# ANNUAL

OF THE

# NATIONAL ACADEMY OF SCIENCES

FOR

1863-1864.



CAMBRIDGE:
WELCH, BIGELOW, AND COMPANY,
PRINTERS TO THE UNIVERSITY.
1865.

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# PREFACE.

A BY-LAW of the National Academy of Sciences (XVIII.) makes it the duty of the Secretaries to prepare an Annual, and to publish the same on the first day of each year. As but one meeting, that for organization, was held in 1863, the Secretaries were excused from the duty during that year, and the Annual now presented is intended to cover the whole period from the organization of the Academy in April, 1863, to January 1st, 1865.

WOLCOTT GIBBS.
LOUIS AGASSIZ.

# CONTENTS.

# I.

## AN ACT

### TO INCORPORATE THE NATIONAL ACADEMY OF SCIENCES.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, St. Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States Navy, Kentucky; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania; J. L. Le Conte, United States Army, Pennsylvania; J.

Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, Jr., Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California; their associates and successors duly chosen, — are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SECT. 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institutions, and to report the same to Congress.

SECT. 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and re-

ports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

SOLOMON FOOTE,
*President of the Senate pro tempore.*

GALUSHA A. GROW,
*Speaker of the House of Representatives.*

Approved, March 3, 1863.

ABRAHAM LINCOLN, *President.*

## II.

UNITED STATES SENATE, March 5, 1863.

SIR: —

A bill to incorporate the "National Academy of Sciences" has been introduced by me in the Senate, and, having passed through the several stages of legislation, has now become a law, under which you are one of the corporators. In the third section of this act it is enjoined, "that the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated." In order to fulfil the injunction, and to take the first step towards the organization of the Academy, I have to request that you will be pleased to inform me, as soon as possible, at what time it will be most convenient to you to attend a meeting in New York. In naming this time, it is not necessary that you should be more specific than to give the month and part of the month.

After receiving the replies to this circular, I will select a day of meeting which will be most convenient to a majority of the members, and notify you accordingly.

I have the honor to be, with high respect,

Your most obedient servant,

HENRY WILSON.

## III.

WASHINGTON, D. C., March 18, 1863.

SIR: —

Replies have been received to my circular letter of March 5th from more than three fifths of the members of the National Academy of Sciences named in the act of incorporation, a large majority of whom indicate no special date as more acceptable than another, leaning, however, to an early organization.

Where a choice is indicated, the dates indicated are between the last of March and beginning of July, the average being before the middle of May. May and June are excepted by some of the members.

I would therefore select, as convenient to the large part of the members, Wednesday, April 22d.

I shall, if practicable, as suggested by many of the members, be present at 11 A. M., to call the meeting to order, at the Chapel of the University of the City of New York.

I have the honor to be, with high respect,

Your most obedient servant,

HENRY WILSON.

# IV.

# ADDRESS

OF THE

## HON. HENRY WILSON,

DELIVERED AT THE OPENING OF THE FIRST SESSION OF THE ACADEMY, APRIL 22, 1863.

GENTLEMEN:—I hold in my hand the Act, passed in the closing hours of the Thirty-seventh Congress, "To incorporate the National Academy of Sciences." In compliance with many kind requests I am here to call the corporators to order. In rising to perform this agreeable task, I crave for a moment your indulgence.

This Act, under which you have met to organize, incorporates in America, and for America, a National Institution, whose objects, ranging over the illimitable fields of science, are limited only by the wondrous capacities of the human intellect. Such an institution has been for years in the thought and on the tongue of the devotees of science, but its attainment seemed far in the future. Now it is an achieved fact. Our country has spoken it into being, in this "dark and troubled night" of its history, and commissioned you, gentlemen, to mould and fashion its organization, to infuse into it that vital and animating spirit that shall win in the boundless domains of science the glittering prizes of achievement that will gleam forever on the brow of the nation.

