
  Steam, William Ripper, 341

Australia Twice Traversed, Ernest Giles, 341
New Zealand for the Emigrant, Invalid, and Tourist, John Murray Moore, 342
Report on the Scientific Results of the Exploring Voyage of H.M.S. *Challenger*, 361
The Human Foot, Thos. S. Ellis, 365
Das australische Florenelement in Europa, Dr. Constantin Freiherr von Ettingshausen, 365
Is the Copernican System of Astronomy True?, W. S. Cassedy, 366
Naturalistic Photography, P. H. Emerson, 366
A Dictionary of Applied Chemistry, Prof. T. E. Thorpe, F.R.S., Vol. I., 387
Oates's Ornithology of India, 388
The Nests and Eggs of Indian Birds, by Allan O. Hume, 388
Die Arten der Gattung Ephedra, by Dr. Otto Stapf, 390
Geological Mechanism, by J. Spottiswoode Wilson, 390
The Scenery of the Heavens, by J. E. Gore, 391
A Trip to the Eastern Caucasus, by the Hon. John Abercromby, 391
Gimpses of Animal Life, W. Jones, 409
Toilers in the Sea, M. C. Cooke, 409
Les Industries des Animaux, F. Houssay, 409
A General Formula for the Uniform Flow of Water in Rivers and other Channels, E. Ganguillet and W. R. Kutter, 411
Der Kompass an Bord, Dr. Neumayer, 412
Library Reference Atlas of the World, John Bartholomew, 413
The Bala Volcanic Series of Caernarvonshire and Associated Rocks; being the Sedgwick Prize Essay for 1888, Alfred Harker, 414
Ethnographische Beiträge zur Kenntniss des Karolinen Archipels, J. S. Kubary, 433
Railways of England, Railways of Scotland, W. M. Acworth, 434
Diseases of Plants, Prof. H. Marshall Ward, F.R.S., 436
The Physician as Naturalist, W. T. Gairdner, 436
Materials for a Flora of the Malayan Peninsula, Dr. Geo. King, F.R.S., 437
Report of the Scientific Results of the Voyage of H.M.S. *Challenger* during the Years 1873-76, 443
A Naturalist in North Celebes, Sydney J. Hickson, Dr. F. H. H. Guillemard, 457
The Elastical Researches of Barré de Saint-Venant, Prof. A. G. Greenhill, F.R.S., 458
Hues's Treatise on the Globes (1592), 459
The Psychology of Attention, Th. Ribot, 460
Handleiding tot de Kennis der Flora van Nederlandsch Indië, 461
The Elements of Laboratory Work, A. G. Earl, 461
Magnetism and Electricity, Prof. Jamieson, 461
Astronomy with an Opera Glass, Garrett P. Serviss, 462
Wissenschaftliche Resultate der von N. M. Przewalski nach Central-Asien unternommenen Reisen, 468
Dr. A. B. Meyer's Celebes Photographs, 471
Geologische Uebersichtskarte der Alpen, Dr. Franz Noë, Prof. T. G. Bonney, F.R.S., 483
Old Age, Geo. M. Humphrey, 484
Elements of Astronomy, Prof. C. A. Young, 485
Physiology of Bodily Exercise, Dr. Fernand Lagrange, 485
Boilers, Marine and Land, T. W. Traill, 486
History and Pathology of Vaccination, E. M. Crookshank, Dr. Robert Cory, 486
Cave Fauna of North America, with Remarks on the Anatomy of the Brain, and Origin of Blind Species, A. S. Packard, 507
A Treatise on Linear Differential Equations, Thomas Craig, 508
Bacteria of Asiatic Cholera, Dr. E. Klein, 509
Manuel de l'Analyse des Vins, Ernest Barillot, 510
British Journal Photographic Almanac, 1890, 510
Four-Figure Mathematical Tables, J. T. Bottomley, F.R.S., 510
New Lights from Solar Eclipses, William M. Page, William E. Plummer, 529
The Evolution of Sex, Prof. Patrick Geddes and J. Arthur Thomson, 531
Geology of the Quicksilver Deposits of the Pacific Slope, G. F. Becker, 532
Illustrations of some of the Grasses of the Southern Punjab, being Photo-lithographs of some of the Principal Grasses found at Hissar, William Coldstream, 533
Elementary Dynamics of Particles and Solids, W. M. Hicks, F.R.S., 534
Catalogue of the Fossil Reptilia and Amphibia in British Museum (Natural History), Richard Lydekker, 534
The Growth of Capital, by Robert Giffen, 553
Contributions to the Fauna of Mergui and its Archipelago, 556
How to know Grasses by their Leaves, by A. N. M'Alpine, 557
Facsimile Atlas to the Early History of Cartography, with Reproductions of the most Important Maps printed in the Fifteenth and Sixteenth Centuries, by A. E. Nordenskiöld, 558
Light and Heat, by the Rev. F. W. Aveling, 558
Warren's Table and Formula Book, by the Rev. Isaac Warren, 558
Short Lectures to Electrical Artisans, J. A. Fleming, 561
Absolute Measurements in Electricity and Magnetism, Andrew Gray, 561
Theory and Practice of Absolute Measurements in Electricity and Magnetism, Andrew Gray, 561
Electricity in Modern Life, G. W. de Tunzelmann, 561
Cultivated Oranges and Lemons of India and Ceylon, Dr. E. Bonavia, C. B. Clarke, F.R.S., 579
A Naturalist among the Head-hunters, C. M. Woodford, 582
Recherches sur les Tremblements de Terre, Jules Girard, 583
La Photographie à la Lumière du Magnésium, Dr. J. M. Eder, translated by H. Gauthier-Villars, 584
Un Viaggio a Nias, Elio Modigliani, Prof. Giglioli, 587
Revue d'Anthropologie, 357
Revue Générale des Sciences Pures et Appliquées, 160
Reymond (Dr. René du Bois), on the Striated Muscles of the Tench, 95
Rhizocarps, Fossil: Sir J. Wm. Dawson, F.R.S., 10; Alfred W. Bennett, 154
Ribot (Th.), Psychology of Attention, 460
Riccò (Prof.), Sun-Spot of June, July, and August, 1889, 115
Richardson (Dr. A.), Action of Light on Moist Oxygen, 142
Righi (Prof.), New Method of Measuring Differences of Potential of Contact, 18
Rings of Saturn, Stability of the, O. Callandreau, 548
Ripper (William), Steam, 341
Rivista Scientifico-Industriale, 380
Road at Sea, Rule of the, Admiral Colomb, 515
Roberts (A. Ernest), the Relation of the Soil to Tropical Diseases, 31
Roberts (Isaac), a Photographic Method for Determining Variability in Stars, 332
Roberts-Austen (Prof. W. C., F.R.S.): on the Hardening and Tempering of Steel, 11, 32; the Relation between Atomic Volumes of Elements present in Iron and their Influence on its Molecular Structure, 420
Robinson (H. H.), Frangulin, 262
Roborovsky (Colonel), Expedition in Central Asia, 234; Discovery of New Pass from Nia to Tibet by, 327
Rock-Sepulchre in Morea, Vaphio, S. Reinach, 500
Rock-Specimens Collected in Oceanic Islands, Prof. A. Renard, 363
Rocks, the Bala Volcanic Series of Caernarvonshire and Associated, being the Sedgwick Prize Essay for 1888, Alfred Harker, 414
Rocks, Chemical and Physical Studies in the Metamorphism of, Rev. A. Irving, 49
"Rollers," the, of Ascension and St. Helena, Prof. Cleveland Abbe, 585
Romanes (Prof. Geo. J., F.R.S.): Darwinism, 59; Galls, 80, 174, 369; Panmixia, 437, 511, 585; Before and After Darwin, 524; Like to Like, a Fundamental Principle in Bionomics, 535
Rome: Earthquake at, 401; Solar Observations at, Prof. Tacchini, 595
Rorqual musculus Stranded in Médoc District, 113
Roscoe (Sir Henry, M.P., F.R.S.): the City Guilds and Technical Education, 160; on the Future of our Technical Education, 183; Technical Education Bill, 493; a Dictionary of Applied Chemistry by Prof. T. E. Thorpe, F.R.S., Vol. I., 387
Rose (T. Kirke), the New Assistant Surveyor at Royal Mint, 493
Rosenberger (Otto), Death of, 324

Rotation of Mercury, on the, Signor Schiaparelli, 257
Roth (Hy. Ling): a Surviving Tasmanian Aborigine, 105
Roth (Herr), on the South American Pampas Formation, 231
Roumania, Meteorological Institute of, 181
Roux (G.), Morphology and Biology of *Oidium albicans*, 72
Rowley (F. R.), on a Mite of the Genus *Tetranychus* found Infesting Lime-trees in the Leicester Museum Grounds, 31
Royal Botanic Society, 448, 494
Royal Geographical Society, 351; Honours for 1890, 571
Royal Horticultural Society, 182, 282
Royal Institution Lecture Arrangements, 136, 181, 256, 426, 519, 545
Royal Irish Academy, 469
Royal Meteorological Society, 93, 212, 301, 358, 406, 503, 598; Exhibition of the, 491
Royal Microscopical Society, 93, 191, 263, 335, 371, 550
Royal Society, 17, 118, 140, 166, 189, 212, 237, 287, 309, 332, 357, 380, 430, 477, 501, 525, 550, 573, 598; Medals, 41; Anniversary Meeting, 84, 116, 234; Election of Foreign Members of, 135; Key to the Royal Society Catalogue, James McConnel, 342, 391, 418; the Government Grant, 347; the Royal Society Proceedings, 400
Royal Society of New South Wales, 311; Prizes offered by, 349
Royal Society of Tasmania, 43
Royal Victoria Hall and Morley Memorial College, 343
Rubens (Dr.), Use of Bolometer for Observing Electrical Radiations of Hertz, 504
Rücker (Prof. Arthur W., F.R.S.): Physical Properties of Water, 416; and Prof. T. E. Thorpe, F.R.S., Magnetic Surveys of Special Districts in the British Isles, 598
Rudge (W. A.), Specific Inductive Capacity, 10
Ruhemann (Dr. S.), Action of Chloroform and Alcoholic Potash on Hydrazines, 263
Rule of the Road at Sea, Admiral Colomb, 515
Russell (Hon. F. A. R.), the Causes and Character of Haze, 60
Russell (H. C.), Meteorology of New South Wales, 113
Russia: Russian Botanical Appointments, 42; Geography in Russia, Baron Kaulbars, 208; Russian Geographical Society, and the Black Sea, 348; Russian Academy of Sciences, 302; Eighth Congress of Russian Naturalists, 356; a Uniform System of Russian Transliteration, 396; Chas. E.-Groves, F.R.S., 534; W. F. Kirby, 535; Mammoth Skeleton in Russia, 448; New Russian Natural Science Review, 469
Rutley (Frank), Composite Spherulites in Obsidian from Hot Springs near Little Lake, California, 551

Sacchiero (G. B.), the Chin Tribes, North Burma, 375
St. Andrews, Bequest of £100,000 to the University of, 41
St. Helena: the Native Ebony of, Morris, 519; the "Rollers" of, Prof. Cleveland Abbe, 585
St. Louis Botanic Garden, the Shaw Bequest for the Endowment of the, 324
St. Louis, Earthquake at, 18
St. Petersburg Academy of Sciences, 495
St. Petersburg Problem, the, Sydney Lupton, 165
Saint-Venant (Barré de), the Elastical Researches of, Prof. A. G. Greenhill, F.R.S., 458
Salad-Plants, H. de Vilmorin, 494
Salet (G.), the Blue Flame of Common Salt, 383
Salisbury (the Marquis of): on Electrical Science, 21; on Free Education, 84
Salmon, the Habits of the, Major John P. Traherne, 74
Salmon in Tasmania, Acclimatized, 43
Salt, Common, Experiments upon Simultaneous Production of Pure Crystals of Sodium Carbonate and Chlorine from, Dr. Hempel, 19
Salvadori (Count), Agguinte alla Ornitologia della Papuasia e delle Molucche, 85
Sanitary Assurance Association, 136, 401
Sanitary Institute, 302
Saporta (G. de), some Provençal Tree-Hybrids, 23
Sardines in Moray Firth, Prof. Ewart, 282
Satellite of Algol, W. H. S. Monck, 198
Saturn: Mass of, Asaph Hall, 429; Stability of the Rings of, O. Callandreau, 548
Savelief (R.), Actinometric Observations (1888–89) at, 359
Scale: Sir G. Shuckburgh's Unit of Length of a Standard, General J. T. Walker, R.E., F.R.S., 381; Shuckburgh Scale and Kater Pendulum, O. H. Tittmann, 538
Scenery of the Heavens, J. E. Gore, 391
Schafhäutl (Dr. von), Death and Obituary Notice of, 448
Scheiner (Dr.), some Photographic Star Spectra, 163
Schiaparelli (Signor), on the Rotation of Mercury, 257
Schick (Herr), Troglodytic Remains in Jerusalem, 284
Schleinitz (Admiral von), the North Coast of New Guinea, 21
Schlich (Dr. William): a Manual of Forestry, Sir D. Brandis, F.R.S., 121; Forestry in India, 470
Schlœsing, Fils (Th.): Air in the Soil, 23; the Fermentation of Stable Manure, 143; Absorption of Atmospheric Ammonia of Soils, 479
Schneider (Dr.), Iron in the Animal Organism, 24
Schools, Technical Education in Elementary, 356
Schorr (Dr. R.): Comet Swift (*f* 1889, November 17), 139; on the Star System ξ Scorpii, 374
Schuster (Dr., F.R.S.), Total Solar Eclipse of 1886, 327
Science, Australasian Association for the Advancement of, Prof. Orme Masson, 441
Science Collections at South Kensington, the Housing of the, 399, 409
Science in Dutch East Indies, 547
Science at Eton, Lieut.-General Tennant, F.R.S., 587
Science of Every-day Life, J. A. Bower, 78
Science, Experimental, George M. Hopkins, 102
Science and the Future Indian Civil Service Examinations, 25; Henry Palin Gurney, 53
Science and Law, 399
Science and the New English and Scotch Codes, 385
Scientific Education in China, the Question of Language, 162
Scientific Literature, Native Indian, 569
Scientific Missions, French, under the Old Monarchy, Dr. Hamy, 427
Sclater (Dr. P. L., F.R.S.): Argentine Ornithology, R. Bowdler Sharpe, 7; la Pietra Papale, 31; African Monkeys in the West Indies, 368
Scorpii, on the Star System ξ, Dr. Schorr, 374
Scotland: Railways of, W. M. Acworth, 434; certain Devonian Plants from, Sir J. W. Dawson, F.R.S., 537
Scott (R. H., F.R.S.), Variability of Temperature of British Isles, 1859–83, 550
Scottish Journal of Natural History, 373
Scottish Meteorological Society, 518
Scouller (William), Rainbow due to Sunlight reflected from the Sea, 271
Sea, Rainbow due to Sunlight reflected from the, Sir William Thomson, F.R.S., 271; William Scouller, 271
Sea, Rule of the Road at, Admiral Colomb, 515
Sea, Toilers in the, M. C. Cooke, 409
Seal (W. P.), the Management of Aquaria, 18
Sedgwick and Murchison, Cambrian and Silurian, Prof. James D. Dana, 421
Sedgwick Prize Essay for 1888, 414
Seismology: Record of British Earthquakes, Charles Davison, 9; the Earthquake of Tokio, April 18, 1889, Prof. Cargill G. Knott, 32; Earthquake in Servia, 113; Brassart Brothers' New Seismoscopes, 137; British Earthquakes, William White, 202, 248; Atmospheric Circulation, A. Buchan, 363; Recherches sur les Tremblements de Terre, Jules Girard, 583
Selenite, Salts of, M. Boutzoureano on, 87
Selenium: the Chlorides of, M. Chabrié, 284; Compounds of, Prof. William Ramsay, F.R.S., 343
Self-luminous Clouds: Geo. F. Burder, 198; C. E. Stromeyer, 225
Semites, the Cradle of the, Dr. Brinton, Prof. Jastrow, 569
Semites, Lectures on the Religion of the, Prof. W. Robertson Smith, 337
September, Chiff-Chaff Singing in, F. M. Burton, 298
Severn Valley Field Club, 86
Servia, Earthquake in, 113
Serviss (Garrett P.), Astronomy with an Opera Glass, 462
Sex, the Evolution of: M. S. Pembrey, 199; Dr. A. B. Meyer, 272; Prof. Patrick Geddes and Arthur Thomson, 531
Shan States, a Thousand Miles on an Elephant in, Holt S. Hallett, 265
Sharp (Dr. Davis) appointed Curator in Zoology at Cambridge, 324
Sharpe (R. Bowdler): Argentine Ornithology, P. L. Sclater, F.R.S., and W. H. Hudson, 7; Notes on Sport and Ornithology, H.I.H. Prince Rudolph of Austria, 169; Matabele Land and the Victoria Falls, Frank Oates, 169; Index Generum Avium, F. H. Waterhouse, 169; the Birds of Oxford-

shire, O. V. Aplin, 169; the Birds of Berwickshire, Geo. Muirhead, 169; the Birds in my Garden, W. T. Greene, 169; Oates's Ornithology of India, Vol. I., 388; Hume's Nests and Eggs of Indian Birds, Vol. I., 388
Shaw Bequest for Endowment of St. Louis Botanic Garden, 324
Sheep-farming in Australia, Prof. Wallace, 113
Shell, Deformation of an Elastic, Prof. Horace Lamb, F.R.S., 549
Sherrington (C. S.), Outlying Nerve-cells in Mammalian Spinal Cord, 358
Shining Night Clouds, Robert B. White, 369
Ships, Steel, Leak-stopping in, Captain C. C. P. Fitzgerald, R.N., 516
Ships, the Strength of, Prof. P. Jenkins, 515
Shooting-stars, the Origin of, 92
Shore (T. W.), Characteristic Survivals of Celts in Hampshire, 406
Shot, on certain Approximate Formulæ for Calculating the Trajectories of, Prof. J. C. Adams, 258
Shrubs, Evergreen, in Manchester, Proposed Planting of, 401
Shuckburgh Scale and Kater Pendulum, O. H. Tittmann, 538
Shufeldt (R. W.), Craniology of *Heloderma suspectum*, the Poisonous Lizard of South-West United States, 181
Shufeldt (Dr. R. W.), Work on Avian Anatomy, 594
Siam, Life in, 265
Siberia, Limits of Ever-frozen Soil in, Yatchevsky, 472
Sidgreaves (Rev. W.), Melde's Vibrating Strings, 355
Sieber (Dr. J.), Diethylene Diamine, 428
Simaschko (Prof.), the Méguéia Meteorite, 472
Sinclair (W. E.), Flint Remains in Kolaba District, 114
Singapore, Noxious Grass (Lalang) at, 182
Skin-Colour in Arctic Voyagers, Causes of Change of, Holmgren, 546
Skin, Electric Currents from Mental Excitation in, Herr Tarchenoff, 232
Sluiter (Dr. C. Ph.), the Coral Reefs of the Java Sea and its Vicinity, Dr. H. B. Guppy, 300
Smith (Prof. C. Michie): the Green Flash at Sunset, 538; a New Green Vegetable Colouring-Matter, 573; Determination, by Measurement of Ripples, of Surface Tensions of Liquids, 575
Smith (Prof. W. Robertson), Lectures on the Religion of the Semites, 337
Smokeless Explosives, Sir Frederic Abel, F.R.S., 328, 352
Smolenski (Dr.), the Suspected Connection between Influenza and Cholera Epidemics, 282
Smyth (Robert Brough), Death of, 112
Snake and Fish, Herr Fischer-Sigwart, 162
Snake-bite in Ratnagherry District, Mortality from, Vidal, 325
Society of Arts, 42
Society for Psychical Research, 17
Sohncke (Prof.), Cause of Blue-Green Flame Phenomenon of Sunset at Sea, 495
Soil, the Relation of the, to Tropical Diseases, A. Ernest Roberts, 31
Soils, Sources of Nitrogen in, Prof. John Wrightson, 286
Solar Activity in 1889, 522
Solar Corona, Mathematical Study of the, Prof. F. H. Bigelow, 595
Solar Eclipse of 1886, Total, 88; Dr. Schuster, F.R.S., 327
Solar Eclipse, Total, of December 22, 1889, M. A. De La Baume Pluvinel, 428
Solar Eclipses, New Light from, William M. Page, William E. Plummer, 529
Solar Halos and Parhelia, 330; J. Lovell, 560
Solar and the Lunar Spectrum, the, Prof. Langley, 450
Solar Observations at Rome, Prof. Tacchini, 595
Solar Spots and Prominences, Prof. Tacchini, 233
Solar Spectrum, Maximum Light-Intensity of the, Dr. Mengarini, 374
Solar and Stellar Motions, Prof. J. R. Eastman, 351, 392. *See also* Sun
Sollas (Prof., F.R.S.), Mica in Mourne Mountain Geodes, 469
Solomon Islands: Further Explorations of, C. M. Woodford, 403; a Naturalist among the Head-hunters, C. M. Woodford, 582
Sorbite, Vincent and Delachanal, 23
Sorbonne, Mathematical Teaching at, Prof. Ch. Hermite, 597
Sorby (H. C., F.R.S.), on Meteorites, 307
Sormani (Prof. G.), Antidotes and Treatment of Tetanus, 212
Sound, Propagation of, MM. Violle and Vautier, 359
South American Pampas, Mirage in the, W. Larden, 69
South Kensington, Science Collections at, the Housing of the, 399, 409
South Sea, Through Atolls and Islands in the, F. J. Moss, 151
Souza (J. A. de), Death of, 135
Specific Inductive Capacity: W. A. Rudge, 10; Prof. Oliver J. Lodge, F.R.S., 30
Spectrum Analysis: Objects for the Spectroscope, 44, 68, 87, 114, 138, 163, 183, 210, 232, 257, 285, 304, 326, 350, 374, 402, 428, 449, 472, 496, 521, 548, 571, 595; Photography of the Red End of the Spectrum, Colonel J. Waterhouse, 67; some Photographic Star Spectra, Dr. Scheiner, 163; Spectrum of Algol, Prof. Vogel, 164; Colour Spectrum of Fluorine, H. Moissan, 214; Spectrum of a Metallic Prominence, 233; Spectrum of ζ Ursæ Majoris, on the, Prof. Pickering, 285; Spectroscopic Observations of Algol, Prof. Vogel, 285; New Fluorescent Materials, Lecoq de Boisbaudran, 287; Maxwell Hall on the Spectrum of the Zodiacal Light, 351, 402; Spectrum of Borelly's Comet (*g* 1889), 374; Maximum Light-Intensity of the Solar Spectrum, Dr. Mengarini, 374; Spectra of δ and μ Centauri, 374; Blue Flame of Common Salt, G. Salet, 383; Spectroscopic Observations of the Zodiacal Light, A. Fowler, 402; the Solar and the Lunar Spectrum, Prof. Langley, 450; Kirchoff's Law and Gaseous Radiation, Dr. E. Pringsheim, 480; the Spectrum of Subchloride of Copper, Prof. A. S. Herschel, F.R.S., 513; Bright Lines in Stellar Spectra, Rev. J. E. Espin, 549; Fundamental Common Property of two Kinds of Spectra, Lines and Bands, Distinct Characteristics of each of the Classes, Periodic Variations to Three Parameters, H. Deslandres, 576; Spectrum of Aqueous Vapour, Chas. S. Cook, 598
Spencer (Herbert): Inheritance of Acquired Characters, 414; Nebular Hypothesis, 450; Panmixia, 511
Spencer (Perceval), Successful Use of Asbestos Hot-air Balloon in India, 325
Spitaler (Dr. R.), Temperature "Anomalies," 303
Spitta (E. J.), a New Wedge Photometer, 287
Sponges: Discovery of Sponge-bank near Lampedusa, 284; the Horny Sponges, Robert von Lendenfeld, 146; Sponges attached to Crabs, Dr. R. von Lendenfeld, 317; Physiology of Sponges, Dr. Lendenfeld, 570
Spörer (Prof.), Sun-spots in 1889, 383
Spots, Solar, and Prominences, Prof. Tacchini, 233
Stability of the Rings of Saturn, O. Callandreau, 548
Stalactite Cave discovered in Westphalia, 113
Stalybridge Mechanics' Institute, Chemical Laboratory at, 85
Stanley (H. M.), his Explorations in Africa, 20, 73, 111
Stapf (Dr. Otto), Die Arten der Gattung Ephedra, 390
Stapley (A. M.), the Composition of the Chemical Elements, 56
Stars: Double, Measurements of S. W. Burnham, E. E. Barnard, 19; New Double Stars, Miss A. M. Clerke, 132; Star Distances, Miss A. M. Clerke, 81; New Variable Stars in Hydra, 88; Y Cygni, 88; Period of U Coronæ, S. C. Chandler, 163; in Cluster G.C. 3636, Prof. Pickering, 183; Observations of some Suspected Variables, Rev. John G. Hagen, 233; New Short-period Variable in Ophiuchus, 403; New Variable in Cælum, 571; the Origin of Shooting-stars, 92; Photographic Star Spectra, 115; Dr. Peters's Catalogue, 210; Star-Land, Sir Robert S. Ball, F.R.S., 315; Star System ξ Scorpii, Dr. Schorr, 374; the Distance of the Stars, Dr. W. H. S. Monck, 392; Observations of ζ Ursæ Majoris and β Aurigæ, 403; Melbourne Star Catalogue, 522; Discovery of Asteroids, Dr. Palisa, 522; M. Charlois, 522
State, the, Elements of Historical and Practical Politics, Woodrow Wilson, 196
Steam, Electrification of, Shelford Bidwell, F.R.S., 213
Steam, William Ripper, 341
Steam-engine Design, Jay M. Whitham, 29
Steam-ships, the Steering of, A. B. Brown, 516
Stearns (R. E. C.): Effect of Music on Animals, 470; on a Canary, 593
Stebbing (Rev. T. R. R.), the Moon in London, 586
Steel: on the Hardening and Tempering of, Prof. W. C. Roberts-Austen, F.R.S., 11, 32; Behaviour of, under Mechanical Stress, C. H. Carus-Wilson, 213; Physical Properties of Nickel Steel, Dr. J. Hopkinson, F.R.S., 332; the Rupture by Longitudinal Stress of, C. A. Carus-Wilson, 574; Steel and Iron Manufacture, Arthur H. Hiorns, 150
Stellar Parallax by Means of Photography, Prof. Pritchard, 19
Stellar Spectra, Bright Lines in, Rev. J. E. Espin, 549