When, a few months ago, a gentleman whose name is known and honored in both hemispheres, expressed to me the desire that an Academy of Physical Sciences should be founded in America, and that I would at least make the effort to obtain such an act of incorporation for the scientific men of the United States, I replied, that it seemed more fitting that some statesman of ripe scholarship should take the lead in securing such a measure, but that I felt confident I could prepare, introduce, and carry through Congress a measure so eminently calculated to advance the cause of science, and to reflect honor upon our country. I promptly assumed the responsibility, and with such aid and suggestions as I could obtain, I prepared, introduced, and by personal effort with members of both Houses of Congress, carried through this act of incorporation without even a division in either House.

The suggestion was sometimes made that the nation is engaged in a fearful struggle for existence, and the moment was not well chosen to press such a measure. But I thought otherwise. I thought it just the fitting time to act. I wanted the *savans* of the old world, as they turn their eyes hitherward, to see that amid the fire and blood of the most gigantic civil war in the annals of nations, the statesmen and people of the United States, in the calm confidence of assured power, are fostering the elevating, purifying, and consolidating institutions of religion and benevolence, literature, art and science. I wanted the men of Europe, who profess to see in America the failure of republican institutions, to realize that the people of the United States, while eliminating from their system that ever-disturbing element of discord, bequeathed to them by the colonial and commercial policy of England, are cherishing the institutions that elevate man and ennoble nations. The land resounds with the tread of armies, its bright waters are crimsoned, and its fields reddened with fraternal blood. Patriotism surely demands that we strive to make this now discordant, torn, and bleeding nation one and indivisible. The National Academy of Sciences will, I feel sure, be now and hereafter another element of power to keep in their orbits, around the great central sun of the Union, this constellation of sovereign commonwealths.

This act of incorporation may not be, is not, perfect. The task has been one of difficulty and delicacy. The number of members must be limited, while the most eminent men of science must be recognized, and sectional claims harmonized. If unintentional injustice has been done to any one, if mistakes have been made, time will, I trust, correct the injustice and the mistakes. Changes will surely come. "Death is in the world," and this original list of honored names will not remain long unbroken. If men of merit have been forgotten in this act of incorporation, the Academy should seize the first and every occasion to right the seeming wrong.

This Academy is destined, I trust, to live as long as the republic shall endure, and to bear upon its rolls the names of the *savans* of coming generations. Let it then advance high its standard. Let it be as inflexible as justice, and as uncompromising as truth. Let it speak with the authority of knowledge, that pretension may shrink abashed before it, and merit everywhere turn to it confident of recognition.

In the Providence of God, the Thirty-seventh Congress was summoned to the consideration of measures of transcendent magnitude. It enacted measures, empowering the government to raise hundreds of millions of dollars and millions of men, to protect the menaced life of the nation and preserve the vital spirit of freedom. It dealt with great questions of revenue and of finance. It obliterated an abhorrent system from the national capital, and engraved freedom upon every rood of the national territory. It consecrated the public domain to homesteads for the homeless and landless, and authorized the construction of a railway to unite the Atlantic and the Pacific seas. The enactment of this act to incorporate the Academy of Sciences, was not the least in the long list of acts the Thirty-seventh Congress gave to the country, which will leave their impress upon the nation for ages yet to come. It was my fortune to take a humble part in these great measures of legislation. It is a source of profound gratification to me, that, amid the pressure of public affairs, I have been enabled to contribute something to found this Academy for the advancement of the physical sciences in America. It will ever be among my most cherished recollections, that I have been permitted through your courtesy to unite with you in organizing this National Academy, which, we fondly hope, will gather around it, in the centuries yet to come, the illustrious sons of genius and of learning, whose researches will enrich the sciences, and reflect unfading lustre upon the republic.

# V.

# CONSTITUTION AND BY-LAWS

## OF THE ACADEMY.

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### PREAMBLE.

Empowered by the Act of Incorporation adopted by Congress, and approved by the President of the United States, on the 4th day of March, A. D. 1863, the National Academy of Sciences do enact the following Constitution and By-Laws: —

### ARTICLE I.

*Of Members.*

Section 1. The members of the Academy shall be designated as Members, Honorary Members, and Foreign Associates.

Sect. 2. The Academy shall consist of the fifty members named in the Act of Incorporation, and of such others, citizens of the United States, as shall from time to time be elected to fill vacancies, in the manner hereinafter provided.

Sect. 3. Every member shall, upon his admission, take the oath of allegiance prescribed by the Senate of the United States for its own members, and, in addition thereto, an oath faithfully to discharge the duties of a member of

the National Academy of Sciences to the best of his ability. He shall also subscribe the laws of the Academy.

SECT. 4. The members of the Academy shall be arranged in two Classes, according to their special studies, viz.: A, the Class of Mathematics and Physics, and B, the Class of Natural History. The corporate members may select the Class in which they desire to be arranged.

SECT. 5. The members of the Classes shall arrange themselves in Sections, by inscribing their names under one of the following heads: — Class A. *Mathematics and Physics.* Sections: — 1. Mathematics; 2. Physics; 3. Astronomy, Geography, and Geodesy; 4. Mechanics; 5. Chemistry. Class B. *Natural History.* Sections: — 1. Mineralogy and Geology; 2. Zoölogy; 3. Botany; 4. Anatomy and Physiology; 5. Ethnology.

But the Academy retains the power of transferring a member from one Section to another.

SECT. 6. A member may be elected an honorary member of any Section by a vote of a majority of such Section.

SECT. 7. The Academy may elect fifty Foreign Associates, who shall have the privilege of attending the meetings of the Academy, and of reading and communicating papers to it, but shall take no part in its business, and shall not be subject to its assessments.

They shall be entitled to a copy of the publications of the Academy.

## ARTICLE II.

### *Of the Officers.*

SECT. 1. The officers of the Academy shall be a President, a Vice-President, a Foreign Secretary, a Home Secretary, and a Treasurer, all of whom shall be elected for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner, at the next stated session after the vacancy occurs.

SECT. 2. The officers of the Classes shall be a Chairman and a Secretary, who shall be elected at each January session. The nominations shall be open, and a majority of votes shall be necessary to elect.

SECT. 3. The officers of the Academy and the Chairmen of the Classes, together with four members, two from each Class, to be annually elected by the Academy, at the January session, by a plurality of the votes, shall constitute a Council for the transaction of such business as may be assigned to them by the Constitution or the Academy.

SECT. 4. The President of the Academy, or, in case of his absence or inability to act, the Vice-President, shall preside at the meetings of the Academy and of the Council; shall name all committees, except such as are otherwise especially provided for; refer investigations required by the Government of the United States to members specially conversant with the subject, and report thereon to the Academy at its next January session; and, with the Council, shall direct the general business of the Academy.

It shall be competent for the President, in special cases, to call in the aid, upon committees, of experts, or men of remarkable attainments, not members of the Academy.

SECT. 5. The Foreign and Home Secretaries shall conduct the correspondence proper to their respective departments, advising with the President and Council in cases of doubt, and reporting their action to the Academy at its January session. It shall be the duty of the Home Secretary to give notice to the members of the place and time of all meetings, and to make known to the Council all vacancies in the list of members.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the Home Secretary.

SECT. 6. The Treasurer shall attend to all receipts and disbursements of the Academy, giving such bond, and furnishing such vouchers, as the Council may require. He shall collect all dues from members, and keep a set of books, showing a full account of receipts and disbursements. He shall present at each stated session a list of the members entitled to vote, and a general report at the January session. He shall be the custodian of the corporate seal of the Academy.

## ARTICLE III.

### *Of the Meetings.*

SECT. 1. The Academy shall hold two stated sessions in each year, — one in the city of Washington, on the 3d day of January (unless that day falls on Sunday, when the session shall be held on the succeeding Monday), and one in August, at such time and place as the Academy shall have determined upon, in private meeting, on the last day of the preceding January session.

SECT. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SECT. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business closed.

SECT. 4. The Academy may divide into Classes for scientific or other business. In like manner, the Classes may divide into Sections.