Stieltjes (M.), the Exponential Function, 382
Stiffe (Captain), Glaciation of Valleys in Kashmir Himalayas, 190
Stockholm, Royal Academy of Sciences, 24, 168, 192, 288, 408, 576, 600
Story, the Earth and its, edited by Dr. Robert Brown, 341
Story of a Tinder-Box, Chas. M. Tidy, 30
Strabismus, H. Parinaud, 72
Straits Settlements, Meteorology of, 114
Strasburger (E.), Hand-book of Practical Botany for the Botanical Laboratory and Private Student, 223
Stricker (Prof.), New Electrical Lantern, 593
Strickland (Father, S.J.), Last Days of Father Perry, F.R.S., 301
Strings, Vibrating, Melde's, Rev. W. Sidgreaves, 355
Strips, the Behaviour of Twisted, Prof. J. Perry, F.R.S., 47
Stromeyer (C. E.): Self-luminous Clouds, 225; the Evaporative Efficiency of Boilers, 516; Structure of Jupiter's Belt 3, III., Dr. Terby, 45
Struggle for Existence in Plants, Prof. Walter Gardiner, 90
Stuart (Prof.), Proposed Address to, on his Resignation, 426
Students, Foreign, in Paris, 520
Subchloride of Copper, the Spectrum of, Prof. A. S. Herschel, F.R.S., 513
Sub-oceanic Crust, Physics of the, Rev. Osmond Fisher, A. J. Jukes-Browne, 53; J. Starkie Gardner, 103
Subsidence at Northwich, 230
Suffolk: Flora of, by Dr. W. M. Hind, 149; Dr. Wheelton Hind on the Geology of, 149
Sugar losing its Attractions for Lepidoptera, Joseph Anderson, 349
Sugar-Cane: Disease at St. Vincent, 372; Seeding of, D. Morris, 478
Sulphur, Crystalline Allotropic Forms of, Dr. Muthmann, 449
Sumpner (Dr. W. E.), Galvanometers, 310, 381
Sun's Way, Apex of the, Lewis Boss, 548
Sunlight reflected from the Sea, Rainbow due to, Sir William Thomson, F.R.S., 271; W. Scouller, 271
Sunset, the Green Flash at, C. Michie Smith, 538
Sunset at Sea, Cause of Blue-green Flame Phenomenon of, Prof. Sohncke, 495
Sun-spots: Minimum Sun-spot Period, M. Bruguière, 68; Sun-spot of June, July, and August, 1889, Prof. Riccò, 115; Sun-spots and Prominences, Prof. Tacchini, 233; Sun-spot in High Latitudes, G. Dierckx, 472; Sun-spots in High Southern Latitudes, Rev. S. J. Perry, F.R.S., 88; Observations of Sun-spots made at Lyons Observatory in 1889, Em. Marchand, 599. *See also* Solar
Survey, the Indian, 230
Sutherland (Geo.), Earth-Currents and the Occurrence of Gold, 464
Swift (Dr. Lewis): a New Comet discovered by, 69; Comet Swift (*f* 1889, November 17), Dr. Zelbr, 115, 233; Dr. R. Schorr, 139; Dr. Lamp, 233, 429; Swift's Comet (V. 1880), Orbit of, 257; the Cluster G.C. 1420 and the Nebula N.G.C. 2237, 285
Sydney, Royal Society of New South Wales, 96
Symons (G. J., F.R.S.), Remarkable Hailstones, 134
Synoptical Tables of Organic and Inorganic Chemistry, Clement J. Leaper, 510
Synthetic Philosophy, an Epitome of the, F. Howard Collins, 340
Systems of Russian Transliteration, Chas. E. Groves, F.R.S., 534; W. F. Kirby, 535

Table and Formula Book, Rev. Isaac Warren, 558
Tacchini (Prof.): Corona of January 1, 1889, 139; Solar Spots and Prominences, 233; Solar Observations at Rome, 595
Taczanowski (Dr. L.), Death of, 324
Tait (Prof. P. G.): Portrait Memorial of, 135; Glissette of Hyperbola, 214; Compressibility of Water, 361; Physical Properties of Water, 416
Tannin, Nessler's Ammonia Test as a Micro-Chemical Reagent for, Spencer Moore, 585
Tarchenoff (Herr), Electric Currents in Skin from Mental Excitation, 232
Tasmania: Change in Character of Acclimatized Salmon in, 43; the Last Living Aboriginal of, James Barnard, 43; Destruction of Opposum in, 304; a Surviving Tasmanian Aborigine, Hy. Ling Roth, 105
Taste, Sense of, Dr. Goldscheider's Researches on, 600
Tavernier (Jean Baptiste), Travels in India, 313
Taxine, a New Alkaloid from Leaves, &c., of Yew Tree, Drs. Hilger and Brande, 496
Teacher's Manual of Geography, J. W. Redway, 78
Technical Education: Conference on, at Manchester, 84; Dundee Association, 113; on the Future of our Technical Education, Sir Henry Roscoe, M.P., F.R.S., 183; Technical Education in Elementary Schools, 356; the New Codes, English and Scotch, 385, 505; Technical Education in Central India, 470
Teeth in the Ornithorhynchus, Who Discovered the, C. Hart Merriam, 11, 151; Prof. W. H. Flower, F.R.S., 30, 151; Prof. Oswald H. Latter, 30, 174
Telephone, the Pulsion Mechanical, 65
Telephone Transmitter, Carbon Deposit in Blake, F. B. Hawes, 477
Telescope, the Maintaining and Working of the Great Newall, 357
Temperature "Anomalies," Dr. R. Spitaler, 303
Tempering of Steel, on the Hardening and, Prof. W. C. Roberts-Austen, F.R.S., 11, 32
Ten and Tenth Notation, B. A. Muirhead, 344
Tench, the Striated Muscles of, Dr. René du Bois-Reymond on, 95
Tennant (Lieut.-General, F.R.S.), Science at Eton, 587
Tension of Recently Formed Liquid Surfaces, Lord Rayleigh, 566
Terby (Dr.), the Structure of Jupiter's Belt 3, III., 45
Terminology, the Revised, in Cryptogamic Botany, Alfred W. Bennett, 225
Tetanus, Antidote and Treatment of, Prof. G. Sormani, 212
Tetranychus, on a Mite of the Genus, found Infesting Lime Trees in the Leicester Museum Grounds, F. R. Rowley, 31
Texas, Great Find of Rare Minerals of Yttrium and Thorium Groups in, 162
Textiles, Prehistoric, Herr Buschan, 182
Textural Elements, the Longevity of, particularly in Dentine and Bone, John Cleland, 392
Thames Estuary, the, Captain Tizard, R.N., 539
Theory of Least Squares, a Formula in the, D. Wetterhan, 394
Thermal Conductivity in Flints, a Natural Evidence of High, Prof. A. S. Herschel, F.R.S., 175
Thermometer, Electric, Herr Siegefeld, 43
Thermometers, Aspiration, Dr. Assmann's, 239
Thermometry, Exact: Dr. Sydney Young, 152, 271, 488; Herbert Tomlinson, F.R.S., 198; Dr. Edmund J. Mills, F.R.S., 227, 538
Thermometry: Traité pratique de la Thermométrie de Précision, Ch. Ed. Guillaume, Dr. Edmund J. Mills, F.R.S., 100
Thomas (Oldfield), a Milk Dentition in Orycteropus, 309
Thomas (R. Haig), Panmixia, 585
Thompson (Prof. Silvanus P.): Geometrical Optics, II., 213; Electric Splashes, 309; Bertrand's Refractometer, 526; Bertrand's Idiocyclophanous Prism, 574
Thomson (Dr. Arthur): the Veddahs of Ceylon, 303; Prof. Patrick Geddes and, Evolution of Sex, 531
Thomson (Sir William, F.R.S.): Rainbow due to Sunlight reflected from the Sea, 271; Eight Rainbows seen at the same time, 316; Electrostatic Stress, 358
Thoroddsen's Explorations in Iceland, 165
Thorpe (Prof. T. E., F.R.S.): Photometric Intensity of Coronal Light, 139; Frangulin, 262; a Dictionary of Applied Chemistry, Vol. I., Sir H. E. Roscoe, M.P., F.R.S., 387; the Glow of Phosphorus, 523; and Prof. A. W. Rücker, F.R.S., on Magnetic Surveys of Special Districts in the British Isles, 598
Thought and Breathing: R. Barrett Pope, 297; Prof. F. Max Müller, 317; Rev. W. Clement Ley, 317; Mrs. J. C. Murray-Aynsley, 441
Thresh (Dr.), New Method of Estimating Oxygen dissolved in Water, 335
Thuillier and Waterhouse's Conversion Tables for Metric System, 66
Thunderstorms in England and Wales, 93
Thury (Prof.), Changes in Lunar Craters, 183
Tibet, Discovery by Colonel Pevtsoff and M. Roborovsky of New Pass from Nia to, 327
Tidal and Levelling Operations in India, 140
Tiddemann (R. H.), Brilliant Meteors, 105
Tidy (Chas. M.), the Story of a Tinder-box, 30

Tietkens's Explorations in Central Australia, 286
Tilden (Prof. W. A., F.R.S.), Crystalline Substances obtained from Fruits of various Species of Citrus, 527
Time and Tide, a Romance of the Moon, Sir Robert S. Ball, F.R.S., 30
Timehri, Journal of Royal Agricultural and Commercial Society of British Guiana, 549
Tinder-box, the Story of a, Chas. M. Tidy, 30
Tisserand (F.): Nuclei of Great Comet II. of 1882, 358; the Great Comet of 1882, 522; the Movement of Planets, 406
Titanotherium in the British Museum, 346
Titchener (E. B.): Protective Coloration of Eggs, 129; the Cape Weasel, 394
Tittmann (O. H.), Shuckburgh Scale and Kater Pendulum, 538
Tizard (Captain, R.N.), the Thames Estuary, 539
Todd (Prof. David P.), Total Eclipse, 379
Togoland, German, Climate of, Dr. von Danckelman, 545
Toilers in the Sea, M. C. Cooke, 409
Tokio: the Earthquake of, April 18, 1889, Prof. Cargill G. Knott, 32; Redetermination of Latitude in, Watanabe, 427
Tomlinson (Herbert, F.R.S.): Effect of Repeated Heating and Cooling on Electrical Coefficient of Annealed Iron, 166; Exact Thermometry, 198; the Villari Critical Points in Nickel and Iron, 574
Topinard (Dr.), Charlotte Corday's Skull, 500
Topographical Survey of India, 140
Toronto University, Burning of, 371
Torpedo, Cranial Nerves of, J. C. Ewart, 477
Total Eclipse of January 1, 1889, Prof. Holden, 305
Total Eclipse of December 22, 1889, 229; M. A. De La Baume Pluvinel, 428
Total Eclipse, Prof. David P. Todd, 379
Touraco, the Pigment of the, and the Tree Porcupine, Frank E. Beddard, 152
Traherne (Major John P.), the Habits of the Salmon, 74
Traill (T. W.), Boilers, Marine and Land, 486
Trains, Earth-Tremors from, H. H. Turner, 344
Trajectories of Shot, on Certain Approximate Formulæ for Calculating the, Prof. J. C. Adams, 258
Transliteration, a Uniform System of Russian, 396; Chas. E. Groves, F.R.S., 534; W. F. Kirby, 535
Trautweiler (Herr), Proposed Jungfrau Railway, 303
Travels in France, Arthur Young, 294
Travels in India of Jean Baptiste Tavernier, Baron of Aubonne, translated by Dr. V. Ball, F.R.S., 313
Tree Porcupine, the Pigment of the, Frank E. Beddard, 152
Trees growing in an Inverted Position, Herr Kny, 86
Trichosanthes palmata, a New Green Vegetable Colouring Matter, C. Michie Smith, 573
Trieste, Earthquake at, 519
Trivier (Captain), Arrival at Mozambique of, 165
Troglodytic Remains in Jerusalem, Herr Schick, 284
Tropical Diseases, the Relation of the Soil to, A. Ernest Roberts, 31
Trotter (A. B.): Geometrical Construction of Direct-Reading Scales for Reflecting Galvanometers, 478; Parallel Motion suitable for Recording Instruments, 478
Trouton (Fred. T.), Multiple Resonance obtained in Hertz's Vibrators, 295
Tschermak (G.), Die mikroskopische Beschaffenheit der Meteoriten erläutert durch photographische Abbildungen, 127
Tuning-Forks: a Method of Driving, Electrically, W. G. Gregory, 47; the Testing of, Dr. Lehmann, 383
Tunzelmann (G. W. de), Electricity in Modern Life, 561
Turacin, Solubility of, in Pure Water, Frank E. Beddard, 152
Turkestan, Earthquakes in, 230
Turkeys, Brush-, on the smaller Islands North of Celebes, Dr. A. B. Meyer, 514
Turnbull (Robert), Index of British Plants, 196
Turner (A. E.), Compounds of Phenanthraquinones with Metallic Salts, 191
Turner (H. H.): Total Solar Eclipse of 1886, 88; Earth Tremors from Trains, 344
Twenty Years, Progress of NATURE during, 1
Tylor (Dr. E. B., F.R.S.), Explanation of Assyrian Sculptured Group, 283
Typhus and Ground-water Variations, the Hamburg Epidemic, 570
Tyrol, Earthquakes in the, 569

Ungulates, the Titanotherium in the British Museum, 346
Unio, Tasmanian, Variability of, R. M. Johnston, 303
United States: Fishery Industries of the, George Brown Goode 178; Meteorology in, 231; Land Grants to Educational Institutions in, 448; Earthquakes in, 569
University, Burning of Toronto, 371
University Extension Journal, 325
University, Helsingfors, 400
University Intelligence, 23, 92, 140, 166, 212, 332, 357
University, Johns Hopkins, 448
University, Montpellier, Proposed Commemoration of Founding of, 447
University, the Proposed Reconstitution of London, 282, 348
University of St. Andrews, £100,000 Bequest to, 41
Upham (Wm.), the late Prof. H. C. Lewis, 255
Urea, on Animal Heat and the Combustion of, Berthelot and P. Petit, 94
Ursæ Majoris, on the Spectrum of ζ, Prof. Pickering, 285

Vaccination, History and Pathology of, E. M. Crookshank, Dr. Robert Cory, 486
Vade Mecum, J. C. Houzeau, 69
Vandalism in Egypt, 417
Variable Stars: Y Cygni, 88; New, in Hydra, 88; Period of U Coronæ, S. C. Chandler, 163; Variable Star in Cluster G.C. 3636, Prof. Pickering, 183; Observations of some Suspected, Rev. John G. Hagen, 233; Variability of R Vulpeculæ, 257; New Variable Star in Cælum, 571; Prof. Pickering, 571
Variation, Causes of, E. D. Cope on the, Prof. E. Ray Lankester, F.R.S., 128
Vatican Observatory, 472
Vautier (M.), Propagation of Sound, 359
Vegetable Colouring-matter, a New Green, C. Michie Smith, 573
Velocity of the Propagation of Gravitation, J. Van Hepperger, 472
Venn (Dr. John, F.R.S.), Cambridge Anthropometry, 450
Venus (Dr. K. E.), Death of, 207
Verescz's Discovery as to Photographing in Natural Colours, 469
Vertebrate Animals of Leicestershire and Rutland, Montagu Browne, 220
Vesuvius in 1889, Prof. Palmieri, 18
Vesuvius, Mount, J. Logan Lobley, 195
Vèzes (M.): Double Nitrites of Ruthenium and Potassium, 23; a Nitrosoplatinichloride, 576
Vibrating Strings, Melde's, Rev. W. Sidgreaves, 355
Vibration, Microseismic, of the Earth's Crust, Prof. G. H. Darwin, F.R.S., 248
Vico (1884), Identity of Comet, with Brooks's (1889), 233
Victoria Falls, Matabele Land and the, Frank Oates, R. Bowdler Sharpe, 169
Victoria Hall and Morley Memorial College, 343
Victoria, Minor Planet (12), Dr. Gill, 139
Victoria, Report of Bendigo School of Mines, 209
Vidal (Mr.), Mortality from Snake-bite in Ratnagherry District, 325
Vidal (M. Sebastien), Death of, 348
Viking Age, the, Paul B. Du Chailiu, 173
Villari Critical Points in Nickel and Iron, the, Herbert Tomlinson, F.R.S., 574
Vilmorin (H. de), Salad Plants, 494
Vincent and Delachanal, Sorbite, 23
Vines (Dr. Sydney H., F.R.S.), and Prof. A. Weismann's Theory of Heredity, 317, 373, 439
Vins, Manuel de l'Analyse des, Ernest Barillot, 510
Violle (M.), Propagation of Sound, 359
Virchow (Dr.), the Spiracle Gill of Selachians, 119
Vision, Electrical Radiation from Conducting Spheres, an Electric Eye, and a Suggestion Regarding, Prof. Oliver J. Lodge, F.R.S., 462
Vision, Testing for Practical Purposes, Brudenell Carter, 302
Visualized Images Produced by Music, Geo. E. Newton, 417
Viticulture, Congress for, at Rome, 426
Vogel (Prof.), Spectroscopic Observations of Algol, 285
Voice Figures, Mrs. Watts Hughes, 42
Volcanoes: Great Eruption in Japan, 400; Notes on a Recent Volcanic Island in the Pacific, Captain W. J. L. Wharton, F.R.S., 276; Volcanic Rocks of Caernarvonshire, Alfred

Harker, 414 ; Vesuvius in 1889, Prof. Palmieri, 18 ; Geological Excursion to the Active and Extinct Volcanoes of Southern Italy, 133 ; Activity of Queccia de Salsa, 181 ; the Catastrophe of Kantzorik, Armenia, F. M. Corpi, 190 ; the Mount Bandai (Japan) Eruption, 348 ; the Period of the Long Sea-Waves of Krakatão, James C. McConnell, 392 ; the Eruption of Popocatepetl, 592
Vulpeculæ, R, Variability of, 257
Vyestnīk Estestvoznaniya, New Russian Natural Science Review, 469

Wada (J.) : Earthquake of July 28, 1889, at Kiushiu, 23 ; Cyclone of September 11–12, 1889, in Japan, 208 ; Meteorology in Japan, 1887, 400
Wagner (Dr.) : Behaviour of Water in Soil, 383 ; Fire-damp Explosions in Mines in Relationship to Cosmic and Meteorological Conditions, 504
Walford (E. A.), Terraced Hill Slopes of the Midlands, 325
Walker (Alfred O.), Foreign Substances attached to Crabs, 296
Walker (General J. T., R.E., F.R.S.), Unit of Length of Sir G. Shuckburgh's Standard Scale, 381
Wallace (Dr. Alfred R.) : Protective Coloration of Eggs, 53 ; Degree of D.C.L. Conferred on, at Oxford, 84 ; for Degree of D.C.L., Prof. J. Bryce's Speech on Presentation of, 112 ; some Notes on his "Darwinism," T. D. A. Cockerell, 393
Wallace (Prof.), Sheep Farming in Australia, 113
Waller (Dr. Aug.), Electrical Negative Variation of Heart accompanying Pulse, 288
Walls, Training, in Mersey Estuary, Effects of, L. F. V. Harcourt, 380
Walsingham (Lord), Presidential Address to the Entomological Society, 334
Wapiti Acclimatized in Russia, 546
Warburton (Major P. E.), Death and Obituary Notice of, 164
Ward (Prof. H. Marshall, F.R.S.) : Tubercles on Roots of Leguminous Plants, 140 ; Diseases of Plants, 436
Warren (Rev. Isaac), Table and Formula Book, 558
Watanabe (M.), Redetermination of Longitude in Tokio, 427
Water, Compressibility of, Prof. Tait, 361
Water, Effect of Oil on Disturbed, Richard Beynon, 205
Water, a General Formula for the Uniform Flow of, in Rivers and other Channels, E. Ganguillet and W. R. Kutter, 411
Water, Physical Properties of, Prof. P. G. Tait, 416 ; Prof. Arthur W. Rücker, F.R.S., 416
Waterhouse (F. H.), Index Generum Avium, R. Bowdler Sharpe, 169
Waterhouse (Colonel J.), Photography of Red End of Spectrum, 67
Waterhouse and Thuiller's Conversion Tables for Metric System, 65
Waterspout in Atlantic, 470
Watt (James), Proposed Memorial to, 160
Waves, the Production of, Prof. von Helmholtz on, 95
Wayside Sketches, F. Edward Hulme, 270
Weasel, the Cape, E. B. Titchener, 394
Weather Forecasting, 278
Weather, Influenza and, Mitchell and Buchan, 596
Weather in January, Chas. Harding, 425
Weather and Tidal Forecasts for 1890, D. Dewar's, 546
Weeds, European, in America, 18
Weigert's (Dr.), Treatment of Pulmonary Phthisis, Prof. Visconti, 380
Weismann's (Prof.) Essays, Dr. St. George Mivart, F.R.S., 38
Weismann *versus* Lamarck, Prof. E. D. Cope, 79
Weismann (Prof. A.) : Theory of Heredity, 317, 373, 439 ; and the Theory of Panmixia, 437
Weiss (F. Ernest), Foreign Substances Attached to Crabs, 272
Weldon (W. F. R.), Abnormal Shoots of Ivy, 464
Wesley (W. H.), the Corona of 1889 December 22, 450
West Indies, African Monkeys in the, Dr. P. L. Sclater, F.R.S, 368
Westphalia, Stalactite Cave discovered in, 113
Wethered (E.), Occurrence of Girvanella Genus, and on Oolitic Structure, 238
Wetterhan (D.) : Galls, 131 ; a Formula in the Theory of Least Squares, 394
Weyl (Dr., Biology of Anaërobic Bacteria, 359
Whales, Time they can remain under Water, 66
Wharton (Captain W. J. L., F.R.S.) : Notes on a Recent Volcanic Island in the Pacific, 276 ; Self-Colonization of Coconut Palm, 585
Wheat, Field Experiments on, in Italy, Prof. Giglioli, 404
Whipple (G. M.), Photography in Relation to Meteorological Work, 503
Whitaker (W.), a Deep Channel of Drift in the Valley of the Cam, Essex, 527
White (Robert B.), Shining Night-Clouds, 369
White (William), British Earthquakes, 202
Whitechapel, Proposed Free Library at, 161
Whitham (Jay M.), Steam-Engine Design, 29
Will (Dr.), Analysis of Carcote, Chili, Meteorite, 428
Willem (Victor), the Gizzard in Scolopendridæ, 237
Williams (F. N.) : Enumeratio Specierum Varietatumque Generis Dianthus, 51 ; Notes on the Pinks of Western Europe, 78
Williams (R. P.) and B. P. Lascelles, Introduction to Chemical Science, 128
Williamson (Prof. W. C., F.R.S.) : Organization of Fossil Plants of Coal-Measures, 573
Willoughby (Captain Sir John C.), Africa and its Big Game, 298
Wilson (Sir Daniel), on the Recent Toronto Meeting of the American Association for the Advancement of Science, 17
Wilson (J. Spottiswoode), Geological Mechanism, 390
Wilson (R. W.), Magnetism in Brick Buildings, 405
Wilson (William), Practical Observations on Agricultural Grasses and other Pasture Plants, 196
Wilson (Woodrow), the State, Elements of Historical and Practical Politics, 196
Wilson-Barker (Captain David), Foreign Substances attached to Crabs, 297
Wimshurst Machine and Hertz's Vibrator, T. A. Garrett and W. Lucas, 515
Wind, Preponderance of North-East Wind during past Five Years, C. L. Prince, 470
Wind at Summit of Eiffel Tower, Mean Hourly Velocity of, A. Angot, 67
Wind-velocity at top of Eiffel Tower, Angot, 48
Winds, Dependence of Force of, upon Surface over which they blow, Dr. Van Bebber, 372
Winds, a Popular Treatise on the, William Ferrel, 124
Winds, Relative Prevalence of North-East and South-West, William Ellis, 586
Winlock (Prof.), Progress of Astronomy in 1886, 374
Winnecke's Periodical Comet, the Orbit of, M. H. Faye, 94
Wolves and Bears in Bosnia, 325
Wolves, &c., in Germany, Dr. Lampert, 182
Wood (Rev. J. G.), the Brook and its Banks, 53 ; the Zoo, 53
Woodall (Herbert J.), How not to Teach Geometry, 60
Woodford (C. M.) : Further Explorations of Solomon Islands, 403 ; a Naturalist among the Head-hunters, 582
Woodthorpe (Colonel), the Aka Expedition of 1883, 86
Woodward (A. S.), some British Jurassic Fish-remains, 310
World, Library Reference Atlas of the, John Bartholomew, 413
Worthington (Prof. A. M.), Bourdon's Pressure-Gauge, 296, 517
Wright (M. R.), Elementary Physics, 78
Wrightson (Prof. John) : Sources of Nitrogen in Soils, 286 ; How to know Grasses by their Leaves, by A. N. M'Alpine, 557
Wynne (W. P.), Constitution of Tri-derivatives of Naphthalene, 454

Yatchevsky (M.), Limits of Ever-frozen Soil in Siberia, 472
Yeast, Fermentation with Pure, Prof. Percy F. Frankland, 339
Young (Arthur), Travels in France, 294
Young (Prof. C. A.), the Elements of Astronomy, 485
Young (Dr. Sydney), Exact Thermometry, 152, 271, 488
Yule (Sir Henry), Death of, 207

Zeiss's New Apochromatic Microscope Objective, 494
Zelbr (Dr.), Comet Swift (*f* 1889, November 17), 115, 233
Zepharovich (Ritter von), Death and Obituary Notice of, 448
Zodiacal Light, Maxwell Hall on the Spectrum of the, 351, 402
Zodiacal Light, J. Norman Lockyer, F.R.S., on, 402
Zoo, the, Rev. J. G. Wood, 53
Zoogeography : Wolves, &c., in Germany, Dr. Lampert, 182
Zoological Discoveries, N. M. Przewalsky's, 468

Zoological Floating Station at Isefiord, Denmark, 569
Zoological Gardens, Additions to, 44, 68, 87, 114, 138, 163, 210, 232, 256, 284, 304, 326, 349, 402, 449, 472, 496, 521, 548, 571, 595
Zoological Society, 94, 143, 335, 382, 406, 478, 550, 575, 599
Zoological Results of the *Challenger* Expedition, 217
Zoology: Who Discovered the Teeth in Ornithorhynchus?, C. Hart Merriam, 11, 151; Prof. W. H. Flower, F.R.S., 30 151; Prof. Oswald H. Latter, 30, 174; the Old English Black Rat in Cornwall, Thos. Cornish, 161; Snake and Fish, Herr Fischer-Sigwart, 162; Arrangement of Excitable Fibres of Internal Capsules of Bonnet Monkey, Beevor and Horsley, 166; *Heloderma suspectum*, the Poisonous Lizard of South-West United States, the Craniology of, R. W. Shufeldt, 181; a Milk Dentition in Orycteropus, O. Thomas, 309; the Catalogue of the Indian Museum, 594
Zsigmondy (Dr. Emil), his Alpine Expeditions, 291
Zwardmaaker (Dr.), Olfactometer, 349

NATURE

A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

> *"To the solid ground*
> *Of Nature trusts the mind which builds for aye."*—WORDSWORTH.