SECT. 5. The Classes shall meet during such periods of the stated meetings of the Academy as may be fixed by the Academy. Special meetings of a Class may be called by the Council at the request of five members of the Class.

SECT. 6. The stated meetings of the Council shall be held at the times of the stated or special meetings of the Academy. Special meetings shall be convened at the call of the President and two members of the Council, or of four members of the Council.

SECT. 7. No member who has not paid his dues shall take part in the business of the Academy.

## ARTICLE IV.

### *Of Elections, Regulations, and Expulsions.*

SECT. 1. All elections shall be by ballot, unless otherwise ordered by this Constitution; and each election shall be held separately.

SECT. 2. Whenever any election is to be held, the presiding officer shall name a Committee to conduct it, to collect the votes, count them, and report the result to the Academy. The same law shall apply in the Classes.

SECT. 3. Nominations for officers shall be made at the close of the first daily meeting of a stated session; and no candidate shall be voted for unless thus nominated.

SECT. 4. For election of members, the Council shall first decide the Class in which the vacancy shall be filled. Each Section of that Class may then select one or more candidates, after a discussion of their qualifications, and present their claims to the Class, who shall select three to be presented, in the order of their preference, to the Academy; from these three the Academy shall elect by a majority of the members present. The member elect shall be assigned to the Section in which he has been proposed. The Academy may nominate candidates in any Section which fails to propose them for itself.

SECT. 5. Every member elect shall accept his membership personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the Secretary has formally notified him of his election, his name shall not be entered on the roll of members.

SECT. 6. Elections of Foreign Associates shall be conducted as follows:—

Each Section shall report to its Class, nominating a candidate whose special researches need not belong within the province of the Section, but must be comprised within the range of the Class.

From these candidates each Class shall select one name to be presented to the Academy, and from these two names the Academy, after full discussion, shall make the election, at such time as it may have previously appointed for the purpose.

SECT. 7. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate Secretary to each member on his acceptance of his membership.

SECT. 8. Resignations shall be addressed to the President and acted on by the Academy. No resignation of membership shall be accepted unless all dues have been paid.

SECT. 9. Members resigning in good standing will retain an honorary membership; being admitted to the meetings of the Academy, but without taking part in the business. Honorary members will not be liable to assessment.

SECT. 10. If any member be absent from four consecutive stated meetings of the Academy, without communicating to the Academy a valid reason for his absence, his name shall be stricken from the roll of members.

SECT. 11. Members and officers habitually neglecting their duties shall be impeached by the Council, and at once notified thereof in writing by the Home Secretary.

SECT. 12. Impeachments of members or officers shall first be tried before the Council; which may be convened specially for such purpose. If it decides that the impeachment is proper, such impeachment shall be tried in private session before the Academy at its next stated meeting.

SECT. 13. The expulsion of a member shall be formally and publicly announced by the President at the stated session during which such expulsion shall take place.

## ARTICLE V.

### *Of Scientific Communications, Publications, and Reports.*

SECT. 1. Papers on scientific subjects may be read at the meetings of the Academy or of the Classes or Sections to which the subject belongs.

SECT. 2. Any member of the Academy may read a paper from a person who is not a member; and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

SECT. 3. The Academy shall provide for the publication, under the direction of the Council, of Proceedings, Memoirs, and Reports.

SECT. 4. Propositions for investigations or reports shall originate with the Classes to which the subjects belong, and be by them submitted to the Academy for approval; except requests from the Government of the United States, which shall be acted on by the President, who will in such cases report, if necessary, at once to the Government, and to the Academy at its next stated meeting.

SECT. 5. The judgment of the Academy shall be at all times at the disposition of the Government, upon any matter of Science or Art within the limits of the subjects embraced by it.

SECT. 6. An Annual Report to be presented to Congress, shall be prepared by the President, and before its presentation submitted by him, first to the Council, and afterwards to the Academy at its January meeting.