THURSDAY, NOVEMBER 7, 1889.

TWENTY YEARS.

A REMINDER that to-day is the twentieth anniversary of the first issue of NATURE, will not, perhaps, be without interest to our readers, and certainly affords food for reflection to those who in various capacities have been more or less closely connected with this journal from the first.

"When another half-century has passed," said Prof. Huxley in our first number, "curious readers of the back numbers of NATURE will probably look on *our* best 'not without a smile.'"

It will probably be so, but though twenty years is hardly a sufficient interval to make our smiles at our earlier efforts supercilious, it is enough to test whether progress has been made, and whether the forward path is pursued with growing or with waning force.

As regards this journal itself, we may claim that it has not disappointed the hopes of its founders, nor failed in the task it undertook; and we make this claim all the more emphatically because we feel that what has been accomplished has not been due to our own efforts so much as to the unfailing help we have always received from the leaders in all branches of natural science. This help has not been limited to their contributions to our columns, but has consisted also of advice and suggestions which have been freely asked and as freely given. Not the least part of our duty, and even privilege, to-day is to state openly how small our own part has been, and to render grateful thanks to those to whom it is chiefly due that NATURE has a recognized place in the machinery of science, and has secured an audience in all parts of the civilized world.

We do not wish, however, to narrow our retrospect of the last twenty years by confining our attention to the measure of success which these pages have won. It has been attained, as we have shown, by the aid of nearly all the best-known scientific writers and workers, not in Britain only but in many countries old and new; and we cannot believe that they would thus have banded themselves together if evidence had not been given of an honest desire for the good of science and for the "promotion of natural knowledge," or if the attainment of these objects had not been regarded by us as of more importance than a journalistic success. Thus, on its twentieth birthday, we would think not so much of the growth of NATURE as of the advance which in the last twenty years it has chronicled.

A formal history of science for that period would be a formidable task, but it is already possible to discern what will probably appear to posterity to be the most salient characteristics of the last two decades.

In the physical sciences, the enormous development of the atomic theory, and the establishment of a connection between the theories of electricity and light, are perhaps the two main achievements of the years we are considering. Methods of accomplishing the at first sight impossible task of measuring atomic magnitudes have been devised. Our own volumes contain some of the most interesting papers of Sir William Thomson on this subject, and the close agreement in the results attained by very different methods is sufficient proof that, if only approximations, they are approximations we may trust. The brilliant vortex atom theory of Sir William Thomson has not as yet achieved the position of a proved hypothesis, but has stimulated mathematical inquiry. A number of very powerful researches have added to our knowledge of a most difficult branch of mathematics, which may yet furnish the basis of a theory which shall deduce the nature of matter and the phenomena of radiation from a single group of assumptions.

The theory of gases has been extended in both directions. The able attempt of Van der Waals to bring both vapour and liquid within the grasp of a single theory is complementary to the extension by Crookes, Hittorf, and Osborne Reynolds of our knowledge of phenomena which are best studied in gases of great tenuity.

The gradual expansion of thermodynamics, and in general of the domain of dynamics from molar to molecular phenomena, has been carried on by Willard Gibbs, J. J. Thomson, and others, until, in many cases, theory seems to have outrun not only our present experimental powers, but almost any conceivable extension which they may hereafter undergo.

The pregnant suggestion of Maxwell that light is an electro-magnetic phenomenon has borne good fruit. Gradually the theory is taking form and shape, and the epoch-making experiments of Hertz, together with the recent work of Lodge, J. J. Thomson, and Glazebrook, furnish a complete proof of its fundamental hypotheses. The great development of the technical applications of electricity has stimulated the public interest in this science, and has necessitated a more detailed study of magnetism and of the laws of periodic currents. The telephone and the microphone have eclipsed the wonders of the telegraph, and furnish new means of wresting fresh secrets from Nature.

Science has become more than ever cosmopolitan, owing chiefly to the imperative necessity for an early agreement as to the values of various units for a common nomenclature, and for simultaneous observations in widely separated localities. International Conferences are the order of the day, and the new units which they have defined are based upon experiments by many first-rate observers in many lands, amongst whom the name o Lord Rayleigh stands second to none.

On the side of chemistry the periodic law of Mendeleeff has become established as a generalization of the first importance, and the extraordinary feat of foretelling the physical properties of an as yet undiscovered element has attracted to it the attention of the whole scientific world.

The once permanent gases are permanent no more. Dulong and Petit's law has found a complement in the methods of Raoult. The old doctrine of valency is giving way to more elastic hypotheses. The extraordinary progress of organic chemistry, which originated in the work and influence of Liebig and the Giessen school, has continued at an accelerated rate. The practical value of even the most recondite investigations of pure science has again been exemplified by the enormous development of the coal-tar industry, and by the numerous syntheses of organic products which have added to the material resources of the community.

The increase of our knowledge of the sun by means of localized spectroscopic observation; the application of photography to astronomy, and more recently still the extension and generalization of the nebular hypothesis are perhaps the most remarkable developments of those branches of science which relate to astronomy. Stars which no human eye will ever see are now known to us as surely as those which are clearly visible. The efforts to reduce nebulæ, comets, and stars under one common law, as various cases of the collision or aggregation of meteoritic swarms, and the striking investigations of Prof. Darwin on the effects of tidal action, and on the application of the laws of gases to a meteoritic plenum, give promise of a fuller knowledge of the birth and death of worlds.

In the biological sciences, the progress during the last twenty years has consisted chiefly in the firm establishment of the Darwinian doctrine, and the application of it and its subordinate conceptions in a variety of fields of investigation. The progress of experimental physiology has been marked by increasing exactitude in the application of physical methods to the study of the properties of living bodies, but it has not as yet benefited, as have other branches of biology, from the fecundating influence of Darwin's writings: hence there is no very prominent physiological discovery to be recorded. The generation of scientific men which is now coming to middle age has been brought up in familiarity with Mr. Darwin's teaching, and is not affected by anything like hostility or *a priori* antagonism to such views. The result is seen in the vast number of embryological researches (stimulated by the theory that the development of the individual is an epitome of the development of the race) which these twenty years have produced, and in the daily increasing attention to that study of the organism as a living thing definitely related to its conditions which Darwin himself set on foot. The marine laboratories of Naples, Newport, Beaufort, and Plymouth, have come into existence (as in earlier years their forerunners on the coast of France), and served to organize and facilitate the study of living plants and animals. The *Challenger* and other deep-sea exploring expeditions have sailed forth and returned with their booty, which has been described with a detail and precision unknown in former times. The precise methods of microscopic study by means of section-cutting—due originally to Stricker, of Vienna—have within these twenty years made the study of cell-structure and cell-activity as essential a part of morphology as it had already become of physiology. These, and the frank adoption of the theory of descent, have swept away old ideas of classification and affinities, and have relegated the Ascidian "polyps" of old days to the group of Vertebrata, and the Sponges to the Cœlenterates. The nucleus of the protoplasmic cell—which twenty years ago had fallen from the high position of importance accorded to it by Schwann—has, through the researches of Bütschli, Flemming, and Van Beneden, been reinstated, and is now shown to be the seat of all-important activities in connection with cell-division and the fertilization of the egg. The discovery of the phenomena of karyokinesis and their relation to fertilization will be reckoned hereafter as one of the most, if not the most, important of the biological discoveries of the past twenty years.

Apart from Darwinism, the most remarkable development of biological studies during these "twice ten tedious years" is undoubtedly the sudden rise and gigantic progress of our knowledge of the Bacteria. Though the foundations were laid fifty years ago by Schwann and Henle, and great advances were made by Pasteur and by Lister just before our period, yet it is within this span that the microscope and precise methods of culture have been applied to the study of the "vibrions," or "microbes," and the so-called "bacteriology" established. We now know, through the labours of Toussaint, Chauveau, Pasteur, and Koch, of a number of diseases which are definitely caused by Bacteria. We also have learnt from Pasteur how to control the attack of some of these dangerous parasites. Within these twenty years the antiseptic surgery founded by Sir Joseph Lister has received its full measure of trial and confirmation, whilst his opportunities and those of his fellow-countrymen for making further discovery of a like kind have been ignorantly destroyed by an Act of Parliament.

To particularize some of the more striking zoological discoveries which come within our twenty years, we may cite—the Dipnoous fish-like creature *Ceratodus* of the Queensland rivers, discovered by Krefft; the jumping wheel-animalcule *Pedalion*, of Hudson; the development and the anatomy of the archaic Arthropod Peripatus worked out by Moseley, Balfour, and Sedgwick; the Hydrocorallinæ of Moseley, an entirely new group of compound animals; the fresh-water jelly-fish *Limnocodium* of the Regent's Park lily-tank; the Silurian scorpion of Gotland and Lanarkshire; the protozoon Chlamydomyxa discovered by Archer in the Irish bogs; the Odontornithes and the Dinocerata of the American palæontologists; the intracellular digestion obtaining in animals higher than Protozoa, and the significance of the "diapedesis" of blood-corpuscles in inflammation, and the general theory of phagocytes due to Mecznikow; the establishment of the principle of degeneration as of equal generality with that of progressive development, by Anton Dohrn; the demonstration by Weismann and others that we have no right to mix our Darwinism with Larmarckism, since no one has been able to bring forward a single case of the transmission of acquired characters. Perhaps the attempt to purify the Darwinian doctrine from Lamarckian assumption will hereafter be regarded—whether it be successful or not—as the most characteristic feature of biological movement at the end of our double decade Its earlier portion was distinguished by the publication of some of Darwin's later works. Its greatest event was his death.

In botany, twenty years ago, the teaching in our Universities was practically sterile. In one of our earliest numbers, Prof. James Stewart defended with some vigour the propriety of intrusting botany to a lecturer at Cambridge who was also charged with the duty of lecturing on electricity and magnetism. It is startling to compare a past, in which botany was regarded as a subject which might be tacked on anywhere, with its present condition, in which there is scarcely a seat of learning in the three kingdoms which is not turning out serious work. The younger English school would be ungrateful if it did not acknowledge its debt to the eminent German teachers from whom it has derived so much in the tradition and method of investigation. Sachs and De Bary have left an indelible mark on our younger Professors. But it would be a mistake to suppose that English modern botany has simply derived from Germany. It has developed a character of its own, in which the indirect influence of Darwin's later work can be not indistinctly traced. There has been a gradual revolt in England, the ultimate consequences of which have still to be developed, against the too physical conception of the phenomena of plant life which has been prevalent on the Continent. Darwin, by his researches on insectivorous plants and plant movements from a purely biological point of view, prepared the way for this; Gardiner followed with a masterly demonstration of the physical continuity of protoplasm in plant tissues. This has thrown a new light on the phenomena studied by Darwin, and we need not, therefore, be surprised that his son, F. Darwin, has started what is virtually a new conception of the process of growth, by showing that its controlling element is to be sought in the living protoplasm of the cell, rather than in the investing cell-wall. On the whole, English botanists have shown a marked disposition to see in the study of protoplasm the real key to the interpretation of the phenomena of plant life. The complete analogy between the processes of secretion in animals and vegetables, established by Gardiner, and the essential part played by ferments in vegetable nutrition, illustrated by Green, are examples of the results of this line of inquiry. To Germany we owe a flood of information as to the function of the cell-nucleus, which it is singular has met with general acceptance but little detailed corroboration in this country.

In morphology a review would be ineffective which did not go somewhat deeply into detail. The splendid hypothesis of Schwendener, of the composite nature of lichens as a commensal union of Algæ and Fungi, has gradually won its way into acceptance. In England there is little of the first rank which calls for note except the researches of Bower on the production of sexual organs on the leafy plant in ferns without the intervention of an intermediate generation.

In vegetable physiology there seems a pause; the purely physical line of inquiry, as already suggested, seems to have yielded its utmost. The more biological line of inquiry has only yet begun to yield a foretaste of the results which will undoubtedly ultimately flow from it.

Something must be added as to systematic and geographical botany. The "Genera Plantarum" of Bentham and Hooker, the work of a quarter of a century at Kew, affords a complete review of the higher vegetation of the world, and has been accepted generally as a standard authority. To Bentham also we owe the completion of the "Flora Australiensis," the first complete account of the flora of any great continent.

In geographical botany, perhaps the most interesting results have been the gradual elaboration of a theory as to the distribution of plants in Africa, and the botanical exploration of China, of the vegetable productions of which, twenty years ago, almost nothing was known.

In the classification of the lower plants, perhaps the most interesting result has been the happy observations of Lankester upon a coloured Bacterium, which enabled him to show that many forms previously believed to be distinct might be phases of the same life-history.

In geology probably the greatest advance has been in the application of the microscope to the investigation of rock structure, which has given rise to a really rational petrology. All except the coarser-grained rocks were only capable of being described in vague terms; with modern methods their crystalline constituents are determinable, however minute, and the conditions under which they were formed can be inferred.

It is, impossible, even in a brief review of this kind, to think only of what has been won, and to ignore the loss of leaders who were once foremost in the fray. In England three names which will never be forgotten have been removed from the muster-roll. Darwin, Joule, and Maxwell can hardly be at once replaced by successors of equal eminence. As the need arises, however, men will no doubt be found adequate to the emergency, and it is at least satisfactory to know that they will appeal to a public more capable than heretofore of appreciating their efforts.

The support afforded by the Governments of Western Europe to scientific investigation has been markedly increased within the period which we survey. France has largely extended her subsidies to scientific research, whilst Germany has made use of a large part of her increased Imperial revenue to improve the arrangements for similar objects existing in her Universities. The British Government has shown a decided inclination in the same direction: the grant to the Royal Society for the promotion of scientific research has been increased from £1000 to £4000 a year; whilst subsidies have been voted to the Marine Laboratory at Plymouth, to the Committee on Solar Physics, to the Meteorological Council, and quite recently to the University Colleges throughout the country, of which last it is to be hoped that a fair proportion will be devoted to the promotion of research rather than to the reduction of class fees.

Twenty years ago England was in the birth-throes of a national system of primary instruction. This year has seen the State recognition of the necessity of a secondary and essentially a scientific system of education, and the Technical Instruction Act marks an era in the scientific annals of the nation.

The extension of scientific teaching has gone on rapidly within and without our Universities. Twenty years ago the Clarendon Laboratory at Oxford was approaching completion, and was the only laboratory in the country which was specially designed for physical work. Now, not only has Cambridge also its Cavendish Laboratory, but both Universities have rebuilt their chemical laboratories, both have erected buildings devoted to the study of biology, and the instruction of students in both zoology and botany has taken a characteristic practical form which we owe to the system of concentrating attention on a series of selected "types" introduced by Rolleston and by Huxley. Oxford has been furnished with an astronomical observatory by the liberality of Warren De la Rue, and Cambridge has accepted the noble gift of the Newall telescope. Nor have such proofs of the vitality of science been confined to the Universities.

Twenty years ago the Owens College was a unique institution: now, united with two thriving Colleges in Leeds and Liverpool, it forms the Victoria University; while science is studied in appropriate buildings in Birmingham, Newcastle, Nottingham, and half a dozen towns beside.

A race is thus springing up which has sufficient knowledge of science to enforce due recognition of its importance, and public opinion can now, far more than in the past, be relied on to support its demands. Fortunately, too, these can be authoritatively expressed. The Royal Society wields, if it chooses to exercise it, an enormous power for good. Admitted on all hands to be the supreme scientific authority in this country, its decisions are accepted with a deference which can spring only from respect for the knowledge and scrupulous fairness by which they are dictated. If sometimes it moves slowly, *pur se muove*, and it is delightful to turn from the babble of the politicians to the study of an institution which does its work well, and perhaps too noiselessly. But even the House of Commons, hitherto ignorant and therefore apathetic in matters scientific, is awakening to the fact that there are forces to be reckoned with and impulses to be stimulated and controlled which are of more enduring import to the national welfare than mere party politics. And the people, too, are beginning to see that it is to the economic working of these forces, and to the right direction of these impulses, that their representatives are bound to give attention. True it is that another generation may possibly pass away before either the House of Commons or even Ministers are sufficiently instructed in science to recognize fully their responsibility in this direction.

Whatever, then, the future may bring, the last twenty years have been characterized by progress both steady and rapid. The tide flows on with no sign of check, and we accept the success of NATURE in no spirit of self-gratulation, but as a straw by which the speed of the current may be gauged.

MODERN VIEWS OF ELECTRICITY.

Modern Views of Electricity. By Oliver J. Lodge, D.Sc., LL.D, F.R.S. (London: Macmillan and Co., 1889.)

IN this interesting book Prof. Lodge gives a very lively and graphic account of many of the most recent speculations about the nature of electrical phenomena. A work with this object was urgently needed, as the method of regarding these phenomena given in popular treatises on electricity is totally different from that used by those engaged in developing the subject.

The attention called by Faraday and Maxwell to the effects produced by and in the medium separating electrified bodies has had the effect of diverting attention from the condition of the charged bodies in the electric field to that of the medium separating them, and it is perhaps open to question whether this of late years has not been too much the case. To explain the effects observed in the electric field we should require to know the condition not only of the ether, but also of the conductors and insulators present in it; just as a complete theory of light would include the state of the luminous bodies as well as of the ether transmitting the radiations excited by them. Since matter is more amenable to experiment than the ether, it seems most probable that we shall first gain an insight into the nature of electricity from a study of those cases where matter seems to play the chief part—such as in the electric discharge through gases, and the phenomena of electrolysis—rather than from speculations, however interesting, as to what takes place in the ether when it is transmitting electrical vibrations. Prof. Lodge, however, in the work under consideration, devotes most of his space to the consideration of the ether. In his preface he says, "Few things in physical science appear to me more certain than that what has so long been called electricity is a form, or rather a mode, of manifestation of the ether;" and he proceeds to give precision to this somewhat vague statement by developing a theory that electricity is a fluid, and a constituent of a very complex ether. In the first few chapters he supposes that all insulators, including the ether, have a cellular structure the cells being filled with a fluid which is electricity, and which is not able to get from one cell to another unless the walls of the cells are broken down; in conductors, however, there are channels between the cells, so that the electricity is able to flow more or less freely through them. A flow of this fluid is an electric current. But if this is the case, anything which sets the ether in motion will produce an electric current. Now, Fizeau's experiments show that moving bodies carry the ether with them to an extent depending on their index of refraction; so that a disk made of glass or other refracting substance, if set in rapid rotation about an axis through its centre, and at right angles to its plane, ought to act as if currents were circulating in the disk, and produce a magnetic field around it. In order to avoid the allied difficulty that nothing has ever been observed which indicates that a magnet or a current flowing through a coil possesses gyroscopic properties, Prof. Lodge assumes, in subsequent chapters, that the fluid in the cells of the ether is a mixture of two fluids, and that these two fluids are positive and negative electricity: and that, in order to exhibit any electrical effect, the compound fluid has first to be decomposed into positive and negative electricity by the application of an electromotive force. A current of electricity, on this view, consists of the flow of equal quantities of positive and negative electricity in opposite directions. Thus this, the most "modern view of electricity," is in its most important features almost identical with the old two-fluid theory published by Symmer in 1759. We confess we do not think the theory in its present form advances the science of electricity much: it does not suggest new phenomena, nor does it lend itself readily to explain the action of matter in modifying electrical phenomena; it demands, too, a very artificial ether. It would seem that the first steps required to make a theory of this kind a real advance on the old two-fluid theory would be the discovery of a structure for the ether, which would possess the same kind of properties as the mixture of the two electricities on that theory. A great deal, too, is left indefinite in the theory: thus, for example, we are not told whether for a given current these streams are moving slowly or with prodigious velocities. In fact, there is throughout the book rather a want of definite conclusions, and this is rather hidden by the vigorous style in which Prof. Lodge writes: he develops his ideas in such an enthusiastic and interesting way that on the first reading they seem to be a good deal more definite than they prove to be on calmer reflection.

But whatever may be thought of Prof. Lodge's theory of electricity, there can be, we think, no two opinions of the value of the numerous models illustrating the properties of electrical systems which he has invented. These must prove of the greatest assistance in enabling the student to gain a clear and vivid idea of electrical processes, and ought to be largely employed by all teachers of electricity.

In a work dealing so briefly with such a multitude of different and difficult subjects it is natural that there should be many statements to which exception might be taken. Prof. Lodge disarms criticism by his frank admission of this; sometimes, also, by an amusing vagueness of statement: thus, on p. 206, in speaking of the condition of the ether inside a strongly-magnetizable substance, he says: "Perhaps it is that the atoms themselves revolve with the electricity; perhaps it is something quite different." There are, however, some statements of a less theoretical kind which seem to us likely to mislead the student. Thus it is stated that the amount of the Peltier effect shows that the difference of potential between zinc and copper is only a few micro-volts. The Peltier effect, however, without further assumption, cannot tell us anything about the absolute magnitude of the difference of potential between the metals; it can only give us the value of the temperature coefficient, which is equal to the Peltier effect divided by the absolute temperature. Then, again, the pyro-electricity of tourmaline is explained by the unilateral conductivity of a tourmaline crystal whose temperature is changing, discovered by the author and Prof. Silvanus Thompson. If this unilateral conductivity is regarded as proving the existence of an electromotive force in a crystal which is increasing or decreasing in temperature, the explanation is valid, but in the text nothing is said about an electromotive force, and the student might be led to infer that a mere difference in resistance could explain pyro-electricity. The way in which a current flows past an insulating obstacle, the lines of flow closing in on the obstacle, and leaving nothing corresponding to "dead water" behind it, is given as a proof that the electric current has no mechanical momentum; but unless the corners of the obstacle were infinitely sharp, a slowly-moving fluid might flow in the same way as electricity, even though it possessed inertia, so that the proof is not conclusive. It is also stated that the effects on light produced by a magnetized body, discovered by Dr. Kerr, of Glasgow, have been deduced by Prof. Fitzgerald from Maxwell's theory of light. As a matter of fact, however, the results deduced from this theory by Fitzgerald do not coincide with those observed by Dr. Kerr and Prof. Kundt. The production in an unequally-heated conductor of an electromotive force is explained by supposing the atoms in such a body to be moving faster in one direction than the opposite, and therefore, since they are supposed to drag the ether with them, producing a flow of ether in the direction in which they are moving fastest; but, on the dualistic theory of electricity adopted in this book, this ether stream would consist of equal quantities of positive and negative electricity moving in the *same* direction, and this would not produce any electrical effect.

At the end of the book are three popular lectures delivered by Prof. Lodge, the first on the relation between electricity and light, the second on the ether and its functions, and the third his admirable one at the Royal Institution, on the discharge of a Leyden jar, which is a model of what such a lecture ought to be.

Taken as a whole, we think that the book is one which ought to be read by all advanced students of electricity; they will get from it many of the views which are guiding those who are endeavouring to advance that science, and it is so stimulating that no one can read it without being inspired with a desire to work at the subject to which it is devoted.

THE CALCULUS OF PROBABILITIES.

Calcul des Probabilités. Par J. Bertrand. (Paris: Gauthier-Villars, 1889.)

"EVERYBODY makes errors in Probabilities at times, and big ones," writes De Morgan to Sir William Hamilton. M. Bertrand appears to form an exception to this dictum, or at least to its severer clause. He avoids those slips in the philosophical part of the subject into which the greatest of his mathematical predecessors have fallen. Thus he points out that, in investigating the "causes" of an observed event, or the ways in which it might have happened, by means of the calculus of probabilities, it is usual to make certain unwarranted assumptions concerning the so-called *a priori* probability of those causes. Suppose that a number of black and white balls have been drawn at random from an urn, and from this datum let us seek to determine the proportion of black and white balls in the urn. It is usual to assume, without sufficient grounds, that *a priori* one proportion of balls, one constitution of the urn, is as likely as another. Or suppose a coin has been tossed up a number of times, and from the observed proportion of heads and tails let it be required to determine whether and in what degree the coin is loaded. Some assumption must be made as to the probability which, prior to, or abstracting from, our observations, attaches to different degrees of loading. The assumptions which are usually made have a fallacious character of precision.

Again, M. Bertrand points out that the analogy of urns and dice has been employed somewhat recklessly by Laplace and Poisson. It is true that the ratio of male to female births has a constancy such as the statistics of games of chance present. But, before we compare boys and girls to black and white balls taken out at random from an urn, we must attend not only to the average proportion of male to female births, but also to the deviations from that average which from time to time or from place to place may be observed. The analogy of urns and balls is more decidedly inappropriate when it is applied to determine the probable correctness of judicial decisions. The independence of the judges or jurymen which the theory supposes does not exist.

> "Quand un juge se trompe il y a pour cela des raisons: il n'a pas réellement mis la main dans une urne où le hazard l'a mal servi. Il a ajouté foi à une faux témoignage, le concours fortuit de plusieurs circonstances a éveillé à tort sa défiance, un avocat trop habile l'a ému, de hautes influences peutêtre l'ont ébranlé. Ses collègues ont entendu les mêmes témoins, on les a instruits des mêmes circonstances, le même avocat a plaidé devant eux, on a tenté sur eux la même pression."

With equal force does M. Bertrand expose the futility of the received reasoning by which it is pretended to determine the probability that the sun will rise to-morrow from the fact that it has risen so many days in the past.

These reflections are just and important; but their value is somewhat diminished by the fact that they have been, for the most part, made by previous writers with whom our author seems unacquainted. Thus Prof. Lexis has more carefully considered the extent of the error committed by Laplace and Poisson in applying to male and female births and other statistics rules derived from games of chance. The fundamental principles of Probabilities have been more fully explored by Dr. Venn. M. Bertrand, like Laplace, starts by defining the probability of an event as the ratio of the number of favourable cases to the number of possible cases. He does not explain what constitutes a "favourable case"—that, when a die is thrown, the probability of obtaining the 3 or 4 is one-sixth, because as a matter of fact each side in the long run turns up once out of six times. Accordingly, when he argues that in a great number of trials each event is most likely to occur with a frequency corresponding to its probability, he lays himself open to the charge of circularity which Dr. Venn has brought against Bernouilli's theorem. Without pronouncing on this delicate question, we may safely say, with respect to the first principles of the subject, that no point which has been left obscure by Dr. Venn has been cleared up by M. Bertrand.

It is with respect to the purely mathematical portion of the calculus, or that part of its metaphysics which is inextricably mixed with mathematics, that we expected and have found most assistance from M. Bertrand. Hitherto the study of Probabilities has been barred by the dilemma which M. Bertrand thus states:—

> "On ne peut bien connaître le calcul des probabilités sans avoir lu le livre de Laplace; on ne peut lire le livre de Laplace sans s'y préparer par les études mathématiques les plus profondes."

Much of Laplace's analysis which must have affected many eager students like stickjaw has been simplified by M. Bértrand. He is in general more readable than Poisson. Several of the theorems which he gives seem to be new. His methods of determining from a given set of observations the characteristic, or *modulus*, appertaining to the source of error are specially interesting.

M. Bertrand's mathematical power enables him to carry the torch of common-sense to those perplexed parts of the subject where less qualified critics, awed by the imposing mass of symbols, have hesitated to differ from Laplace or Poisson. Of this kind is the simultaneous determination of several quantities from a great number of equations. When Laplace computes that the odds are a million to one against the occurrence of an error of assigned magnitude in the determination of Jupiter's mass, M. Bertrand shows reasons for suspecting the accuracy of such computations. In fact, he carries out Poinsot's witty direction:

> "Après avoir calculé la probabilité d'une erreur il faudrait calculer la probabilité d'une erreur dans le calcul."

The true import and proper application of the theory of errors of observation are thus well expressed:—

> "On peut accepter sans crainte le résultat, mais il est téméraire d'évaluer en chiffres la confiance qu'il doit inspirer."

M. Bertrand teaches with authority—and not like those who have not followed the higher mathematical reasonings of the calculus—in what spirit its conclusions should be accepted.

Still, even with regard to those parts of the subject where a first-rate mathematician has so great an advantage, we venture to think that the work would have been much more valuable if the writer had taken the trouble to acquaint himself more fully with what his predecessors had done. For example, in discussing the reasons for taking the arithmetic mean of a set of observations (presumed to be equally good) relating to a single quantity, M. Bertrand does not dwell on the argument that the probability-curve —with which the arithmetic mean is specially correlated—is apt to represent the grouping of errors for this reason, that an error may be regarded as a function of a great number of elements each obeying some definite law of facility, and that the values of such a function conform to the probability-curve. It is true that Laplace, from whom this argument may be derived, has not himself used it very directly. But in a writer on the method of least squares we may expect some conversance with more recent works, in particular with Mr. Glaisher's classical paper in the Memoirs of the Astronomical Society (London). Moreover, Laplace does employ the mathematical theorem which we have indicated, not indeed to prove that the law of facility for errors of observation in general is the probability-curve, but that, whatever that law of facility be, the most advantageous combination is a certain linear function. A treatise in which this celebrated argument is not discussed cannot be regarded as exhaustive. But it is remarkable that with respect to the combination of observations, M. Bertrand seems to defer more to Gauss than to his own eminent countryman.

M. Bertrand has indeed slipped in a doctrine for which the authority of Laplace may be quoted, that in choosing the best combination of a set of observations "there is an essential difference between the most probable value of a quantity and the value which it is best to adopt" (Bertrand, Art. 138); the latter being the mean (first power) of the observations (Art. 155)—which M. Bertrand rather awkwardly terms "la valeur probable." M. Bertrand does not seem to realize the gravity of the assumption which is contained in the latter clause. Later on he employs Gauss's criterion of erroneousness—namely, the mean square of error. But the ground, nature, and relation of these two principles are not very clearly explained by the writer. With respect to the philosophical foundation of the method of least squares he has not superseded the necessity of studying Laplace.

With these reservations, M. Bertrand's work may be regarded as one of the most complete treatises on the subject. Nowhere else are the two elements so peculiarly combined in the science of Probabilities—commonsense and mathematical reasoning—to be found existing together in such abundance. F. Y. E.

ARGENTINE ORNITHOLOGY.

Argentine Ornithology. By P. L. Sclater, Ph.D., F.R.S., and W. H. Hudson, C.M.Z.S. Vol. II. (London: W. H. Porter, 1889.)

THE completion of this important work is an event of considerable importance to every lover of neotropical zoology, and the authors have both performed their parts well, while the ten plates by Mr. Keulemans are beautifully drawn and admirably coloured. Among the increasing number of Englishmen who settle in the Argentine Republic, there are sure to be many who will pursue natural history studies, and to all such a well-executed book like the present will be invaluable. The joint authors of the work are happy in their association, for while Dr. Sclater brings to the work a vast experience, and a sound scientific knowledge of his subject, it is certain that never was there a better describer of the habits of birds than Mr. Hudson. Although of English parentage, he is a native-born Argentine, and he has grown up among the birds whose life and history he so well knows how to portray. In turning over the pages of this volume, we have found many interesting extracts which we should have liked to present to our readers, and we feel that we should not be doing justice to Mr. Hudson if we did not quote for their benefit one specimen of this naturalist's writing. He is describing the habits of the Carancho (*Polyborus tharus*):—

> "When several of these birds combine they are very bold. A friend told me that while voyaging on the Paraná River a black-necked Swan flew past him hotly pursued by three Caranchos; and I also witnessed an attack by four birds on a widely different species. I was standing on the bank of a stream on the Pampas watching a great concourse of birds of several kinds on the opposite shore, where the carcass of a horse, from which the hide had been stripped, lay at the edge of the water. One or two hundred Hooded Gulls and about a dozen Chimangos were gathered about the carcass, and close to them a very large flock of Glossy Ibises were wading about in the water, while amongst these, standing motionless in the water, was one solitary white Egret. Presently four Caranchos appeared, two adults and two young birds in brown plumage, and alighted on the ground near the carcass. The young birds advanced at once and began tearing at the flesh; while the two old birds stayed where they had alighted, as if disinclined to feed on half-putrid meat. Presently one of them sprang into the air and made a dash at the birds in the water, and instantly all the birds in the place rose into the air screaming loudly, the two young brown Caranchos only remaining on the ground. For a few moments I was in ignorance of the meaning of all this turmoil, when, suddenly, out of the confused black and white cloud of birds the Egret appeared, mounting vertically upwards with vigorous measured strokes. A moment later, and first one, then the other, Carancho also emerged from the cloud, evidently pursuing the Egret, and only then the two brown birds sprang into the air and joined in the chase. For some minutes I watched the four birds toiling upwards with a wild zigzag flight, while the Egret, still rising vertically, seemed to leave them hopelessly far behind. But before long they reached and passed it, and each bird as he did so would turn and rush downwards, striking at the Egret with his claws, and while one descended the others were rising, bird following bird with the greatest regularity. In this way they continued toiling upwards until the egret appeared a mere white speck in the sky, about which the four hateful black spots were still revolving. I had watched them from the first with the greatest excitement, and now began to fear that they would pass from sight and leave me in ignorance of the result; but at length they began to descend, and then it looked as if the Egret had lost all hope, for it was dropping very rapidly, while the four birds were all close to it striking at it every three or four seconds. The descent for the last half of the distance was exceedingly rapid, and the birds would have come down almost at the very spot they started from, which was about forty yards from where I stood, but the Egret was driven aside, and sloping rapidly down struck the earth at a distance of two hundred and fifty yards from the starting point. Scarcely had it touched the ground before the hungry quartette were tearing it with their beaks. They were all equally hungry no doubt, and perhaps the old birds were even hungrier than their young; and I am quite sure that if the flesh of the dead horse had not been so far advanced towards putrefaction they would not have attempted the conquest of the Egret. I have so frequently seen a pure white bird singled out for attack in this way, that it has always been a great subject of wonder to me how the two common species of snow-white Herons in South America are able to maintain their existence; for their whiteness exceeds that of other white waterfowl, while, compared with Swans, Storks, and the Wood-ibis, they are small and feeble. I am sure that if these four Caranchos had attacked a Glossy Ibis they would have found it an easier conquest; yet they singled out the egret, purely, I believe, on account of its shining white conspicuous plumage."

In his introduction Dr. Sclater gives a *résumé* of the number of genera and species inhabiting the Argentine Republic, and shows that the avifauna of that portion of South America belongs to the Patagonian sub-region. A little sketch-map would have been useful, to show the configuration of the country and the proportions of the mountain-ranges, as it is evident that a district which can boast of a Dipper, and be at the same time the home of two Cariamas, must possess elements of two very different avifaunæ. Some day, no doubt, an exact exploration, such as that now being undertaken in Mexico by Messrs. Salvin and Godman, will trace the limits of the avifaunæ of the Pampas and the mountain regions. If Mr. Hudson could only be induced to resume his work of exploration and visit the interior of the Argentine Republic, the results would be, we venture to say, of the first importance to science.

Dr. Sclater, we notice, draws his comparisons of the different orders of Argentine birds from the "Nomenclator Avium Neotropicalium" of 1873, which is rather ancient history. The statistics of American birds must have altered considerably since that date, if we may judge from the Tanagers alone, which numbered 302 species in 1873, and in 1886 had reached 377 in number, according to Dr. Sclater's own estimate. In dividing the Neotropical Region into the sub-regions he adopts the conclusions of Prof. Newton in the "Encyclopædia Britannica," but the names of one or two of them are changed. The boundaries seem to be extremely natural, according to our present state of knowledge, though we would scarcely consider the Central American sub-region (or the Transpanamic sub-region, as Dr. Sclater renames it) to be bounded on the north by Tehuantepec! The author probably intended to give only a general outline, for the northern boundaries of the Central American sub-region are much more elaborately defined in fact.

R. BOWDLER SHARPE.

OUR BOOK SHELF.

The Chemistry of the Coal-tar Colours. From the German of Dr. R. Benedikt. Translated, with Additions, by Dr. E. Knecht. Second Edition. (London: George Bell and Sons, 1889.)

DR. BENEDIKT'S little book is a standard treatise in Germany, where the literature of the coal-tar colours is fast becoming a most important branch of the general literature of applied chemistry; and Dr. Knecht has done excellent service in making the work more generally known to English readers by means of his translation. It is remarkable that, although England may be said to have originated the coal-tar colour industry, she has contributed comparatively little to the general literature of the subject. Practically, all the systematized information we possess has come to us through the medium of French and German manuals. A number of our chemists could be named who have communicated original memoirs on the constitution of organic colouring-matters to the recognized organs of chemical research, but their work is very special in its character, and appeals rather to the pure chemist than to the technologist, and hence is seldom read by the latter. The want of a good, sound, and comprehensive treatise on the subject of the coal-tar colour industry has, we think, not been without its influence on the development of this branch of applied organic chemistry in this country. Dr. Knecht's translation merits a place on the bookshelf of every person engaged in the manufacture and use of the so-called coal-tar colours.

A Bibliography of Geodesy. By J. Howard Gore, B.S., Ph.D. (Washington: Government Printing Office, 1889.)

THIS valuable work forms Appendix No. 16 to the 1887 Report of the United States Coast and Geodetic Survey, and is another example of the disinterested energy displayed by our Transatlantic cousins in scientific matters. With great perseverance, and at the cost of much time and trouble, Mr. Gore personally explored thirty-four of the principal libraries of America and Europe, and numerous minor libraries by proxy; and, in addition, he checked and completed many of his references by correspondence with the living authors of both continents. The extent of his labours is shown by the four hundred columns of references, and short remarks where the title alone is not sufficiently explanatory. An alphabetical arrangement is adopted, and this includes authors, abbreviations, and subjects.

It is gratifying to note that our own country, besides the assistance rendered by its libraries, lends its aid to such an important work in the shape of a manuscript supplement by Colonel Herschel to his pendulum bibliography, which was placed unreservedly at Mr. Gore's disposal, through the courtesy of the Royal Society. After the offers of publication made by various institutions, including the International Geodetic Association at Berlin, no further testimony to Mr. Gore's fitness for the work is needed, and the compiler is justly proud "to see the results of his labours issuing from an institution of his own country, which throughout the world is the recognized advance guard in geodetic science."

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Method of Quarter Squares.

I OMITTED any reference to Leslie in my review of Mr. Blater's table (NATURE, vol. xl. p. 573), as I have never supposed that he was an independent discoverer of the method, or an independent calculator of a table, of quarter squares. I have referred to his table in my Report on Mathematical Tables Brit. Assoc. Report, 1873, p. 23); and the passage quoted by Prof. Carey Foster (p. 593) is given in full in the preface to Mr. Blater's table. It seems to me that the words in question—"This application of a table of quarter squares, as it is derived from the simplest principles, might have readily occurred to a mathematician; yet I have nowhere seen it brought into practical use till, last summer, I met with, at Paris, a small book by Antoine Voisin, printed in 1817"—do not indicate an independent discovery; and this view is confirmed by the fact that, in the first edition of the "Philosophy of Arithmetic" (1817), Leslie makes no mention of quarter squares. It was only in the second edition (1820), after having seen Voisin's work in the previous year, that he added, at the end of the volume, an account of the method, and a table extending to 2000. The table was copied, I presume, from Voisin, as Leslie does not claim it as the result of his own calculation. In the British Association Report I have described it as "reprinted from Voisin," and have pointed out that it did not appear in the first edition. In the preface to Mr. Blater's letter it is described as "an extract from Voisin's table." Although we may, I think, infer, almost with certainty, that the table is only a reprint,[1] it is to be regretted that Leslie did not say so explicitly.

J. W. L. GLAISHER.

Trinity College, Cambridge, October 26.

Darwinism.

MR. ROMANES states that it is "absurd" to call his essay on physiological selection an elaborate (I said "laborious") attack upon Mr. Darwin's theory of the origin of species. In that essay I find these words (p. 345), "the theory of natural selection has been misnamed: it is not strictly speaking a theory of the origin of species"; and on p. 403, "the theory of physiological selection [*i.e.* Dr. Romanes's theory] has this advantage over every other theory that has ever been propounded on the origin of species"; and again, "the problem of the origin of species which, as shown in the preceding paper [viz. the laborious essay], his [Mr. Darwin's] theory of natural selection serves only in small part to explain."

On the other hand, Mr. Darwin entitled his great work, "The Origin of Species by means of Natural Selection, or the preservation of favoured races in the struggle for life." He considered his theory of natural selection to be a theory of the origin of species. Mr. Romanes says it is not. I say that this is an attack on Mr. Darwin's theory, and about as simple and direct an attack as possible. Why Mr. Romanes wishes us to believe that he did not attack Mr. Darwin's theory it is difficult to conceive. That he should hope to persuade anyone that it is absurd to call his essay an attack on Mr. Darwin's theory when this is what it distinctly professes to be is curious. I trust you will not permit an empty discussion on this matter, but leave it to your readers to find out by reference to the Proc. Linn. Soc., vol. xix., where the absurdity exists.

E. RAY LANKESTER.

42 Half-moon Street, November 1.

Record of British Earthquakes.

WILL you allow me to ask your readers to help me in compiling notes of the earthquakes felt in this country during the present and following years?

Mr. Mallet's great Catalogue of all recorded earthquakes ends, as is well known, with the year 1842. Previously to this, Mr. David Milne had published a series of papers on the earthquakes of Great Britain in the *Edinburgh New Philosophical Journal* (vols. xxxi. to xxxvi. for the years 1841-44). These papers, which are of very great value, bring down our record to the end of August 1843. In recent years we have had the Catalogues of Prof. J. P. O'Reilly (Trans. Roy. Irish Acad., vol. xxviii. pp. 285-316 and 489-708) and the late Mr. W. Roper (published by T. Bell, *Observer* Office, Lancaster). The latter is a useful chronological list of shocks felt during the Christian era, down to February 10, 1889; but, except in a few cases, it is little more than a list. Prof. O'Reilly's important catalogues are arranged alphabetically according to the localities affected, and do not pretend to give detailed information with reference to the shocks themselves.

To make our seismic record more complete, I propose, therefore, to compile a descriptive list of British shocks noticed in newspapers and scientific journals from the time at which Mr. Milne's Catalogue closes down to the end of the year 1888; and I should be very grateful if your readers can in any way help me in this work.

What I wish particularly to ask for, however, is information relating to the shocks of the present and future years. For our knowledge of British earthquakes we must at present rely to a great extent on newspaper accounts; and these accounts, which for some points are fairly trustworthy, become difficult of access in after years. If any of your readers are willing to assist me in preserving these notices in a convenient and systematic form, may I ask if they would be good enough to send, to the address below, the names and dates of newspapers, and more especially local ones, in which any descriptions, however short, are given of British shocks? It is hardly necessary to say that any other notes, communicated by those who have felt the shocks or observed their effects, would be of great value, and would be most thankfully received.

The days are past for compiling earthquake catalogues for the

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[1] After quoting the full title of Voisin's table, Leslie refers to his own table as "the specimen which I have given."

whole surface of the earth, and the value of an attempt at such a task would now be extremely doubtful. But for limited districts, like this country, the case is very different. It would indeed be difficult to over-estimate the value of a seismic record which can claim any approach to completeness for a definite earthquake area, however feeble the shocks which visit it may be.

I may add that I hope shortly to publish some notes or directions for the study of earthquakes, with special reference to those which occur in this country. CHARLES DAVISON.

38 Charlotte Road, Birmingham, October 10.

Effects of Lightning.

I HAVE known of the following case since July last, but owing to absence from this place have only been able to get particulars during the last few days.

During the terrific storm of the 12th of July last, a labourer's cottage was struck by lightning at Leagrave, near here. The lightning descended, according to an eye-witness's report, like a "spout of fire," and struck and descended the chimney, which it destroyed. In the room below there was an old shepherd, an invalid woman, a child, and a shepherd's dog. The shepherd was sitting in a chair leaning on a stick, a kettle was boiling on the fire, and the door was open. The lightning entered the room simultaneously by the chimney and an adjoining window. The window was utterly destroyed, and the kettle was thrown from the fire across the room, the stick on which the shepherd was leaning was torn from his hand and also thrown across the room, the lightning entered a cupboard containing glass and crockery and destroyed every article, and plaster was torn from the walls. The man and woman remained unhurt, but the child was thrown down and its knees stiffened. The dog was struck perfectly stiff, "like a log of wood," and was considered dead. The room seemed full of fire, water, and sulphur, and the occupants said the smell of sulphur was so strong that they would certainly have been suffocated had it not been for the open door. After the storm had abated, the dog, with all its limbs stiff, was laid in a barn, where it very slowly and partially recovered. It long remained both deaf and blind, and was entirely dependent upon smell for its recognition of persons and things. To the present day it has not entirely recovered its injured senses.

Dunstable. W. G. S.

Electrical Cloud Phenomenon.

A SHORT description of a curious cloud appearance observed by me this summer may be of interest to your readers. It was noticed in Kiushu, the southernmost of the three great islands of Japan, early in July, at a distance of ten or twelve miles from the sea.

The season had been, and was, after the time of the observation, an exceptionally rainy one, severe floods being produced in almost all parts of the country, but it was not raining in the place where I made the observation at that particular time. Time shortly after midday, thermometer about 80° F.

The sky was clear overhead, but there was a great bank of heavy "thunderous" looking clouds to the south. It is most difficult to judge even approximately of the distance of clouds, but these might be from one to two miles off; the lower edge was represented by a very nearly straight line, and there was an amount of blue sky visible under the clouds that would perhaps subtend from 10° to 15°.

My attention was attracted to a sort of "tail" of cloud stretching itself downwards from the straight under side of the cloud-bank. It gradually extended till it reached some two-thirds of the distance from the cloud to the earth. It remained of about constant length for a little over ten minutes, the lower end continually waving about in a most curious way, giving the impression almost that it was feeling for something.

Quite suddenly the filament of cloud straightened itself out, and extended itself towards the earth. The lower end became so very thin that, from the distance, it was impossible to see whether it actually made contact with the earth or not, but I have not the smallest doubt that it did, and that a silent discharge took place at the time. There was certainly no sound heard. Immediately after the contact the filament rapidly drew itself up to the cloud, and was incorporated with it. Almost immediately after this, whether as a mere coincidence or not I cannot tell, the cloud discharged a great amount of rain. W. K. BURTON.

Imperial University, Tokio, Japan.

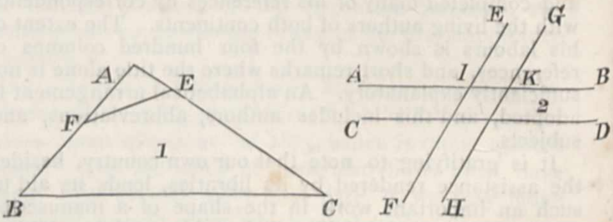
P.S.—The appearance was not unlike the illustrations of "water-spouts" that I have seen, but there was no whirling motion such as is always described as accompanying these, nor, indeed, was there any evidence of violent disturbance of any kind at all.