SECT. 7. Medals and Prizes may be established, and the means of bestowing them accepted, by the Academy, upon the recommendation of the Council; by whom all the necessary arrangements for their establishment and award shall be made.

## ARTICLE VI.

*Of the Property of the Academy.*

SECT. 1. All investments shall be made by the Treasurer in the corporate name of the Academy, in stocks of the United States.

SECT. 2. No contract shall be binding upon the Academy, which has not been first approved by the Council.

SECT. 3. The assessments required for the support of the Academy, shall be fixed by the Academy on the recommendation of the Council.

## ARTICLE VII.

*Of Additions and Amendments.*

Additions and Amendments to the Constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change may be given at any stated session, and shall be referred to the Council, which may amend the proposition, and shall report thereon to the Academy at its next stated session, with a recommendation that it be accepted or rejected. Its report shall be considered by the Academy in Committee of the Whole, and immediately thereafter acted on. If the addition or amendment receive two thirds of the votes present, it shall be declared adopted, and shall have the same force as the original law.

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## EXPLANATORY CLAUSE.

In consequence of differences of opinion in relation to the interpretation of Section 4 of Article IV. of the Constitution of the Academy, the following resolution was passed Aug. 5, 1864: —

"*Resolved*, That the Academy is of opinion that Section 4 of Art. IV. of the Constitution is to be interpreted to mean, that any Section of either Class making a nomination shall be restricted in the choice to persons eminent in the branch or branches of science understood to be included in the title of the Section."

# BY-LAWS.

## OF THE OFFICERS.

I. In the absence of the Chairman or Secretary of a Class, a member shall be chosen to perform his duties temporarily, by a plurality of the *viva voce* votes, upon open nomination.

II. The accounts of the Treasurer shall be referred to an Auditing Committee of three members, to be appointed by the Academy at the meeting at which the accounts are presented; which committee shall report before the close of that session, and shall then be discharged.

## OF THE MEETINGS.

III. A Committee of Arrangements, for each stated session of the Academy, of five members, shall be appointed by the President, the Class Secretaries to be ex-officio two of the members of the Committee. This Committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings, to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, etc.; and to arrange the order of reading, and in general to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be as follows: —

1. Chair taken by the President, or, in his absence, the Vice-President.
2. Roll of members called by Home Secretary.
3. Report by Treasurer of members entitled to vote.
4. Minutes of the preceding meeting read and approved.
5. Stated business.
6. Reports of President, Secretaries, Treasurer, Classes, and Committees.
7. Business from Council.
8. Other business.
9. Communications from members.
10. Communications from persons not members.
11. Announcements of the death of members. Biographical notices read.
12. Rough minutes read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless otherwise directed.

VI. It shall be in order for twelve members to require that any matter of business be discussed in Committee of the Whole, for amendment; the vote upon amendments to be taken in the whole Academy; and the amended proposition or propositions to be similarly voted on.

VII. The scientific meetings shall be convened at twelve o'clock, M., in order to allow time for the business meetings of the Academy, and for the meetings of Classes, Sections, and Committees.

## OF ELECTIONS AND OBITUARIES.

VIII. No more than ten Foreign Associates shall be elected at any one stated session.

IX. The death of members shall be announced by the President on the last day of each stated session, when a

member shall be selected by the Academy to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member shall be selected by the Academy in place of the first, and so on until the duty is performed.

X. The deaths of such eminent scientific men of the country as have taken place since the last session of the Academy shall be announced by the President. The names shall be selected by the Council.

## OF SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

XI. An analysis of the memoirs and reports read in the meeting of the Classes shall be given by the Secretaries of the Classes to the Home Secretary for publication in the proceedings of the Academy. For any failure in this duty, the delinquent officer shall be impeached by the Home Secretary.

XII. The Secretaries shall receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy, Class, or Section, and ordered to be published by the Academy. Papers shall be published in the order in which they were registered, but papers which have not been sent to the Secretary within a month from the time of their reading, shall not be published without a special vote of the Academy.