The Use of the Word Antiparallel.

THE following note on the use of the word antiparallel may prove of interest to the readers of NATURE.

In the second edition of "A New Mathematical Dictionary" by E. Stone, F.R.S. (London, 1743), appears a short article on antiparallels, the whole of which I will quote:—

"Antiparallels, are those lines, as FE, BC, that make the same angles AFE, ACB, with the two lines AB, AC, cutting them, but contrary ways, as parallel lines that cut them. But Mr. Leibnitz, in the *Acta Erudit.*, An. 1691, p. 279, calls antiparallels those lines (see Fig. 2) as EF, GH, which cut two parallels AB, CD; so that the outward angle AIF, together with the inward one AKH, is equal to a right angle. When the sides AB, AC, of a triangle, as ABC (Fig. 1), are cut by a line EF antiparallel to the base BC, the said sides are cut reciprocally proportional by the said line EF; that is, AF : BF : : EC : AE, the triangles AFE, ABC being similar or equiangular."



The error in regard to the ratios of the segments of the sides is the same as the one noted in Hutton's "Miscellanea Mathematica," as quoted by Mr. Langley. I have no doubt that earlier instances of the use of this word can be found, and I would like to know whether the word is used in the first edition of "Stone's Dictionary." W. J. JAMES.

Wesleyan University, Middletown,
Conn. U.S.A., October 15.

Fossil Rhizocarps.

IN Bennet and Murray's "Cryptogamic Botany," at p. 115, I am surprised to find in a reference to my paper on "Fossil Rhizocarps" (in *Bull. Ac. Sciences, Chicago*) the statement, with reference to the macrospores of *Protosalvinia*, that "inasmuch as they are borne on Lepidodendron scales this reference is inadmissible." Now no such fact has come to my knowledge, and on the contrary these bodies are found inclosed in cellular sporocarps like those of Salvinia, and are so described in the paper in question. If anyone has found them on "scales of Lepidodendron," the authority should have been stated.

Montreal, October 15. J. WM. DAWSON.

Specific Inductive Capacity.

ON p. 669 of Ganot's "Physics" (eleventh edition) the following statement is found:—"At a fixed distance above a gold-leaf electroscope, let an electrified sphere be placed, by which a certain divergence of the leaves is produced. If now, the charges remaining the same, a disk of sulphur or of shellac be interposed, the divergence increases, showing that inductive action takes place through the sulphur to a greater extent than through a layer of air of the same thickness."

If this statement were correct, there should be less electric action on the side of the ball furthest from the electroscope when the dielectric is interposed. To test this I arranged an experiment as follows:—

The knob of a charged Leyden jar was placed midway between two insulated plates of metal, each plate being in connection with an electroscope. The leaves of each electroscope now diverged to an equal extent.

A plate of ebonite was now placed between the knob of the jar and one of the plates. If the statement above quoted is correct, the leaves of the electroscope in connection with this plate should show an increased divergence, but the reverse effect was observed. *The leaves partially collapsed.* In all experiments that I have made by inserting dielectrics between a charged body and an electroscope, less electric action has been the result. If while the charged ball be near the electroscope the plate of it be touched with the finger, the leaves collapse, and on removing the finger and then the charged ball they again diverge.

Now let a dielectric be placed between the ball and the electroscope, touch the latter, and remove the finger and ball as before, and much greater divergence will be produced. In both cases the electroscope is charged by induction. Without putting the electroscope to earth, I fail to see theoretically why any greater divergence should occur. I suppose someone must have made the experiment as quoted, but if a greater effect was produced it must have been caused by the substance used for a dielectric being charged itself. I have found very great difficulty in preventing plates of ebonite, paraffin, sulphur, &c., becoming electrified when placed near a charged body.

I should like to know if anyone has experimented in this direction, because either the text-books or myself must be wrong.

In Guthrie's book (p. 101) there is a statement similar to Ganot's. W. A. RUDGE.

Who discovered the Teeth in Ornithorhynchus?

ON returning from Central Arizona, where I have been engaged in biological explorations, I find upon my desk an important paper entitled "On the Dentition of Ornithorhynchus," by my friend Mr. Oldfield Thomas, Curator of Mammals in the British Museum (see Proc. Royal Soc., vol. xlvi, 1889, 126–131, pl. 2).

The opening sentence of this paper is as follows: "At the meeting of the 9th of February, 1888, Mr. E. B. Poulton communicated to this Society the first discovery of the presence of teeth in *Ornithorhynchus*, a discovery which naturally awakened extreme interest throughout the scientific world." A few lines further on Mr. Thomas continues: "The grand fact of the presence of teeth in Monotremes, and their mammalian nature, are discoveries on which Mr. Poulton may well be congratulated."

From the above I infer that considerable stir has been made by the assumed new "discovery" that the young *Ornithorhynchus* has teeth.

If my British colleagues will turn to the masterly work of their illustrious countryman, Sir Everard Home, they will find in the second volume of his "Lectures on Comparative Anatomy" (published in 1814), no less than three beautifully engraved plates, containing eight figures, of the skull and mouth parts of Ornithorhynchus. Four of these figures show the teeth—two on each side of each jaw. The explanation accompanying Fig. 1, Tab. lix., is as follows: "A view of the upper jaw and palate, to show that there are two grinding teeth on each side." Fig. 2 is "a similar view of the under jaw."

Washington, D.C., October 12. C. HART MERRIAM.

ON THE HARDENING AND TEMPERING OF STEEL.[1]

I.

THE fact that the British Association meets this year at Newcastle no doubt suggested to the Council that it would be well to provide, for the first time since 1848, a lecture on a metallurgical subject. In that year a discourse was delivered at Swansea by Dr. Percy, one of the most learned metallurgists of our time, who has recently passed away, after having almost created an English literature of metallurgy by the publication of his well-known treatises, without which it would have been comparatively barren. It was to him that the country turned in 1851 when it became evident that our metallurgists must receive scientific training.

I know that it has occurred to many that the various problems involved in the "hardening and tempering of steel" must be incapable of adequate treatment in the brief limits of a discourse like this, while others will think that the details of the process, which is practised daily in thousands of workshops, are so well known that it is unnecessary to devote a lecture to the subject. It seemed to me that the entire question was the most important I could choose, partly because it will enable a large number of people who are engaged in industrial work, and who are not expected to think about it in a scientific way, to know how such facts as we shall have to examine have been dealt with by scientific investigators; while those of our members who do not consider that their thoughts or work are scientific in its strictest sense, may perhaps be interested to see how absolutely industrial progress depends upon the advancement of science. This consideration has led me to deal with the subject in a somewhat comprehensive way. The treatment of iron in its several forms is the thing that we as a nation do well. If it be true that national virtues are manifestly expressed in the industrial art of a people, we may recall the sentence in Mr. Ruskin's "Crown of Wild Olive" in which he says, "You have at present in England only one art of any consequence—that is, iron-working," adding, with reference to the manufacture of armour-plate, "Do you think, on those iron plates your courage and endurance are not written for ever, not merely with an iron pen, but on iron parchment?" It may be well, therefore, to consider what properties iron possesses which entitle its application to industrial use to specially represent the skill and patience of the nation.

In 1863, Lord Armstrong, in his address as President of this Association, expressed the hope "that when the time again comes round to receive the British Association in this town, its members will find the interval to have been as fruitful as the corresponding period," since the previous meeting in 1838, "on which they were then looking back." In one way at least this hope has been realized, for the efforts of the last twenty years have resulted in the development of an "age of steel." When the Association last met here, steel was still an expensive material, although Bessemer had, seven years before, communicated his great invention to the world through the British Association at its Cheltenham meeting. The great future in store for Siemens's regenerative furnace, which plays so important a part in the manufacture of steel, was confidently predicted in his Presidential address by Lord Armstrong, than whom no one was better able to judge, for no one had done more to develop the use of steel of all kinds.

Steel, we shall see, is modified iron. The name iron is in fact a comprehensive one, for the mechanical behaviour of the metal is so singularly changed by influences acting from within and without its mass, as to lead many to think, with Paracelsus, that iron and steel must be two distinct metals, their properties being so different. Pure iron may be prepared in a form as pliable and soft as copper, steel can readily be made sufficiently hard to cut glass, and notwithstanding this extraordinary variance in the physical properties of iron and certain kinds of steel, the chemical difference between them is comparatively very small, and would hardly secure attention if it were not for the importance of the results to which it gives rise. We have to consider the nature of the transformations which iron can sustain, and to see how it differs from steel, of which an old writer has said,[1] "Its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water, the hardness produced being greater in proportion as the steel is hotter and the water colder. The colours which appear on the surface of steel slowly heated direct the artist in *tempering* or reducing the hardness of steel to any determinate standard." There is still so much confusion between the words "temper," "tempering," and "hardening," in the writings of even very eminent authorities, that it is well

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[1] A Lecture delivered on September 13, by Prof. W. C. Roberts-Austen, F.R.S., before the members of the British Association.

[1] "The First Principles of Chemistry," by W. Nicholson, p. 312 (London, 1790).

to keep these old definitions carefully in mind. I shall employ the word tempering in the sense of softening, as Falstaff uses it when he says of Shallow :—

> "I have him already tempering between my finger and my thumb, and shortly will I seal with him." [1]

softening, that is, as brittle wax does by the application of gentle heat. *Hardening*, then, is the result of rapidly cooling a strongly heated mass of steel. *Tempering* consists in re-heating the hardened steel to a temperature far short of that to which it was raised before hardening: this heating may or may not be followed by rapid cooling. *Annealing* consists in heating the mass to a temperature higher than that used for tempering, and allowing it to cool slowly.

First, let the prominent facts be demonstrated experimentally.

[Three sword-blades of identical quality, made by an eminent sword-smith, Mr. Wilkinson, were taken. It was shown by bending one that it was soft; this was heated to redness and plunged into cold water, when it became so hard that it broke on the attempt to bend it. Another was bent into a bow, the arc of which was four inches shorter than the sword itself, a common test for "temper," and it sprang back to a straight line when the bending force was removed; this had been tempered. A third, which had been softened by being cooled slowly, bent easily and remained distorted.]

The metal has been singularly altered in its properties by comparatively simple treatment, and all these changes it must be remembered have been produced in a solid metal to which nothing has been added, and from which nothing material has been taken. The theory of this operation which I have just conducted has been laboriously built up, and its consideration introduces many questions of great interest both in the history of science, and in our knowledge of molecular physics. First as regards the history of the subject. The knowledge that steel might be hardened must have come to us from remote antiquity. Copper hardened with tin was its only predecessor, and it continued to be used very long after it was known that steel might be hardened. It would, moreover, appear that a desire to appreciate the difficulties of a people to whom cutting instruments of hard steel were unknown, seems to have induced experimenters in quite recent times to fashion implements of bronze, and a trustworthy authority tells us that "Sir Francis Chantry formed an alloy containing about 16 parts of copper, 2½ of zinc, and 2½ of tin, of which he had a razor made, and I believe even shaved with it." [2] The Greek alchemical manuscripts which have been so carefully examined by M. Berthelot give various receipts from which it is evident that in the early days the nature of the quenching fluid was considered to be all-important. There were certain rivers the waters of which were supposed to be specially efficacious. Pliny, who says that the difference between waters of various rivers can be recognized by workers in steel, also knew that oil might be used with advantage for hardening certain varieties of the metal. It is sad to think how many of the old receipts for hardening and tempering have been lost. What would we not give, for instance, for the records of the Gallic prototype of our Iron and Steel Institute, the "*Collegium Fabrorum Ferrariorum*," [3] a guild with similar aims, formed in the time of the Roman Republic, for the advancement of knowledge, for the good of the State, and not for that of its individual members? The belief, however, in the efficacy of curious nostrums and solutions for hardening steel could hardly have been firmer at any period than in the sixteenth century of our era. Shakespeare suggests that Othello's sword "of Spain" had been hardened in a cold stream for he says it had

> "the ice brook's temper";

but cold water was far too simple a material for many a sixteenth century artificer to employ, as is shown by the quaint recipes contained in one of the earliest books of trade secrets, which, by its title, showed the existence of the belief that the "right use of alchemy" was to bring chemical knowledge to bear upon industry. The earliest edition was published in 1531,[1] and the first English translation[2] in 1583, from which the following extracts may be of interest. "Take snayles, and first drawne water of a red die of which water being taken in the two firste moneths of haruest when it raynes," boil it with the snails, "then heate your iron red hote and quench it therein and it shall be hard as steele." "Ye may do the like with the blood of a man of xxx yeres of age, and of sanguine complexion, being of a merry nature and pleasaunt . . . . distilled in the middst of May." This may seem trivial enough, but the belief in the efficacy of such solutions survived into the present century, for I find in a work published in 1810 that the artist is prettily directed[3] "to take the root of blue lilies, infuse it in wine and quench the steel in it," and the steel will be hard; on the other hand, he is told that if he "takes the juice or water of common beans and quenches iron or steel in it, it will be soft as lead." I am at a loss to explain the confusion which has arisen from this source. As must always be the case when the practice of an art is purely empirical, such procedure was often fantastic, but it is by no means obsolete, for probably at the present day there is hardly a workshop in which some artificer could not be found with a claim to possess a quaint nostrum for hardening steel. Even the use of absurdly compounded baths, to which I have referred, was supported by theoretical views. Otto Tachen,[4] for instance, writing of steel in about the year 1666, says that steel when it is "quenched in water acquires strength because the light alcaly in the water is a true comforter of the light acid in the iron, and cutlers do strengthen it with the alcaly of animals," hence the use of snails. Again, Lemery[5] explains in much the same way the production of steel by heating iron in the presence of horns of animals.

I have dwelt so long on these points in order to bring out clearly the fact that the early workers attached great importance to the nature of the fluid in which hot steel was quenched, and they were right, though their theories may have been wrong. The degree of rapidity with which heat is abstracted from the steel during the operation of hardening is as important at the present day as it ever was. Roughly speaking, if steel has to be made glass-hard, ice-cold water, brine, or mercury, is used; if it has only to be made slightly hard, hot water or oil may be employed; while, as Thomas Gill[6] suggested in 1818, both "hardening" and "tempering" may be united in a single operation by plunging the hot metal in a bath of molten lead or other suitable metal, which will of course abstract the heat more slowly.

We must now trace the development of theories relating to the internal constitution of steel. The advent of the phlogistic school with the teaching of Becher and Stahl led to the view that iron gained phlogiston during its conversion into steel. By phlogiston we know that the early chemists really meant *energy*, but to them phlogiston was represented to be a kind of soul possessed by all metals,

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[1] King Henry IV, Part II., Act iv., Scene 3.

[2] "Engines of War," by H. Wilkinson, p. 194 (1841).

[3] "La Ferronnerie," par F. Liger, t. ii. p. 147 (Paris, 1875).

[1] "Rechter Gebrauch d. Alchimei," 1531. There were many English editions.

[2] "A profitable boke declaring dyuers approoued remedies," &c. (London, 1583). See Prof. Ferguson's learned paper "On some Early Treatises on Technological Chemistry," Phil. Soc., Glasgow, January 1886.

[3] "The Laboratory or School of Arts," 6th edition, 1799. p. 228. There is a later edition of 1810.

[4] "His Key to the Ancient Hippocratical Learning," p. 68 (London, 1690).

[5] "A Course of Chemistry," 2nd edition, 1686, p. 131.

[6] *Thomson's Annals of Philosophy*, xii., 1818, p. 58.

which they could lose by burning and regain by the process they called "revivification." "Hardness [in metals] is caused by the jeiunenese of the spirit and their imparity with the tangible parts," said Francis Bacon;[1] while, according to Stahl,[2] steel was merely iron possessing, in virtue of its phlogiston, the characteristics of a metal in a higher degree; and this view prevails in the writings of Henckel, Newmann, Cramer, Gellert, Rinman, and Macquer. This opinion survived with wonderful persistence, but it did not influence the teaching of Réaumur,[3] who, in 1722, was, so far as I know, the first to suggest a physical theory which has been in any way justified by modern research. He assumed that when steel was heated "sulphurs and salts" were driven out from the molecules, which he represents diagrammatically, into the interstitial space between them. The quenching of the steel and its sudden cooling prevented the sulphurs and salts from returning into the molecules, which were thus firmly cemented by the matter between them, and hard rigid steel was the result. In tempering, the sulphurs and salts partially returned into the molecules, and the metal became proportionately soft. I have elsewhere shown[4] that he used the Torricellian vacuum to demonstrate that the hardening of steel is not accompanied by the evolution of gas, and he concluded that "since the hardening of steel is neither due to the intervention of a new substance nor to the expulsion of air, it only remains to seek its cause in the changes occurring in its structure." Notwithstanding this, the phlogistic school were not daunted, and this brings me to the work of Torbern Bergman, the great Professor at the University of Upsala, who in 1781 showed[5] that steel mainly differs from iron by containing about $\frac{2}{10}$ per cent. of plumbago, while iron does not. Read in connection with modern research, his work seems wonderfully advanced. He was so forcibly impressed by the fact that the great difference in the mechanical properties of different specimens of iron is due to the presence of small quantities of impurity, and that the properties of iron do not vary, as he says, unless by chance the iron has gathered foreign matter, "*nisi forte peregrinum paullo uberius inhærat metallum.*" We find, even, the dawn of the view that under the influence of small quantities of foreign matter iron is, as he calls it, polymorphous, and plays the part of many metals. "*Adeo ut jure dici queat, polymorphum ferrum plurium simul metallorum vices sustinere.*"[6] Unfortunately he confounded the plumbago or carbon he had isolated with phlogiston, as did Rinman in 1782, which was strange, because, in 1774, the latter physicist had shown that a drop of nitric acid simply whitens wrought iron, but leaves a black stain on steel. Bergman tenaciously held to the phlogistic theory in relation to steel; it was inevitable that he should. The true nature of oxidation had been explained; no wonder that the defenders of the phlogistic theory should seek to support their case by appealing to the subtle and obscure changes produced in iron by such apparently slight causes. Bergman's view was, however, combated by Vandermonde, Berthollet, and Monge,[7] who showed in a report communicated to the Académie des Sciences, in 1786, that the difference between the main varieties of iron is determined by variation in the amount of carbon, and further that steel must contain a certain quantity of carbon in order that it might possess definite qualities. Bergman died in 1784, and the report to which I have referred is full of respect for "this grand chemist," as its authors call him, "whom science had lost too soon."

Kirwan's essay on phlogiston,[1] in which Bergman's views were defended, elicited a reply from Lavoisier himself, and brought down the French school in strength to contest almost the last position occupied by the believers in phlogiston.[2]

An entire lecture might be profitably devoted to Bergman's work. His was almost the first calorimetric research, and is specially interesting when taken in connection with the calorimetric investigations of Lavoisier and Laplace in 1780, and it is impossible to read it without feeling that in paying the just tribute to Lavoisier's genius Bergman has been overlooked. He desired to ascertain whether pure iron, steel, and cast iron contain the same amount of heat. He therefore attacked the materials with a solvent, and noted the heat evolved. He says the solvent breaks up the assemblage of the aggregation of molecules and forms other unions. If the new body demands more heat than the body which has been disunited, then the thermometer will fall. If, on the other hand, the degree of heat required is less, the environment will be heated, which will result in the rise of the thermometer. The modern development is that, when a chemical compound is formed, heat is evolved and energy is lost, but if one substance, say a metal, simply dissolves another, the solution is attended with absorption of heat, and the product when attacked by a suitable solvent should evolve practically the same amount of heat, but certainly not less than would be evolved by the individual metals present in solution.[3] This is specially interesting from its relation to the calorimetric work of Lavoisier and Laplace in 1780 and of Lavoisier in 1782, which led the latter to explain the nature of oxidation, and to show that a metal could be as truly "calcined" or oxidized by the action of a solution as by the action of air at an elevated temperature. Now that the importance of thermochemistry is beginning to be recognized in relation to industrial chemistry and metallurgy, it is to be hoped that Bergman's merits will be more fully considered. We are, however, mainly concerned with the fact that he taught us that the difference between iron and steel consists in the $\frac{2}{10}$ to $1\frac{1}{2}$ per cent. of carbon which steel contains. It was only natural that Black, writing in 1796, should have attributed the hardening of steel to the "extrication of latent heat"; "the abatement of the hardness by the temper" being due, he says, "to the restoration of a part of that heat."[4] Black failed to see that the work of Bergman had entirely changed the situation. The next step was made in France. It was considered necessary to establish the fact that carbon is really the element which gives steel its characteristic properties, and with this object in view, Clouet,[5] in 1798, melted a little crucible of iron, weighing 57·8 grammes, containing a diamond, weighing 0·907 gramme, and obtained a fused mass of steel (Fig. 1).

His experiment was repeated by many observers, but the results were open to doubt from the fact that furnace gases could always obtain access to the iron, and might, as well as the diamond, have yielded carbon to the metal.

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[1] "Sylva Sylvarum," 2nd edition, 1628, p. 215.

[2] "Fundamenta Chemiæ," Part 3, p. 451, quoted by Guyton de Morveau in the article "Acier," "Encyc. Méthodique," p. 421 (Paris, 1786).

[3] "L'art de convertir le fer forgé en acier," p. 321 *et seq.* (Paris, 1722).

[4] Proc. Inst. Mech. Engineers, October 1881, p. 706.

[5] "Opuscula Physica et Chemica," vol. iii. "De Analysi Ferri" (Upsala, 1783). A dissertation delivered June 9, 1781.

[6] "De Analysi Ferri," p. 4.

[7] "Histoire de l'Académie Royale des Sciences," 1786 (printed 1788), p. 32.

[1] R. Kirwan, "Essay on Phlogiston and the Constitution of Acids," p. 134 (1787).

[2] "Essai sur le Phlogistique," traduit de l'Anglois de M. Kirwan, avec des notes de MM. de Morveau, Lavoisier, de la Place, Monge, Berthollet, et de Fourcroy (Paris, 1788).

[3] See French translation of Bergman's work (Paris, 1783), p. 72. The question is, however, so important that I append the original Latin text:—"Menstruo laxatur compages molecularum, et nova formantur connubia, quæ, si majorem, quam diruta, figunt materiæ caloris quantitatem, in vicinia calor ad restituendum æquilibrium diminuatur oportet, et thermometri hydrargyrum ideo subsidet: si minorem, differentia liberatur et viciniam calefacit, unde etiam adscendit thermometri liquor; si denique nova connubia eamdem præcise quantitatem postulant, quod raro accidit, nulla in thermometro videbitur variatio."—Torberni Bergman, "Opuscula Physica et Chemica," vol. iii. p. 58, 1783 ("De Analysi Ferri").

[4] "Lectures on the Elements of Chemistry," vol. ii p. 505 (1803).

[5] Experiment described by Guyton de Morveau, *Ann. de Chim.*, xxxi. 1799, p. 328.

The carbon might have been presented to the iron in the form of a gas capable of yielding carbon, and this element would as surely have found its way into the steel.

Margueritte,[1] for instance, in 1865, repeated Clouet's experiment, and showed that, although carburization can be effected by simple contact of iron and carbon, it is nevertheless true that in the ordinary process of cementation the gas carbonic oxide plays an important part, which had until then been overlooked. The discovery by Graham,[2] in 1866, of the occlusion of carbonic oxide by iron, gave additional support to this theory. I am glad to remember that he intrusted the experiments to me.

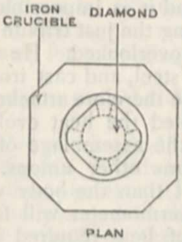

FIG. 1.—Plan of iron crucible and diamond from the drawing in Guyton de Morveau's paper. In the original, the diamond and the crucible are drawn, in plan, separately.

The question, however, of the direct carburization of iron by the diamond has never been doubted since 1815, when a working cutler, Mr. Pepys,[3] heated iron wire and diamond dust together and obtained steel, the heat being afforded by a powerful electric battery. I am anxious to make this absorption of carbon in the diamond form clear by this diagram (Fig. 2).

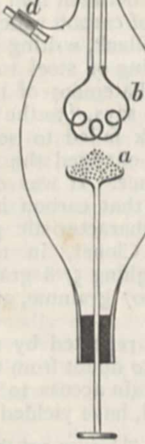

FIG. 2 represents a glass vessel which may either be rendered vacuous or may be filled with an atmosphere of gas through the tube *d*. An iron wire, *b*, placed between the terminals of a battery, *c*, *c'*, is heated to redness, and remains glowing until it is touched by pure diamond dust, which is effected by raising the cup *a*. The iron combines with the diamond dust and fuses.

Do not think for a moment that the steel owes its hardness to the passage of diamond into the iron, *as diamond*. I have repeated Margueritte's form of Clouet's experiment, using, however, a vacuum instead of an atmosphere of gas, and employing the form of apparatus shown in this diagram (Fig. 3). [The carburized iron which was the result of the experiment was thrown upon the screen.] The diamond by union with iron has passed partially at least to the other form of carbon, graphite, while treatment with a solvent which removes the iron shows that carbon has entered into intimate association with the iron, a fact which leads us to the next step in the study of the relations between carbon and iron.

Hempel[1] has shown that, in an atmosphere of nitrogen, iron appears to assimilate the diamond form of carbon more readily than either the graphitic or the amorphous forms, but directly carbon is associated with ***molten*** iron it behaves like the protean element it is, and the state which this carbon assumes is influenced by the rate of cooling of the molten mass, or even by the thermal treatment to which the solidified mass is subjected. Let me repeat, all are familiar with carbon in the distinct forms of diamond, graphite, and soot: all are alike carbon. It need not be considered strange, then, that carbon should be capable of being present in intimate association with iron, but in very varied forms.

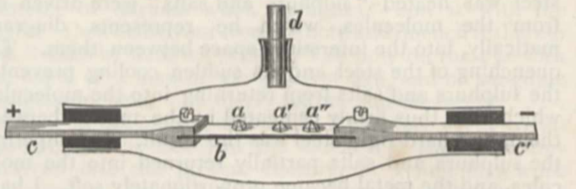

FIG. 3 represents an arrangement for heating the diamond and iron *in vacuo*. A strip of pure iron, *b*, is placed between two terminals, *c*, *c'*, which are connected with a dynamo. The vessel (of glass) is rendered vacuous by connecting the tube *d* with a Sprengel pump. The iron is then heated by the dynamo, and maintained glowing until all occluded gas is expelled from the iron, which is then allowed to cool *in vacuo*. Small pure diamonds, *a*, *a'*, *a''*, are then placed on the strip of iron through the orifice into which the tube *d* fits. The vessel is rendered vacuous, and when the iron is again heated in contact with the diamonds it fuses and combines with them.

Now the mode of existence of carbon in soft annealed steel is very different from that in which it occurs in hard steel. I believe that Karsten was the first to isolate, in 1827, from soft steel a true compound of iron and carbon. Berthier[2] also separated from soft steel a carbide of iron, to which he assigned the formula FeC; but to attempt to trace the history of the work in this direction would demand an entire lecture. I will only add that within the last few years Sir F. Abel has given much experimental evidence in favour of the existence in soft cold rolled steel of a carbide, Fe_3C, which he isolated by the slow solvent action of a chromic acid solution. His work has been generally accepted as conclusive, and has been the starting-point of much that has followed.

It will occur to you that the microscope should reveal wide differences between the structure of various kinds of iron and steel, and I am happy to be able to give you enlarged diagrams made from the drawings of Mr. Sorby, the eminent microscopist, which illustrated his very delicate investigations into the structure of steel.[3]

The point I am mainly concerned with is the existence of a substance which Sorby called the "pearly constituent" in soft steel. This pearly constituent is closely related to the carbide of iron, Fe_3C of Abel,[4] and is probably a mixture of Fe_3C and pure iron. I have diagrammatically indicated its presence in Fig. 4, which will enable me to summarize the work of many experimenters. The diagram (Fig. 4) will serve, for the purpose of illustration,

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[1] "Sur l'aciération," *Ann. Chim. et Phys.*, t. vi. [4]. 1865.
[2] Phil. Trans. Roy. Soc., 1866, pp. 399-439.
[3] *Ibid.*, 1815, p. 371.

[1] *Ber. der deutsch. chem. Gesellschaft*, vol. xviii. p. 998.
[2] *Ann. des Mines.* t. iii, 1833, p. 229.
[3] The reader must refer to the Journal of the Iron and Steel Institute, No. i., 1887, 255.
[4] Proc. Inst. Mech. Engineers, January 1883.

to indicate the appearance when soft, hardened, and tempered steel are respectively treated with a solvent which acts gently on the mass.

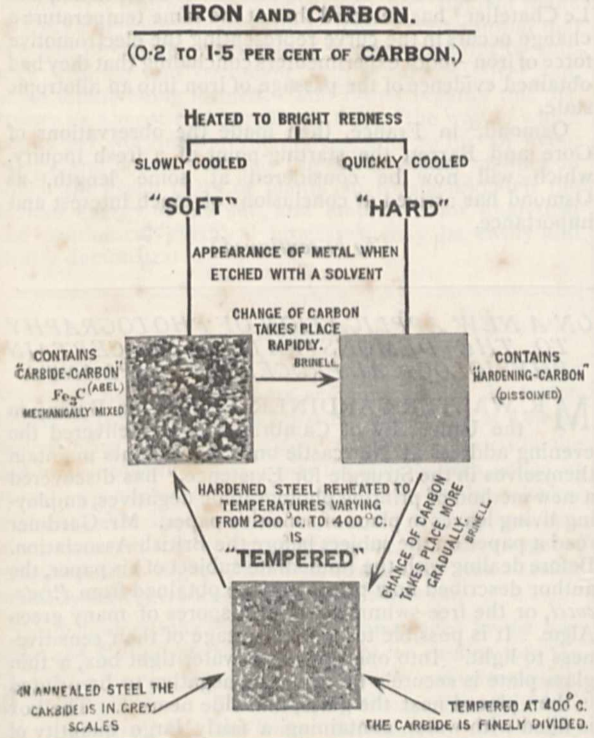

Fig. 4.

A study of the above diagram and of the admirable work of Ledebur[1] will show how complex the relations of carbon and iron really are, but, for the purposes of the present inquiry it may fairly be asked, Does a change in the "mode of existence" of carbon in iron sufficiently explain the main facts of hardening and tempering? It does not. It is possible to obtain by rapid cooling from a certain temperature steel which is perfectly soft, although analysis proves that the carbon is present in the form which we have recognized as "hardening carbon." No doubt in the hardening of steel the carbon changes its mode of existence, but we must seek some other theory to explain all the facts, and in order to do this we will turn to the behaviour of the iron itself.

In approaching this portion of the subject a few elementary facts relative to the constitution of matter must be recalled, and in doing so I must again appeal briefly to history. It is universally accepted that metals, like all elements, are composed of atoms of definite weights and volumes grouped in molecules. In order actually to transmute one metal into another it would be necessary to discover a method of attacking not the molecule but the *atom*, and of changing it, and this, so far as is known, has not yet been done; but it is possible, by influences which often appear to be very slight, to change the relations of the molecules to each other, and to alter the arrangements or distribution of the *atoms* within the *molecules*, and by varying in this sense the molecular arrangement of certain elements, they may be made to pass into forms which are very different from those in which we ordinarily know them. Carbon, for instance, when free, or when associated with iron, may readily be changed from the diamond to the graphitic form, though the converse change has not as yet been effected.

Sulphur, again, with which you are familiar as a hard, brittle, yellow solid, may be prepared and maintained for a little time in the form of this brown viscous mass, but this latter form of sulphur soon passes spontaneously and slowly at the ordinary temperature, and instantaneously at 100°, to the solid octahedral yellow modification with evolution of heat. The viscous form of sulphur is an allotropic modification of that element. A few cases of allotropy in metals have already been established, and when they do occur they give rise to problems of vast industrial importance. Such molecular changes in metals are usually produced by the addition of a small quantity of foreign matter, and I have elsewhere tried to show that the molecular change produced by the action of *traces* upon *masses* is a wide-spread principle of nature, and one which was recognized at the dawn of the science of chemistry, even in the seventh century, although distorted explanations were given of well-known facts, and gave rise to entirely false hopes. But it is the same story now as in mediæval times: the single grain of powder which Raymond Lully said would transmute millions of its weight of lead into gold—the single grain of stone that Solomon Trismosin thought would secure perpetual youth—had their analogues in the small amount of plumbago which, to Bergman's astonishment in the eighteenth century, converted iron into steel. By his time it was recognized that the right use of alchemy consisted in the application of its methods to industry, and we still wonder at the minuteness of the quantity of certain elements which can profoundly affect the properties of metals. The statements are true, and are not derived from poetical literature, early or late. Even in the moral world the significance of the action of traces upon masses has been recognized, and the method of the alchemist survives in the administration of the small quantity of powder which, in the imagination of Robert Louis Stevenson, will produce the malevolent Hyde modification of the benevolent Dr. Jekyll. In thus borrowing an illustration from one of the most refined and subtle writers of our time, I do not fear the taunt of Francis Bacon,[1] that "sottishly do the chymics appropriate the fancies and delights of poets in the transformation of bodies to the experiments of their furnaces;" for, although it may not be possible to *transmute* metals, it is easy so to *transform* them, by very slight influences, that as regards special service required from them they may behave either usefully or entirely prejudicially.

In attempting to illustrate this part of the subject I cannot take the most striking cases, as it is difficult to demonstrate them in the time at my disposal. The following experiment, which does not, however, depend upon the action of a trace upon a mass, will enable me to lead up to the point I wish to insist upon. It consists in the release of gold from its alloy with potassium. When the alloy is treated with water, the gold comes down in a finely divided, dark brown, chemically active state. [Experiment shown on the screen.]

I have chosen this experiment because it was a similar one that first roused suspicion that pure iron could exist in more than one form.

The question at once suggests itself, Can iron behave in a similar manner: is an allotropic form of iron known? Joule afforded experimental evidence for an affirmative answer to this question nearly forty years ago by communicating to the British Association in 1850 a paper on some amalgams. The result of his experiments, published in detail later,[2] in a paper which has been sadly neglected, showed that iron released from its amalgam with mercury is chemically active, as it com-

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[1] *Stahl und Eisen*, vol. viii., 1888, p. 742.

[1] Preface to the "Wisdom of the Ancients."

[2] "On some Amalgams," Mem. Lit. Phil. Soc. Manchester, vol. ii. [3] p. 115.

bines readily with the oxygen of the air at the ordinary temperature, and he claims that the iron so set free is allotropic; but Joule did much more than this. Magnus had shown (1851) that the thermo-electric properties of hard and soft steel and iron differ. Joule, in a paper on some thermo-electric properties of solids, incidentally shows that the generation of a thermo-electric current affords a method of ascertaining the degree of carburization of iron, and he appeals to the "thermo-electricity of iron in different states" as presenting a "fresh illustration of the extraordinary physical changes produced in iron by its conversion into steel," and he adds the expression of the belief "that the excellence of the latter metal might be tested by ascertaining the amount of change in thermo-electric condition which can be produced by the process of hardening."[1] It is by a thermo-electric method that the views as to the existence of iron in allotropic forms has been confirmed. Jullien seems to have inclined to the view that iron is allotropic in his "Théorie de la Trempe,"[2] published in 1865, but he cannot be said to have added much to our knowledge, although he certainly directed attention to the importance of hardening and tempering steel.

The next step was made in Russia, in 1868. Chernoff, who has found an admirable exponent to English readers in Mr. W. Anderson, President of Section G, showed that steel could not be hardened by rapid cooling until it had been heated to a definite temperature—to a degree of redness which he called *a*. Then in 1873, Prof. Tait[3] used this expression in a Rede Lecture delivered at Cambridge: "It seems as if iron becomes, as it were, a different metal on being raised above a certain temperature; this may possibly have some connection with the ferricum and ferrosum of the chemists." He also published his now well-known "first approximation to a thermo-electric diagram," which is of great interest in view of recent work. At about this time those specially interested in this question remembered that Gore[4] had shown that a curious molecular change could be produced by heating an iron wire, which sustains a momentary elongation on cooling. Barrett repeated Gore's experiment, and discovered that as an iron wire cools down it suddenly *glows*, a phenomenon to which he gave the name *recalescence*, and these investigations have been pursued and developed in other directions by many skilful experimenters.[5] In 1879, Wrightson[6] called attention to the abnormal expansion of carburized iron at high temperatures.

The next point of special importance seems to me to be that recorded by Barus, who, by a thermo-electric method, showed, in an elaborate paper published in 1879,[7] that "the hardness of steel does not increase continuously with its temperature at the moment of sudden cooling, but at a point lying in the dark-red heat the glass-hard state" may suddenly be attained by rapid cooling. I shall have again to refer to the remarkable series of papers published by Barus and Strouhal,[8] embodying the results of laborious investigations, to which, in the limited space of this lecture, I can do but scanty justice; and finally, within the last few years, Pionchon[1] showed that at a temperature of 700° the specific heat of iron is altogether exceptional, and Le Chatelier[2] has detected that at the same temperature a change occurs in the curve representing the electromotive force of iron—both experimenters concluding that they had obtained evidence of the passage of iron into an allotropic state.

Osmond,[3] in France, then made the observations of Gore and Barrett the starting-point of a fresh inquiry, which will now be considered at some length, as Osmond has arrived at conclusions of much interest and importance.

(*To be continued.*)

ON A NEW APPLICATION OF PHOTOGRAPHY TO THE DEMONSTRATION OF CERTAIN PHYSIOLOGICAL PROCESSES IN PLANTS.

MR. WALTER GARDINER, Lecturer on Botany in the University of Cambridge, who delivered the evening address at Newcastle on "How Plants maintain themselves in the Struggle for Existence," has discovered a new method of printing photographic negatives, employing living leaves in place of sensitive paper. Mr. Gardiner read a paper on the subject before the British Association. Before dealing with the immediate subject of his paper, the author described how prints may be obtained from *Protococci*, or the free-swimming swarm-spores of many green Algæ. It is possible to take advantage of their sensitiveness to light. Into one end of a water-tight box, a thin glass plate is securely fitted. The negative to be printed is then placed next the glass, film side nearest. The box is filled with water containing a fairly large quantity of swarm-spores. The lid is shut down, and the whole is exposed to diffused light. In the case of a strong and well-developed negative, the swarm-spores swim towards the most highly-illuminated parts, and there in the greatest numbers come to rest, and settle upon the glass, so that, after some four or six hours, on pouring out the water and removing the negative, a print in green swarm-spores can be obtained. The print may be dried, fixed with albumen, stained, and varnished. The author then dwelt upon the well-known fact that the whole of the animal life upon the globe depends directly or indirectly upon the wonderful synthetic formation of proteid and protoplasm which takes place in the living tissue of plants containing chlorophyll, *i.e.* green plants, or, to be more exact, in the green chlorophyll corpuscles. He stated that, whatever is the exact chemical nature of the process, this is at least clear, that the first *visible* product of the assimilatory activity is starch, which, moreover, is found in the chlorophyll grains. The presence of this starch can be made manifest by treating a decolorized leaf with a water solution of iodine dissolved in potassic iodide. This formation of starch only takes place under the influence of light; the radiant energy of the sun providing the means of executing the profound synthetic chemical change, and building up proteid from the carbonic acid of the air which is taken up by the leaves and the salts and water of the soil absorbed by the roots. If a plant (and preferably a plant with thin leaves) be placed in the dark over-night, and then brought out into the light next morning, the desired leaves being covered with a sharp and well-developed negative, starch is formed

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[1] Phil. Trans., cxlix., 1859, p. 91.

[2] "Annexe au traité de la Métallurgie du Fer," 1865.

[3] NATURE, viii., 1873, pp. 86, 122; and Trans. Roy. Soc. Edin., xxvii., 1873, p. 125.

[4] Proc. Roy. Soc., xvii., 1869, p. 260.

[5] G. Forbes, Proc. Roy. Soc. Edin., viii., 1874, 363; Norris, Proc. Roy. Soc., xxvi., 1877, 127; Tomlinson, *Phil. Mag.*, xxiv., 1887, 256; xxv., pp. 45, 103, and 372; xxvi. p. 18; Newall, *Phil. Mag.*, xxiv., 1887, 435; xxv., 1888, p. 510.

[6] Journ. Iron and Steel Inst., No. ii. 1879; No. i. 1880.

[7] Barus, *Phil. Mag.*, viii., 1879, p. 341.

[8] "Hardness (Temper), its Electrical and other Characteristics," Barus, *Phil. Mag.*, viii p. 341, 1879; *Wied. Ann.*, vii. p. 383, 1879; Strouhal and Barus, *Wied. Ann.*, xi. p. 930. 1880; *ibid.*, xx. p. 525, 1883. "Hardness and Magnetization," *Wied. Ann.*, xx. pp. 537, 662. 1883. "Density and (Internal) Structure of Hard Steel and of Quenched Glass," Barus and Strouhal, *American Journ.*, xxxi. p. 386, 1886; *ibid.*, p. 439; *ibid.*, xxxi. p. 181, 1886. "Temper and Chemical Composition," *Am. Journ.*, xxxii. p. 276, 1886. "Temper and Viscosity," *Am. Journ.*, xxxii. p. 444, 1886; *ibid.*, xxxiii. p. 20, 1887; Barus, *ibid.*, xxxiv. p. 1, 1887; *ibid.*, xxxiv. p. 175, 1887. These papers, systematically discussed and enlarged, are embodied with new matter in the *Bulletins* of the United States Geological Survey, viz.:—*Bull.*, No. 14, pp. 1-226, 1885; *Bull.*, No. 27. pp. 30-61, 1886; *Bull.*, No. 35, pp. 11-60, 1836; *Bull.*, No. 42, pp. 98-131, 1887.

[1] *Comptes rendus*, cii., 1886, pp. 675 and 1454, ciii. p. 1122.

[2] *Ibid.*, cii. p. 819.

[3] The reader will find the principal part of Osmond's work in the following papers: Osmond et Werth, "Théorie Cellulaire des Propriétés de l'Acier," *Ann. des Mines*, viii., 1885. p. 5; "Transformations du Fer et du Carbone," Paris, Baudoin et Cie., 1888; "Études Métallurgiques," *Ann. des Mines*, Juillet-Août, 1888. There is also a very interesting paper, "Sur les Nouveaux Procédés de Trempe," which he communicated to the Mining and Metallurgical Congress, Paris, 1889.

when light is transmitted, and in greatest quantity in the brightest areas. Thus a positive in starch is produced which can be developed by suitable treatment with iodine. [A leaf was then developed, and handed round to the audience for inspection.] The author showed that it might be possible to obtain a permanent print by suitable washing and treatment with a soluble silver salt, silver iodide being formed. The author regards this discovery as a most striking illustration of the way in which plants are working for themselves, and so for all living things, and points out that the extraordinary manner in which the green parts of plants (so to speak) catch the radiant energy of the sun, and employ it for analytical and synthetical chemical processes, may be easily and clearly demonstrated.

NOTES.

WE understand that the late Mr. John Ball, F.R.S., has bequeathed his botanical library and herbarium to Sir Joseph Hooker, to the Director of the Royal Botanic Gardens at Kew for the time being, and to the President of the Royal Society for the time being, requesting them to give the same to such person or persons or public institution in this country, the British colonies, or elsewhere in the world, as they or any two of them may select, with the sole object of promoting the knowledge of natural science. Right is, however, reserved for Kew to select previously such specimens or books as it may want.

THE following is the list of names recommended by the President and Council of the Royal Society for election into the Council for the year 1890, at the forthcoming anniversary meeting on the 30th inst.:—President: Sir George Gabriel Stokes, Bart. Treasurer: Dr. John Evans. Secretaries: Prof. Michael Foster, the Lord Rayleigh. Foreign Secretary: Dr. Archibald Geikie. Other Members of the Council: Prof. Henry Edward Armstrong, Prof. William Edward Ayrton, Charles Baron Clarke, Prof. W. Boyd Dawkins, Dr. Edward Emanuel Klein, Prof. E. Ray Lankester, Dr. Hugo Müller, Prof. Alfred Newton, Captain Andrew Noble, C.B., Rev. Stephen Joseph Perry, Sir Henry E. Roscoe, Dr. Edward John Routh, William Scovell Savory, Prof. Joseph John Thomson, Prof. Alexander William Williamson, Colonel Sir Charles William Wilson, R.E.

IN the list of Englishmen decorated in connection with the British Section of the Paris Exhibition, the names of the following men of science are included:—Grand Officer of the Legion of Honour: Sir William Thomson, F.R.S. Officers of the Legion of Honour: Sir Douglas Galton, K.C.B., Sir Henry Roscoe, M.P., F.R.S., Mr. W. H. Preece, F.R.S. Chevaliers of the Legion of Honour: Prof. Francis Elgar, Prof. W. Roberts-Austen, F.R.S., Dr. C. Le Neve Foster. Officer of Public Instruction: Mr. C. V. Boys, F.R.S.

THE Naturforschende Gesellschaft at Emden is to celebrate its seventy-fifth anniversary on December 29 next. The Society was founded in 1814 by twenty-four burgesses of Emden. The festivities in December will consist of a general meeting of the Society and the Society's correspondents at noon in the Museum, and a *Festessen* at four o'clock.

A REPORT of the proceedings of the International Zoological Congress, held in Paris two months ago, will be published shortly.

A FRENCH translation of Dr. Wallace's "Darwinism" will be published next year.

THE greater part of the ethnographical collection sent to the Paris Exhibition is to remain in Paris, in the Colonial Museum.

THE following botanical appointments are announced:—The Directorship of the Botanic Garden at Berlin, vacant by the death of Dr. Eichler, having been conferred on Prof. Engler, of Breslau, Prof. Urban becomes Second Director of the Berlin Botanic Garden; and Prof. Prantl, of Aschaffenburg, succeeds Prof. Engler as Director of the Botanic Garden at Breslau. Prof. Sadebeck, of Hamburg, is appointed Director of the Botanic Garden in that town, in the place of the late Dr. Reichenbach. Dr. G. von Lagerheim vacates the Professorship at Lisbon, to which he was lately appointed, and goes to Ecuador as Professor of Botany and Director of the Botanic Garden at Quito. Dr. H. Molisch, of Vienna, takes the Chair of the late Dr. Leitgeb in the Polytechnic at Gratz. Dr. F. Hueppe is appointed Professor of Bacteriology at the University of Prague, and is succeeded in the same Chair at Wiesbaden by Dr. G. Frank, of Berlin. The venerable Professor von Naegeli retires from the Directorship of the Botanic Garden at Munich. Mr. F. S. Earle, Prof. E. S. Goff, and Prof. L. R. Taft have been appointed special agents in the Section of Vegetable Pathology of the United States Department of Agriculture. Mr. H. H. Rusby has been appointed Professor of Botany and Materia Medica in the New York College of Pharmacy.

THE Economic Museum, Calcutta, has completed and despatched the first instalment of important Indian fibres required by the India Office for presentation to the Museums of the Royal Botanical Gardens at Kew and Edinburgh, and to the Chambers of Commerce at Dundee and Manchester.

A PRIZE of about £20 is offered by the Geographical Societies of Dresden and Leipzig, for "a physico-geographical description of the course of the Elbe between Bodenbach and its entrance on the flat country, with special reference to depth, quantity of water and its variations, ice, and changes in the form of the banks." The date is the end of 1890.

IN his address at the opening of the winter session of the University of Toronto, Sir Daniel Wilson, the President of the University, referred to the recent Toronto meeting of the American Association for the Advancement of Science. "Everything available for the special requirements of the Association," he said, "was placed at the disposal of the Sections; and we are gratified by the assurance that, at the close of a highly successful meeting, our visitors carried away with them pleasant memories of their reception here." The meeting of the representatives of science in the buildings of the Toronto University was in some respects, as the President pointed out, peculiarly opportune. "The long-felt need of adequately furnished and equipped laboratories and lecture-rooms for our scientific staff was anew brought into prominence by the restoration to the University of its Medical Faculty; and we now enter on the work of another year provided with buildings admirably adapted for biological and physiological study and research. Plans, moreover, have been approved of, which, when carried out to their full extent, will furnish equally satisfactory accommodation for the departments of botany, chemistry, geology, and palæontology, along with laboratories, work-rooms, museum, and other requisites for efficient instruction in the various branches of science."

THE thirty-fourth general meeting of the Society for Psychical Research was held on Friday afternoon, October 25, at the Westminster Town Hall. The President (Prof. Sidgwick) gave an account of the International Congress of Experimental Psychology held in Paris last August. The Congress had adopted the scheme of a census of hallucinations, already set on foot by the Society for Psychical Research in England, France, and the United States, and it was hoped that the collection of statistics might gradually be extended to other European countries. Much matter valuable to psychologists was thus being collected; and he trusted that fresh light would be thrown on the subject of coincidental or veridical hallucinations, which specially interested their Society. He would be glad to supply information in reply to letters addressed to him at Hill Side, Cambridge. A paper on recent telepathic experiences was also read.

WE learn from *Humboldt* that the project of a lacustrine biological station on Lake Plön, in East Holstein, is likely to be soon carried out, thanks to the energy of Dr. Otto Zacharias, and the liberality of the Bohemian Baron Bela Dertcheni. This station is to afford Prof. Anton Fritsch, of Prague, and his assistants, constant opportunities of research on fresh-water fauna. The scheme finds a good deal of favour in Berlin, and it is hoped that the researches at the station may prove of considerable benefit to fisheries.

WE send to America some return for the Colorado beetle and the Canadian water-weed. The "weed-law" of the State of Wisconsin requires from farmers, under penalties, the destruction of the following weeds:—*Cnicus arvensis*, *Arctium Lappa*, *Chrysanthemum Leucanthemum*, *Sonchus arvensis*, *Xanthium strumarium*, *Linaria vulgaris*, and *Rumex crispus*. Only one of these is a native of the United States; all the rest being naturalized importations from Europe, and common wild plants in this country.

PROF. RIGHI showed, last year, that ultra-violet radiations reduce to the same potential two conductors, a plate and a piece of netting, applied to each other, the rays being thrown on the netting-side. He now points out (*Riv. Sci. Ind.*, July–August) that this suggests a very simple and convenient way of measuring differences of potential of contact. One notes the deflection of an electrometer connected with the plate (the netting being permanently connected with earth); then, having connected the electrometer for an instant with earth, makes the radiations act a sufficient time. He used a zinc electric lamp, and the metals examined were placed in some cases in a bell jar, to which some gas or vapour was admitted. From measurements of different plates with the same metallic net (copper, zinc, or platinum), the differences of potential of pairs of metals could be deduced. Prof. Righi found the differences sensibly the same in dry and moist air and in carbonic anhydride; but with hydrogen, very different values (from those in air) appeared, where one of the metals examined was platinum, palladium, nickel, or iron (doubtless owing to absorption). In ammonia all the metals, examined with zinc net, seemed to have become less oxidizable; and in coal gas, carbon and platinum behaved like more oxidizable metals. A memoir on the subject will shortly appear.

IN an interesting paper on the management of aquaria, printed in the Bulletin of the United States Fish Commission, Mr. W. P. Seal points out that, in the feeding of the fish, care must be taken to introduce no more food than they can eat in a short time, as what is not eaten will soon decompose and make the water cloudy, and generate noxious gases as well. If due care is observed in regard to quantity, it does not matter how often fish are fed, except that if fed abundantly they will grow rapidly, which is not generally desired. Fish may be fed every day, or but two or three times a week, with equally good results apparently. They will always find a small amount of food in the aquarium in the vegetation. Where they are not fed sufficiently, they are apt to strip the plants of their leaves. In a natural condition fish are feeding continually and grow very rapidly.

ON November 2 a slight shock of earthquake was felt in St. Louis, U.S.A., and the vicinity.

THE following summary of the phases of Vesuvius during the past year has been supplied by Prof. Palmieri, of the Vesuvian Observatory of the University of Naples, to the British Consul there, and is appended by the latter to his last Report. Mount Vesuvius, during the past year, has continued its moderately eruptive activity, which began in the month of December 1875. There were various emissions of small lava streams, which did not reach further than the base of the cone. An additional cone was gradually formed, caused by the activity of the motive power of the crater which, towards the end of the year, had reached a height of 100 metres (equal to 328 feet) above its original level. On various occasions the detonations and the red-hot projectiles thrown up with the large quantities of smoke indicated greater eruptive power. During the whole year no ashes were thrown up, and consequently the crops in the surrounding country were not destroyed. The sublimations on the smoke issues were relatively scarce, and did not present any product that called for attention. The seismographic instruments at the Observatory did not show an activity proportionate to that of the volcano. All the lava streams that issued during the year flowed towards the eastern slopes of the mountain.

THE Meteorological Council have published Part I. of the Quarterly Weather Report for 1880. The work is (as before) divided into three sections: (1) a general summary of the chief features of the weather for the quarter; (2) tables showing the movements and peculiarities of the principal cyclonic and anti-cyclonic systems; and (3) remarks on the distribution of the various elements for each month, illustrated by charts. An appendix contains tables and diagrams illustrating the diurnal range of the barometer in Great Britain and Ireland during the years 1876–80, by F. C. Bayard. The data used are the hourly observations at seven Observatories in connection with the Meteorological Office, and at Greenwich and Liverpool Observatories. The paper shows that, even in these high latitudes, the daily range is well marked during all months, notwithstanding the interference caused by non-periodic changes. Important seasonal differences are shown, the morning maximum being distinctly higher than the evening maximum in winter, while in summer the evening maximum is the higher of the two. The values exhibit the influence of locality on the amplitude and epoch of the diurnal inequalities, and furnish material for more minute inquiry.

IT is interesting to read of a part of the world where the buffalo is not dying out, but increasing in numbers. A journal of Perth, in Western Australia, says that few Australians are aware that certain parts of Northern Australia have vast herds of the wild buffalo (*Bos bubalus*) careering over its plains and wallowing in its shady pools. The *Sydney Mail* states that the animals are massive and heavy, with splendid horns, and afford sport of a sufficiently dangerous nature to possess charms for the most daring hunter, a wounded buffalo being one of the most dangerous animals known, his great weight, prominent horns, and splendid courage, making him as well respected as sought after. The first buffaloes were landed at Port Essington, North Australia, about the year 1829.

THE *Naturalist's Gazette* has issued an excellent series of what it calls "label lists." On one sheet there is a list of British birds' eggs; on another, a list of dragon-flies; on another, a list of British butterflies; and so on. The names are printed in suitable type on gummed paper, and collectors, in labelling their specimens, will find the lists of considerable service.

THE next volume of Messrs. Ward, Lock, and Co.'s "Minerva Library of Famous Books" will be "Travels on the Amazon and Rio Negro," by Dr. Alfred Russel Wallace.

F. A. BROCKHAUS, 16 Querstrasse, Leipzig, has issued a catalogue, in four parts, containing lists of works relating to various branches of botany.

THE *Colonies and India* states that a discovery has recently been made on a Fiji plantation, which will probably prove extremely valuable in all tropical countries where the cultivation of bananas is regarded as a settled industry. The banana disease had for some time been causing much havoc on a plantation on Vanua Levu, and it appears that the discovery of an antidote was due to an accidental occurrence. On a flat near the sea-shore there was a patch of bananas much diseased, and some time ago the sea swept into it and remained on it for about an hour. All the plants were killed as far as the standing stems were concerned, but vigorous young shoots came up freely from the roots, and were not only quite free from disease, but soon began to bear much larger bunches of fruit than the parent plants ever did. Upon noting this effect the planters determined to try the experiment upon a number of badly diseased plants which the sea had not reached. They cut down the diseased plants, and, having stirred the ground about them, poured from one to four buckets of sea-water over each. The result was that, while the parent stems withered, vigorous young shoots came freely away, without a sign of disease.

A SERIES of successful experiments upon the simultaneous production of pure crystals of sodium carbonate and chlorine gas from common salt are described by Dr. Hempel in the current number of the *Berichte*. The experiments simply consisted in passing a current of carbon dioxide gas through a solution of salt contained in a special form of electrolytic cell, through which an electric current from a few Bunsen's cells or a small dynamo was circulated. The kathode found most convenient consisted of a plate of iron or carbon perforated with numerous holes about 4 millimetres in diameter, bored obliquely, so that bubbles of gas could readily escape upwards. For anode a similar plate of thin perforated carbon was employed. Both electrodes were circular in shape, and between them was placed a diaphragm of thick asbestos paper, which was directly squeezed between the two plates. This arrangement was found to possess the double advantage of bringing the two electrodes within 1 millimetre of each other, and so greatly diminishing the internal resistance, and of affording such excellent support to the asbestos diaphragm that any rupture of the latter was entirely prevented. The electrodes and their enclosed diaphragm were supported in a circular glass cell in such a manner that they divided the cell into two distinct chambers. To the glass wall of the cell on the positive or anode side was fitted a wide side tube, through which the salt was supplied as often as necessary in solid pieces, a little water being also from time to time added to replace that taken up in the crystallization of the sodium carbonate. A delivery tube was also attached to the upper portion of the anode chamber in order to conduct away the liberated chlorine gas. The negative or kathode chamber was supplied at its upper end with an opening serving on the one hand to introduce the carbon dioxide delivery tube, and on the other to extract the crystals of sodium carbonate. The apparatus was thus found to work continuously for weeks together, the asbestos diaphragm withstanding the pressure very satisfactorily. The separation of the soda crystals is readily explained by the well-known fact of the difficult solubility of sodium carbonate in solutions of sodium chloride; as fast as the electric current decomposes the sodium chloride into chlorine and sodium, the carbon dioxide converts the sodium hydrate formed by the reaction of the sodium upon water into the normal carbonate, which, in presence of the constantly replenished common salt, at once separates in the usual monoclinic form of $Na_2CO_3 . 10H_2O$. The total resistance of the cell is only about five and a half volts, which may be still further reduced by constructing both electrodes of carbon. Using a small dynamo-electric machine, 64·5 grams of chlorine and 259·8 grams of $Na_2CO_3 . 10H_2O$ per horse-power of 680 volt-amperes were produced per hour, so that the experiments, in addition to their interest from a purely chemical point of view, may turn out to bear fruit technically. The soda produced is stated to be chemically pure, and the chlorine to contain but a very small admixture with other gases.

THE additions to the Zoological Society's Gardens during the past week include a Patas Monkey (*Cercopithecus patas* ♂) from West Africa, presented by the Rev. James Vernall; a Cheetah (*Cynælurus jubatus* ♂) from South Africa, presented by Captain M. P. Webster, s.s. *Roslin Castle;* a Ring-tailed Coati (*Nasua rufa* ♀) from South America, presented by Mr. J. A. Martin; two Short-toed Larks (*Calandrella brachydactyla*) from Devonshire, presented by Commander W. N. Latham, R.N., F.Z.S.; a Sharp-nosed Crocodile (*Crocodilus acutus*) from Jamaica, presented by the Jamaica Institute; two Tuatera Lizards (*Sphenodon punctatus*) from New Zealand, presented by Rear-Admiral Henry Fairfax, R.N., C.B., F.Z.S.; a Smooth-headed Capuchin (*Cebus monachus* ♂) from Brazil, deposited; a Collared Peccary (*Dicotyles tajaçu* ♀), four Rosy-billed Ducks (*Metopiana peposaca* ♂ ♂ ♀ ♀) from South America; two Grey Squirrels (*Sciurus cinereus*) from North America; four —— Finches (*Munia nana*) from Madagascar, purchased.

OUR ASTRONOMICAL COLUMN.

STELLAR PARALLAX BY MEANS OF PHOTOGRAPHY.—Prof. Pritchard has sent us his eminently successful "Researches in Stellar Parallax" by the aid of photography, from observations made at the Oxford University Observatory. The advantage in point of convenience and rapidity in the multiplication of observations which this method possesses over all others is incalculable, and it is interesting to note that in the case of 61_1 Cygni the parallax obtained was 0″·4294 ± 0″·0162, and that Bessel's probable error is practically identical with this here stated. Hence, as far as the present results are concerned, photographic and heliometric measures of parallax may be regarded as possessing an equality of accuracy.

The following list contains the stars whose parallax has been determined by this novel method, and some of the results obtained:—

61_1 Cygni	+ 0″·429	± 0″·016
61_2 ,, ...	+ 0·432	± 0·019
μ Cassiopeiæ	+ 0·021	± 0·023
Polaris	+ 0·052	± 0·011
α Cassiopeiæ	+ 0·035	± 0·024
β ,, ...	+ 0·157	± 0·036
γ ,, ...	− 0·032	± 0·026
α Cephei	+ 0·073	± 0·031

The almost identical parallax of the two components of 61 Cygni is worthy of note. The average of eight determinations gives a value 0″·437, which is a close approximation to Dr. Belopolsky's value of 0·50 as the *absolute* parallax of 61 Cygni.

Bessel determined a small negative parallax for μ Cassiopeiæ, but Dr. Struve assigned it a value + 0″·342. The very small positive parallax given by Prof. Pritchard may be explanatory of Bessel's negative determination.

The small negative parallax found for γ Cassiopeiæ would indicate that it and the comparison stars are in the same group, although its bright line spectrum points to a constitution different from that of other stars in this constellation.

Even a cursory examination of the summary of results renders it evident that no relation exists between the lustre and parallax of stars, and indeed, since we probably view bodies which are still in various stages of condensation, we should hardly expect to find any such relation.

MEASUREMENTS OF DOUBLE STARS.—*Astronomische Nachrichten*, Nos. 2929–30, contain a series of double star observations made with the 36-inch refractor of the Lick Observatory by Mr. S. W. Burnham. The discovery is claimed of two very faint stars in the trapezium of Orion, and an excessively faint double has also been detected by Mr. E. E. Barnard just outside and preceding the trapezium. The observers believe that, in spite of the numerous alleged discoveries of faint stars in this region, it is impossible to see such as these now found with an aperture much less than that of the Lick telescope. A list is therefore given of the principal communications to astronomical periodicals relating to the alleged discovery of faint stars in the trapezium of Orion.

BARNARD'S COMET, 1888-89.—*Comptes rendus*, No. 17, October 21, 1889, contains some observations made by MM. Rayet and Courty of the motion of Barnard's comet, the positions of the comparison stars being also given. The series of observations extend from September 11, 1888, to September 27, 1889.

BIOGRAPHICAL NOTE ON J. C. HOUZEAU.—M. A. Lancaster, the collaborator with Houzeau of the most comprehensive bibliography extant, has proved himself, in this note, to be the most capable of writing his deceased friend's biography. Houzeau's scientific and literary labours cover an extensive field: astronomy and geodesy, mathematics and meteorology, geology and geography, are all represented in his works; and when but a young man, he directed the triangulation of his country. In politics Houzeau was an enthusiast, and whilst in America, about 1861-69, he gave a considerable amount of attention to the subject of the emancipation of the slaves, and wrote numerous and important articles upon it. In 1875, Houzeau completed a series of astronomical and meteorological observations made at Jamaica, and in the following year was appointed Director of the Brussels Observatory. His crowning work—the "Vade Mecum of Astronomy," was finished in 1882. It represented the work of a lifetime, and as a guide to astronomers is invaluable. Such a compilation, however, calls for continual additions, and a general bibliography was published in 1887, with the assistance of M. A. Lancaster. This was Houzeau's last work, but before his death, on July 12, 1888, he earnestly expressed the wish that it should be carried on by his collaborator. Houzeau's life was full of vicissitudes, and his biography is most interesting.

THE KARLSRUHE OBSERVATORY.—The third volume of the Publications of the Grand-Ducal Observatory of Karlsruhe has recently been published by Dr. W. Valentiner, the Director. The bulk of the volume is by Dr. E. von Rebeur-Paschwitz, and consists, first, of a series of measures with the 6-inch refractor of the two star-clusters M. 35 and M. 25; secondly, of a discussion of the orbit of Comet Wells, 1882 I., and the derivation of definitive elements; and lastly, of auxiliary tables for the computation of parallax for 169 different observatories.

Dr. Boy Mattheissen adds a short paper on the orbit of Comet Denning, 1881 V.

The volume contains three plates, the first two being maps of the star-clusters under observation, whilst the third gives photographs of the same two clusters as taken by Dr. E. von Gothard at Herény.

OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich, at 10 p.m. November 7 = 1h. 9m. 9s.

Name.	Mag	Colour.	R.A. 1890·0.	Decl. 1890·0.
			h. m. s.	° ′
(1) Nebula in Andromeda	—	Greenish-white.	0 35 4	+40 30·14
(2) γ Cassiopeiæ	2	Bluish-white.	0 50 1	+60 7
(3) 47 Piscium	5	Yellowish-red.	0 42 58	+ 6 59·2
(4) ι Ceti	3	Yellowish-white.	0 13 48	− 9 26
(5) γ Pegasi	3	White.	0 7 34	+14 34
(6) D.M. + 34° 55′	8	Deep red.	0 21 42	+34 53
(7) T Herculis	Var.	Reddish.	18 4 56	+31 0

Remarks.

(1) Dr. Huggins notes that the spectrum ends abruptly in the orange. Maxima of brightness have since been recorded by myself at, approximately, 468-474, 517, and 546, and the latter two have also been confirmed by Mr. Taylor. Further confirmation is required. For comparison, a Bunsen or spirit-lamp flame will be found convenient for the first two, and the brightest fluting seen when lead chloride is introduced into the flame for the third. Mr. Lockyer suggests that since the central condensation is probably at a higher temperature than the surrounding portions of the nebula, different parts of the nebula should show differences in their spectra. Observing with Mr. Lockyer's 30-inch reflector at Westgate-on-Sea, on October 20, I suspected some change in the spectrum away from the nucleus, but was unable to complete the observation on account of clouds, and have not since had an opportunity of repeating it.

(2) The bright lines most constantly seen in the spectrum of this star are C, F, and D_3, but their appearance is somewhat irregular. Continuous observations, with special reference to the relative intensities of the lines, are suggested. The lines are well seen in a 10-inch equatorial with a Maclean spectroscopic eye-piece. Bright flutings of carbon have also been suspected, and comparisons should be made with the Bunsen or spirit-lamp to confirm these. The continuous spectrum should also be carefully examined for maxima. *b*, D, and other absorption-lines, have also been recorded.

(3) This is a star which gives a spectrum of dark flutings fading away towards the red. Dunér records bands 2 to 9, and describes the spectrum as superb. Band 3, near D, is of extraordinary width. The spectra of this type have been explained as mixed metallic fluting absorption and carbon fluting radiation. The carbon flutings probably present are 517 and 468-474, which again may be determined by comparison with the spirit-lamp, 517 being the brightest green fluting.

Dunér's notation and mean wave-lengths of the dark bands are as follows:—(1) 648-666, (2) 616·2-629·8, (3) 586 7-596·8, (4) 559·8-564·9, (5) 545·2-551·5, (6) 524·3-528·1, (7) 516·8-522·2, (8) 495·9-503·0, (9) 476·0-483·0, (10) 460·7-473. The bright spaces between 7 and 8, and 9 and 10 are probably due to carbon.

(4) This is a star of Class II.*a*, which is now divided into two groups, one having spectra of the type of α Tauri (Group III.), and the other of the sun (Group V.). The lines should be carefully observed, and differences from the solar spectrum, if any, noted, so that the star can be classed in one group or the other. The principal criteria so far determined for Group III. are strong lines at 409 and 540. 568 and 579. The line at 540 forms with E (5268), and the iron line at 5327 (both solar lines), an equi-distant trio. The difference between the two groups may perhaps best be observed by a comparison of Aldebaran and Capella.

(5) The spectrum of this star is Class I.*a* (Group IV.). The relative intensities of the hydrogen and metallic lines should be noted, in order that the star may be arranged with others in order of temperature.

(6) Dunér gives the spectrum of this star as Class III.*b* (Group VI.), in which the main features are three dark carbon flutings fading away towards the blue. Other absorptions, if any, should be carefully observed, and their relative intensities recorded.

(7) This is a variable star, which reached its maximum on November 6. The magnitude at maximum is given by Gore as 6·9-8·3, and the period as 165·1 days. The spectrum has not yet, so far as I know, been recorded.

A. FOWLER.

GEOGRAPHICAL NOTES.

THE telegrams in the papers of Monday and Tuesday from Mr. Stanley are of the most suggestive and interesting character. For one thing, Emin, Casati, and others who have been holding out, are safe, though the brave Pasha has evidently been deserted by most of his men. That Mr. Stanley's expedition was needed the result has proved. He reached the Albert Nyanza for the third time, not a moment too soon to rescue the retreating party. We need not dwell on the sacrifices that have been entailed; they might to some extent have been avoided, but personally Mr. Stanley is not to blame. The geographical results of the expedition, as shadowed in the too brief telegram in Tuesday's papers, are evidently of the highest interest. There is now no doubt that there is a southern Albert Lake, Muta Nzigé, which Mr. Stanley has named Lake Albert Edward. From the time when he himself discovered what he called Beatrice Gulf until the present, no one had seen this lake. At first it was thought to be a part of the northern lake, Albert Nyanza, but that idea had to be given up. Now it is clear that it is connected with that lake by the River Sempliki. The southern lake is 900 feet higher than the northern, and so is about 3200 feet above sea-level, and 450 feet above Lake Tanganyika, with which it is unlikely to have any connection. Mr. Stanley skirted the snowy mountain range referred to in his letters of six months ago, and found that they send down fifty streams to feed the

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[1] Roy. Soc. Proc., vol. xlv. pp. 380-392.

Sempliki. Awamba, Usongora, Toro, Ahaiyama, Unyampaka, and Anhori, are all districts around the west, north, and east shores of the Lake Albert Edward, three sides of which Mr. Stanley says he has traversed—probably the east, west, and north sides, though it is possible he may have gone round the south side. It is probable that the lake as laid down on our maps is much too large, and that it is comparatively small Mr. Stanley found it to be 15 miles wide at Beatrice Gulf. From the lake he struck south-east to Karagwe and Uzinze, on the south-west and south of Victoria Nyanza, and no doubt found at Mslala the stores which have been accumulating for many months. Thus it will be seen Mr. Stanley has solved one of the few remaining problems of African geography. He has found the south-west source of the Nile, and established the true relations which exist among the great lakes of Central Africa. He has filled up an important blank in our maps, and collected observations which will enable us to understand the physical geography of one of the most interesting regions on the continent. Probably he will be able to tell us what has become of the Alexandra Lake of his former expedition. It may be as well to state that the telegram of Monday was in effect the first part of that of Tuesday, and therefore Emin's safety was not again referred to in the latter.

The Zanzibar Correspondent of the *Times* telegraphed on November 5 that authentic news had reached Lamu that Dr. Peters and the whole of his party had been massacred, except one European and one Somali, wounded, who are at Ngao. Some say they were killed by Masais, and some by Somalis.

From the Journal of the Anthropological Society in Vienna, we take the following conclusions of Dr. B. Hagen, respecting the Malay peoples:—Their great predilection for the sea, which makes them pray to Allah that they may die on sea, seems to render the Malay race adapted for the Polynesian and Further Indian Archipelago. The centre from which they migrated is to be sought in the highlands of West Sumatra, particularly in the old kingdom of Menang-Kabau. Thence the peoples extended slowly eastwards; at first probably the races now to be found only in the interior of the great islands (the Battas in Sumatra, the Sundanese in Java, the Dayaks in Borneo, the Alfurus in Celebes, &c.). These "aborigines" of the islands crushed out a population already in possession, as remains of which the Negritos may be taken. The Malays in the narrower sense occupying Sumatra, Malacca, and North Borneo, are to be regarded as the last emigration from the centre referred to, occurring from the twelfth to the fifteenth century A.D. With the Indians and Chinese, who have been long in intercourse with the archipelago, arose mixtures and crosses, in less measure also with the Arabs. One must not therefore expect the pure racial type, especially in the coast population. The crania of the anthropological collections are too imperfectly determined in respect of their *locale* to be of any service for a judgment of the Malay peoples. Of more value are the measurements of the living begun by Dr. Weisbach and executed by Dr. Hagen in 400 cases. The latter's conclusions are:—(1) The peoples in the interior of Sumatra—the Battas, the Allas, and the Malays of Menang-Kabau—compose a closely allied group always in direct contrast with the hither-Indian peoples, and yet showing just as little community with the Chinese. We must therefore take them for the pure original type, characterizable as follows:—Small, compact, vigorous figure of less than 1600 mm. average size; long arms; very short legs; very long and broad mesocephalous skull of very great compass, with high forehead; a prognathous face 10 per cent. broader than long, with large mouth, and uncommonly short, flat, and broad nose with large round nostrils opening mostly frontwise, and with broad nasal root. (2) The Malays of the east coast of Sumatra and those of the coasts of Malacca indicate a much greater affinity to the Indians than to their tribal peoples of Menang-Kabau. They are plainly therefore thoroughly mixed with Indian blood. (3) The Javanese peoples stand much nearer to the original type of the Sumatrans than to the Malays just mentioned. They show therefore less mixture with Indian, but on the other hand more mixture with Chinese, blood, and the Javanese more so than the Sundanese.

The second number of this year's "Information respecting Kaiser Wilhelmsland and the Bismarck Archipelago," issued by the German New Guinea Company, contains a description of the north coast of New Guinea, from Cape Cretin to the Legoarant Islands, by the former Governor, Vice-Admiral Freiherr von Schleinitz, with a map designed by him. According to this account, Kaiser Wilhelmsland is subject to the south-east trade wind. This is, however, occasionally relieved by the opposite wind, when, viz., the sun in southing imparts to the Australian continent a temperature higher than that of New Guinea. The temperature, averaging 26° to 27° C., is not so high as might be inferred from the equatorial situation of the land, a fact due in part to the prevalence of the trade wind, which also brings with it a cooling sea-current to the coast, and in part to the considerable elevation of most of the island. The north-west, blowing especially from January to April, comes on the whole with greater force than the south-east. Calms often occur from March to May and from October to December. Precipitation is on the whole copious, but there are many differences according to the local variations in the configuration of the land. The navigation of the coast offers no particular dangers and difficulties, either for steamers or sailing-vessels. Serious storms are extremely rare, nor are there any reefs in the channel proper. Sea currents do not strike direct on the coast, and they are not generally very strong. The tides are inconsiderable, the spring floods keeping under 1 metre.

Some interesting remains have been found in Hamburg on the site of the new Rathhaus. At a depth of 0 to 0·7 metre the ground was covered to a height of 10 to 15 centimetres with dams of thin willow twigs (*Salix fragilis*), in many places two, sometimes even three, layers above one another, and separated from one another by equally thick earth layers. The building rests on clay, *i.e.* submerged ground, which contained heaps of freshwater shells, *e.g.* *Valvata piscinalis*, *Bythinia tentaculata*, &c., as also *Cardium edule*, *Tellina baltica*, *Mactra solida*, &c. When therefore the dam was made, the water must have been strongly brackish. The interest in this discovery was heightened when there was found, under St. Anne's Bridge, at a depth of 0·5 metre, a regularly paved street of small boulders, such as were still used for stone pavement in all North German towns in the last century. The stone dam was about 5 metres broad, and encased on both sides by thick wooden planks, in order, in the swampy ground, to prevent the slipping out of the stones sideways. The ascertained changes in the level of the North Sea give no positive clue to the age of the Hamburg finds.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

On Monday evening the first annual dinner of the Institution of Electrical Engineers took place at the Criterion Restaurant, Sir William Thomson, the President, occupying the chair. Many different branches of science were represented on the occasion, and some of the after-dinner speeches rose to a high level of excellence.

Due honour having been done to the usual loyal toasts, and Major Webber and Captain Wharton having responded for the Army and Navy, the Chairman proposed "Her Majesty's Ministers" Lord Salisbury said, in response:—

Sir William Thomson and Gentlemen,—I have to thank you on behalf of my colleagues in the Goverment and myself for the exceedingly kind reception you have given to the kind words in which Sir William Thomson has proposed this toast. I do not feel that I can accept the guise in which he put my name forward. On the contrary, though recognizing, as every individual must do, and as I have especial reason to do, the enormous benefits which electrical science confers upon mankind, I feel that I have reason rather to apologize for my appearance in this assembly. When I look round on so many learned and distinguished men, I feel rather in the position of a profane person who has got inside the Eleusinian mysteries. But I have an excuse. The gallant gentlemen who replied for the Army and Navy were able to show many particulars in which their special professional vocation was sustained and pushed forward by the discoveries of electrical science. But I will venture to say that there is no department under the Government so profoundly indebted to the discoveries of those who have made this science as the Foreign Office, with which I have the honour to be connected. I may say that we positively exist by virtue of the electric telegraph. The whole work of all the Chancelleries in Europe is now practically conducted by the light of that great science, which is not so old as the century in which we live. And there is a strange feeling that you have in communicating constantly and frequently day by day with men whose inmost thoughts you know by the telegraph, but whose faces you have never seen. It is something more than a mere departmental effect which these great discoveries have had upon the government of the world. I have often thought that if history were more philosophically written, instead of being divided according to the domination of particular dynasties or the supremacy of particular races, it would be cut off into the compartments indicated by the influence of particular discoveries upon the destinies of mankind. Speaking only of these modern times, you would have the epoch marked by the discovery of gunpowder, the epoch marked by the discovery of the printing-press, and you would have the epoch marked by the discovery of the steam-engine. And those discoveries have had an influence infinitely more powerful, not only upon the large collective destinies, but upon the daily life and experience of multitudes of human beings, than even the careers of the greatest conquerors or the devices of the greatest statesmen. In that list which our ignorance of ancient history in its essential character forbids us to make as long as no doubt it might be made, the last competitor for notice and not the least would be the science of electricity. I think the historian of the future when he looks back will recognize that there has been a larger influence upon the destinies of mankind exercised by this strange and fascinating discovery than even in the discovery of the steam-engine itself, because it is a discovery which operates so immediately upon the moral and intellectual nature and action of mankind. The electric telegraph has achieved this great and paradoxical result, that it has, as it were, assembled all mankind upon one great plane where they can see everything that is done, and hear everything that is said, and judge of every policy that is pursued at the very moment when those events take place; and you have by the action of the electric telegraph, combined together almost at one moment, and acting at one moment upon the agencies which govern mankind, the influences of the whole intelligent world with respect to everything that is passing at that time on the face of the globe. It is a phenomenon to which nothing in the history of our planet up to this time presents anything which is equal or similar, and it is an effect and operation of which the intensity and power increases year by year. When you ask what is the effect of the electric telegraph upon the condition of mankind, I would ask you to think of what is the most conspicuous feature in the politics of our time, the one which occupies the thoughts of every statesman, and which places the whole future of the whole civilized world in a condition of doubt and question. It is the existence of those gigantic armies held in leash by the various Governments of the world, whose tremendous power may be a guarantee for the happiness of mankind and the maintenance of civilization, but who, on the other hand, hold in their hands powers of destruction which are almost equal to the task of levelling civilization to the ground. What gives these armies their power? What enables them to exist? By what power is it that one single will can control these vast millions of men and direct their destructive energies at one moment on one point? What is the condition of simultaneous direction and action which alone gives to these vast armies this tremendous power? It is nothing less than the electric telegraph. And it is from that small discovery, worked out by a few distinguished men in their laboratories upon experiments of an apparently trivial character, on matter and instruments not, in the first instance, of a very recondite description—it is on that discovery that the huge belligerent power of modern States, which marks off our epoch of history from all that have gone before, must be held, by anyone who investigates into the causes of things, absolutely to depend. I would venture to hope that this is not all, in its great effect upon the history and government of our race, that electricity may achieve. Whether it so far is good or evil in the main, it must be for the future to determine. We only know that the effect, whatever it is, will be gigantic. But in the latter half of the short life of this young science another aspect of it has been developed—an aspect which I cannot help hoping may be connected with great benefits to the vast community of industrious and labouring men—I mean that facility for the distribution of power of which electricity has given such a splendid instance. The event of the last century was the discovery of the steam-engine. But the steam-engine was such that the forces which it produced could only act in its own immediate neighbourhood, and therefore those who were to utilize its forces and translate them into practical work were compelled to gather round the steam-engine in vast factories, in great manufacturing towns, and in great establishments where men were collected together in unnatural, and often unwholesome, aggregation. Now an agent has been discovered, by which the forces of the steam-engine, stiff, confined to its own centre, can be carried along, far away from its original sources, to distances which are already great, and which science promises to make more considerable still. I do not despair of the result that this distribution of forces may scatter those aggregations of humanity, which I think it is not one of the highest merits of the discovery of the steam-engine to have produced. If it ever does happen that in the house of the artisan you can turn on power as now you can turn on gas—and there is nothing in the essence of the problem, nothing in the facts of the science, as we know them, that should prevent such a consummation from taking place—if ever that distribution of power should be so organized, you will then see men and women able to pursue in their own homes many of the industries which now require the aggregation at the factory. You may, above all, see women and children pursue these industries without that disruption of families which is one of the most unhappy results of the present requirements of industry. And if ever that result should come from the discoveries of Oersted and Faraday, you may say that they have done more than merely to add to the physical forces of mankind. They will have done much to sustain that unity, that integrity of the family, upon which rest the moral hopes of our race and the strength of the community to which we belong. These are some of the thoughts which electricity suggests to one of my trade. Pardon me if I have wandered into what may seem to be speculative and unfamiliar fields. But, after all, the point of view from which we must admire the splendid additions to our knowledge which the scientific men of the world, and especially of England, during this century have made, is, that they have enabled mankind to be more happy, to be more contented, and therefore to be more moral.

Sir Frederick Abel proposed, and Sir George Gabriel Stokes responded for, "The Learned Societies"; and Sir John Coode responded for the toast of "The Professional Societies," which was proposed by Mr. Latimer Clark. The toast of "The Institution of Electrical Engineers" was then proposed by Lord Salisbury. In the course of his response, Sir William Thomson said:—

One very remarkable piece of work they should think of especially this year, and during the last few weeks, when they deplored the loss of one of the greatest workers in electrical science and its practical application that the world had ever seen—Joule. The great scientific discoveries of Faraday, which were prepared almost deliberately for the purpose of allowing others to turn them to account for the good of man, had been going on for about fifteen years, when a young man took up the subject with a profound and penetrating genius most rare in any branch of human study, and perceived relations with mechanical power which had never been suspected before. Joule saw the relations between electricity and force, and his very first determination of the mechanical equivalent was an electrical measurement. His communication to the British Association, when it met in Cork in the year 1841, pointed out for the first time the distinct mechanical relation between electric phenomena and mechanical force. Joule was not a mere visionary who saw and admired something in the air, but he pursued what he saw to the very utmost practical point of work, and he it was who determined the mechanical equivalent of heat. Afterwards he thoroughly confirmed the principle of his first determination of the mechanical equivalent of heat. Both in electricity and mechanical action he laid the foundation of the great development of thermodynamics, which would be looked upon in future generations as the crowning scientific work of the present century. It was not all due to Joule, but he had achieved one of the very greatest monuments of scientific work in the present century. For an Institution of Electrical Engineers it was interesting to think that the error relating to one of the most important electrical elements, the unit of resistance (now called the ohm), as determined electrically in the first place by a Committee of the British Association, and by purely electrical method, was first discovered by Joule's mechanical measurement. It was Joule's mechanical measurement which first corrected the British Association unit, and gave the true ohm.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following examiners have been appointed: Natural Sciences Tripos: Physics, Prof. Carey Foster and W. N. Shaw; Chemistry, Prof. W. A. Tilden and Prof. Liveing; Mineralogy, Prof. Lewis and L. Fletcher; Geology, Prof. Green and W. W. Watts; Botany, F. Darwin and D. H. Scott; Zoology, Prof. Lankester and S. F. Harmer; Human Anatomy, Drs. Hill and Windle; Physiology, Prof. Stirling and C. S. Sherrington.

First M.B. and Special B.A.: in Elementary Physics, S. L. Hart and H. F. Newall; Elementary Chemistry, F. H. Neville and S. Ruhemann; Elementary Biology, S. F. Harmer and Prof. H. M. Ward; Special B.A. in Geology, Prof. Green and W. W. Watts; in Pharmaceutical Chemistry for Second M.B., M. M. Pattison Muir and H. Robinson.

The following are Moderators (Mathematical Tripos) for the year beginning May 1, 1890:—W. W. R. Ball and A. J. Wallis. Examiners in Part I., W. L. Mollison and E. G. Gallop; in Part II., Prof. Darwin, J. Larmor, and R. Lachlan.

W. B. Hardy, of Gonville and Caius College, has been appointed Junior Demonstrator of Physiology.

L. R. Wilberforce, M.A., of Trinity College, is approved as a Teacher of Physics for M.B. lectures.

There has been a serious discussion of the financial management and prospects of the mechanical workshops at Cambridge. Whatever be the merits of the points in dispute, such division of opinion and feeling is very unfortunate, and much to be deplored in the interests of mechanical science and engineering in the University. It was unfortunate that the University declined to establish an advanced examination or Tripos in engineering subjects; and it is calamitous that the Museums work should not be given to the Department located within their own borders. We trust a cordial understanding may soon be re-established; for this division is very unlike the strong action by which, even when opinions have been divided, scientific teaching has steadily progressed of late years at Cambridge.

The managers of the John Lucas Walker Fund, have made the following grants in aid of original research in pathology:—£14 2*s.* 3*d.* to J. G. Adami, Demonstrator of Pathology, for expenses of his investigations on the pathology of the heart; £35 to William Hunter, M.D. Edin., John Lucas Walker Student, to defray expenses incurred in his research on the pathology of the blood; £30 to E. Hanbury Hankin, to defray expenses of his research on the nature of immunity from infectious diseases.

Mr. J. W. Clark has been re-elected President of the Philosophical Society.

ST. JOHN'S COLLEGE.—At the annual election of Fellows, on Nov. 4, the choice of the Council fell upon the following members of the College: John Parker, Seventh Wrangler, 1882, well known as the author of numerous papers, in the *Philosophical Magazine* and elsewhere, on thermodynamics and electricity; Humphry Davy Rolleston, First Class Natural Sciences Tripos (Human Anatomy and Physiology), 1886, who has been University Demonstrator in Pathology, in Human Anatomy, and in Physiology, author of memoirs on endocardiac pressure and on other anatomical, physiological, and pharmacological subjects, now one of the Assistant Demonstrators of Anatomy at St. Bartholomew's Hospital; Alfred William Flux, bracketed Senior Wrangler, 1887, and First Class (Division 1) Mathematical Tripos, Part II., 1888, Marshall Prrizeman in Political Economy, 1889, author of papers on physical optics. Mr. Rolleston is the son of the late Prof. Rolleston, of Oxford. The success of students of physical and biological science at this College is striking.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 28.—M. Des Cloizeaux, President, in the chair.—M. Bertrand presented a volume entitled "Lectures on the Mathematical Theory of Electricity, delivered at the College of France."—On some hybrids observed recently in Provence, by M. G. De Saporta. Three are described: (1) between *Pinus halepensis*, Mill., and *P. pinaster*, L.; (2) between *Quercus Mirbeckii* and *Q. pubescens*, Wild.; (3) between *Tilia platyphylla*, Scop., and *T. argentea*, Desf.; in each case, the pollen of a preponderating species acting on that of a subordinate one, or one accidentally introduced, being carried by wind or insects, while the agency of man, birds, or wind, disseminated the hybrid seeds.—On the relation of certain magnetic perturbations to earthquakes, by M. Mascart. The former, in the Park of St. Maur, and the latter, at Gallipoli, seem to have occurred simultaneously at 11.35 p.m. on October 25. The suspended copper bar was not in the least deflected, and the magnetic disturbance cannot be attributed to mechanical transmission of the shock.—On certain harmonic linear elements, by M. Raffy.—On a formula connecting vapour-pressure with temperature, by M. N. de Saloff.—On the equilibrium of distribution between chorine and oxygen, by M. H. Le Chatelier. He shows that the value of all the coefficients may be calculated *a priori*, and supplies the required formulæ.—On some double nitrites of ruthenium and potassium, by MM. A. Joly and M. Vèzes. In contact with alkaline nitrites, the brown sesquichloride of ruthenium is transformed into a red salt. According to the temperature, and according as the nitrite or the red chloride predominate, a deposit is formed either of yellow crystalline powder, sparingly soluble in cold water, or of large, very soluble orange-red crystals. These two substances are double nitrites of potassium and ruthenium. The formulæ obtained do not at all agree with those for similar compounds obtained by Claus.—Fixation of nitrogen by the Leguminosæ, by M. Bréal. Having before found that nodosities full of Bacteria could be easily produced on the roots of a leguminous plant, by pricking with a needle previously inserted in a nodosity, he here shows that such plants, with nodosities, flourish on soil poor in azotized matter; yielding crops rich in nitrogen, and fixing this element in the soil by their roots.—On air in the soil, by M. Th. Schlœsing, *fils*. Ploughed land was found to contain a relatively large amount of oxygen at least to the depth of 50 or 60 cm. The carbonic acid generally increased with the depth; but in two cases the reverse occurred, when high wind (renovating the upper layer) had been followed by hot and calm weather, and more CO_2 was generated in the soil than in the sub-soil. In sloping pastures, most CO_2 was found at the bottom. The mobility of air in the soil should be taken into account.—On sorbite, by MM Vincent and Delachanal. This substance very frequently occurs in nature; it is found in all fruits of Rosaceæ, and is especially abundant in pears (8 grammes per kilogramme), cherries and prunes (7 grammes). Acted on by hydriodic acid it yields β-hexylene and other products (the same as are thus obtained from mannite). The formation of a hexacetyl derivative from sorbite proves that it is a hexatomic alcohol. The formula of anhydrous sorbite is $C_6H_8(OH)_6$.—Researches on crystallized digitaline, by M. Arnaud. He regards it as a definite chemical species; and it appears to be the type of a whole series, including tanghinine (one of the active principles of the tanguin.—Experimental researches on the metamorphosis of Anoura, by M. E. Bataillon. He finds acceleration of the rhythm of respiration (65 to 120), and retardation of that of the heart (70 to 45) during metamorphosis. Before appearance of the fore-legs, the two movements were nearly synchronous. At the stage of this appearance, further, the production of carbonic acid was found to have diminished considerably, and the curve rose suddenly when aërial respiration was established.—On the earthquake of July 28, 1889, in the island of Kiushiu, in Japan, by M. J. Wada. This was preceded by exceptional rains during July. The longer axis of the ellipse of land affected was north-east to south-west, and cut in the middle, at right angles, the line joining two volcanoes, 100 kilometres apart.

BERLIN.

Physiological Society, October 18.—Prof. du Bois-Reymond, President, in the chair.—Prof. Kossel spoke on the application of the microscope in connection with physiological chemistry. It has long been the practice to seek for and identify any minute crystals in tissues which occur either naturally or as the result of treatment with reagents, in order to arrive at a qualitative determination of the localized distribution of certain well-known substances in the organism. To identify a crystal by measurement of its angles is a laborious process, and to determine it by mere comparison of its appearance with drawings of known crystals is insufficient. The optical properties of crystals are extremely well adapted to assist in their identification; this is exemplified in the case of determining the plane of vibration of the ordinary and extraordinary rays when crystals are examined between crossed Nicols. To carry out the determination by this means, the field of view of the microscope is provided with cross-wires, whose directions are parallel to the principal planes of the two Nicols. The crystal under examination is then placed with one edge under one of the cross-wires; if the field of vision remains dark, then the planes of vibration in the crystal are known to correspond to the chief planes of the two Nicols. If, however, the field of vision becomes bright the crystal must be rotated, by means of a graduated object-carrier until it is again dark. The angle through which the carrier has been rotated is a measure of the angular inclination of the planes of vibration to the edges of the crystal. When convergent polarized light is used, the majority of crystals of organic substances, which are mostly biaxial, exhibit a lemniscate whose poles are at varying distances apart for various crystals. The distance between the poles of the lemniscate may be measured by suitable methods, is extremely characteristic for those crystals of greatest physiological importance, and may be used, in conjunction with the measurement of the planes of vibration, as a very certain means of determining the crystal. The pleochromatism of many crystals is itself in many cases sufficiently characteristic.—Dr. Virchow described the distribution of blood-vessels in the eye of Selachians, and the several types according to which the vessels are developed in the eyes of various classes of animals.—Dr. Benda made a communication to the effect that the coiled glands which are so widely distributed as sweat-glands in the skin when they exhibit an enlarged secretory part, and a more complicated structure, are known as cerumenous and as mammary glands. They are characterized specially by the fact that during secretion there is no destruction of their epithelium. These modifications of the typical coiled glands have been found by Dr. Benda in large numbers and widely spread in the skin of Protopterus.—Dr. Schneider spoke on the distribution and significance of iron in the animal organism. He was able to find iron in greater or less quantity in the cell protoplasm and nucleus of all classes of animals, the liver and spleen being the organs in which its occurrence was most marked. The connective tissues were very rich in iron, and it was found with similar constancy in the cuticular layers and quite constantly in the extreme tips of fishes' teeth. The more he extended his investigations over the most widely differing classes of animals, whether on land, or in fresh-water, or in the sea, and the more widely different were the organs he examined, by so much the more was it seen that iron is universally present in the animal organism. Its importance is pre-eminently physiological.

AMSTERDAM.

Royal Academy of Sciences, September 28.—Prof. van der Staals in the chair.—M. Suringar dealt with the Melocacti of Aruba, stating what he had himself observed concerning the development of those plants from seed and their subsequent growth. He spoke also of the manner in which the Melocacti might be classified according to their natural affinities, and sketched a pedigree of the species.—M. Schoute spoke of tetrahedra, bounded by similar triangles, and described a new species with pairs of opposite edges 1 and r^3, r and r, r^2 and r^2.

STOCKHOLM.

Royal Academy of Sciences, October 9.—Musci Asiæ Borealis (second part): feather mosses, by the late Prof. S. O. Lindberg, of Helsingfors, and Dr. H. W. Arnell.—On the permanent committee for a photographic map of the heavens and its work, by one of its members, Prof. Dunér.—On the Metre Congress in Paris, September 14-28, this year, and on the prototypes of the metre and the kilogramme, by Prof. Thalén.—Emanuel Swedenborg as a mathematician, by Dr. G. Eneström.—On naphtoë acids, by Dr. A. G. Ekstrand.—Chemical investigation of some minerals from the neighbourhood of Langesund, by Herr H. Bäckström.—An attempt to determine the velocity of light from observations on variable stars, by Dr. C. Charlier.

DIARY OF SOCIETIES.

LONDON.

THURSDAY, NOVEMBER 7.

LINNEAN SOCIETY, at 8.—On a Collection of Dried Plants chiefly from the Southern Shan States, Upper Burma: Colonel H. Collett and W. Botting Hemsley, F.R.S.

CHEMICAL SOCIETY, at 8.—The Isolation of a New Hydrate of Sulphuric Acid existing in Solution: S. U. Pickering.—Further Observations on the Magnetic Rotation of Nitric Acid, of Hydrogen Chloride, Bromide and Iodide in Solution: Dr. W. H. Perkin, F.R.S.—On Phosphoryl Trifluoride: T. E. Thorpe, F.R.S., and F. T. Hambly.—On the Acetylation of Cellulose: C. F. Cross and E. Bevan.—On the Action of Light on Moist Oxygen: A. Richardson.—Anhydracetophenonebenzil and the Constitution of Linius lepideus: Drs. Japp, F.R.S., and Klingsman.

FRIDAY, NOVEMBER 8.

ROYAL ASTRONOMICAL SOCIETY, at 8.

MONDAY, NOVEMBER 11.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Cyprus: Lieut.-General Sir Robert Biddulph, G.C.M.G.

TUESDAY, NOVEMBER 12.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—Observations on the Natura Colour of the Skin in certain Oriental Races: Dr. J. Beddoe, F.R.S.—Manners, Customs, Superstitions, and Religions of South African Tribes: Rev. James Macdonald.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Inaugural Address of Sir John Coode, K.C.M.G., President, and Presentation of Medals, Premiums, and Prizes awarded during Last Session.

WEDNESDAY, NOVEMBER 13.

ROYAL MICROSCOPICAL SOCIETY, at 8.

THURSDAY, NOVEMBER 14.

MATHEMATICAL SOCIETY, at 8.—Isoscelian Hexagrams: R. Tucker.—On Euler's ϕ-Function: H. F. Baker.

FRIDAY, NOVEMBER 15.

PHYSICAL SOCIETY, at 5.—On the Electrification due to the Contact of Gases and Liquids: J. Enright.—On the Effect of Repeated Heating and Cooling on the Electrical Resistance and Temperature Coefficient of Annealed Iron: H. Tomlinson, F.R.S.—Notes on Geometrical Optics, Part II.: Prof. S. P. Thompson.

INSTITUTION OF CIVIL ENGINEERS, at 7.30.—The New Harbour and Breakwater at Boulogne-sur-Mer: S. C. Bailey.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A Popular Treatise on the Winds: W. Ferrel (Macmillan).—South African Butterflies; vol. iii., Papilionidæ and Hesperidæ: R. Trimen and J. H. Bowker (Trübner).—Light, 2nd edition: P. G. Tait (Edinburgh, Black).—The Vertebrate Animals of Leicestershire and Rutland: M. Browne (Birmingham, M. E. C.).—Sitzungsberichte der k. b. Gesellschaft der Wissenschaften Math.-Naturw. Classe, 1889, i. (Prag).—Outlines of a Course of Lectures on Human Physiology: E. A. Parkyn (Allman).—Flower-Land: R. Fisher (Bemrose).—Potential and its Application to the Explanation of Electrical Phenomena: R. Tumlirz, translated by D. Robertson (Rivingtons).—Index Catalogue of the Library of the Surgeon-General's Office, United States Army, vol. x. (Washington).—The Birds of Berwickshire, vol. i.: G. Muirhead (Edinburgh, Douglas).—Idylls of the Field: F. A. Knight (E. Stock).—Atti della Reale Accademia delle Scienze Fisiche e Matematische, serie seconda, vol. iii. (Napoli).—Ferneries and Aquaria: G. Eggett (Dean).—Traité Encyclopédique de Photographie, 15 Octr. (Paris).

CONTENTS.

PAGE
Twenty Years 1
Modern Views of Electricity 5
The Calculus of Probabilities. By F. Y. E. 6
Argentine Ornithology. By R. Bowdler Sharpe . . . 7
Our Book Shelf:—
  Benedikt and Knecht: "The Chemistry of the Coal-Tar Colours." 8
  Gore: "A Bibliography of Geodesy" 9
Letters to the Editor:—
  The Method of Quarter-Squares.—**J. W. L. Glaisher, F.R.S.** 9
  Darwinism.—**Prof. E. Ray Lankester, F.R.S.** . . 9
  Record of British Earthquakes.—**Charles Davison** . 9
  Effects of Lightning.—**W. G. S.** 10
  Electrical Cloud Phenomena.—**Prof. W. K. Burton** 10
  The Use of the Word Antiparallel. (*With Diagrams.*)—**W. J. James** 10
  Fossil Rhizocarps.—**Sir J. Wm. Dawson, F.R.S.** . 10
  Specific Inductive Capacity.—**W. A. Rudge** 10
  Who discovered the Teeth in Ornithorhynchus?—**Dr. C. Hart Merriam** 11
On the Hardening and Tempering of Steel. (*Illustrated.*) **By Prof. W. C. Roberts-Austen, F.R.S.** . 11
On a New Application of Photography to the Demonstration of Certain Physiological Processes in Plants 16
Notes 17
Our Astronomical Column:—
  Stellar Parallax by Means of Photography 19
  Measurements of Double Stars 19
  Barnard's Comet, 1888-89 20
  Biographical Note on J. C. Houzeau 20
  The Karlsruhe Observatory 20
  Objects for the Spectroscope 20
Geographical Notes 20
The Institution of Electrical Engineers 21
University and Educational Intelligence 23
Societies and Academies 23
Diary of Societies 24
Books, Pamphlets, and Serials Received 24