XIII. Memoirs shall date in the records of the Academy from the day of their presentation to the Academy, and the order of their presentation shall be that on which they were registered, unless changed by consent of the author.

XIV. The publication of any communication to which remonstrance is made by the Section to which the subject belongs, shall be suspended until a second time authorized by a vote of the Academy.

XV. Papers from persons not members, read before the Academy, Classes, or Sections, and intended for publication, shall be referred, at the meeting at which they are read, to a Committee of members competent to judge whether the paper is worthy of publication. Such Committees shall report to the Academy as early as practicable, and not later than the next stated session. If they do not then report, they shall be discharged, and the paper referred to another Committee.

XVI. Abstracts of papers published in the transactions of other societies or in journals may be communicated orally to the Academy; and if, on submitting any such communication to a Committee, its publication be approved, it may be ordered for publication on a vote of the Academy.

XVII. Short communications or abstracts of memoirs may be sent by any member to the Home Secretary, who shall, if requested by the author, without delay circulate them among the members.

XVIII. An Annual of the Academy shall be prepared by the Secretaries, and published on the first day of each year.

XIX. The printing of the Academy shall be under the charge of the Secretaries and the Treasurer, as a Committee of Publication, who shall report in relation thereto at each January meeting of the Academy.

XX. The Annual Report of the Academy may be accompanied by a memorial to Congress, in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XXI. The Home Secretary shall present to the Council estimates for books and stationery, binding, &c., required for the use of the Academy.

## OF THE PROPERTY OF THE ACADEMY.

XXII. The proper Secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XXIII. The books, apparatus, archives, and other property of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles deposited shall be kept by the Home Secretary, who is authorized to employ a clerk to take charge of them.

XXIV. A stamp corresponding to the corporate seal of the Academy shall be kept by the Secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels or other proper marks, of similar device, shall be placed upon objects not admitting of the stamp.

## OF CHANGES IN THE BY-LAWS.

XXV. Any By-Law of the Academy may be amended or repealed on the written motion of any two members, signed by them, and presented at a stated session of the Academy; provided the same shall be approved by a majority of the members present at the next stated session.

# VII.

## ORGANIZATION OF THE ACADEMY.

1863 – 64.

Alexander Dallas Bache, *President.*
James Dwight Dana, *Vice-President.*
Louis Agassiz, *Foreign Secretary.*
Wolcott Gibbs, *Home Secretary.*
Fairman Rogers, *Treasurer.*

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### COUNCIL FOR 1863.

The Officers of the Academy and the Chairmen of the Classes *ex officio.*

Charles Henry Davis.
John Torrey.
Lewis M. Rutherfurd.
J. Peter Lesley.

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# OFFICERS OF THE CLASSES.

## 1863.

### CLASS OF MATHEMATICS AND PHYSICS.

BENJAMIN PEIRCE, *Chairman.*
BENJ. A. GOULD, *Secretary.*

### CLASS OF NATURAL HISTORY.

BENJAMIN SILLIMAN, SR., *Chairman.*
J. S. NEWBERRY, *Secretary.*

## 1864.

### CLASS OF MATHEMATICS AND PHYSICS.

BENJAMIN PEIRCE, *Chairman.*
BENJ. A. GOULD, *Secretary.*

### CLASS OF NATURAL HISTORY.

AUGUSTUS A. GOULD, *Chairman.*
JAMES HALL, *Secretary.*

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# SECTIONS.

### CLASS OF MATHEMATICS AND PHYSICS.

SECTION I. *Mathematics.*

J. G. BARNARD.
H. A. NEWTON.
THEODORE STRONG.
WILLIAM CHAUVENET.
BENJAMIN PEIRCE.
JOSEPH WINLOCK.

### Section II. *Physics.*

A. D. Bache.
W. H. C. Bartlett.
F. A. P. Barnard.
A. A. Humphreys.
Joseph Henry.
Wm. B. Rogers.

### Section III. *Astronomy, Geography, and Geodesy.*

Stephen Alexander.
Alexis Caswell.
J. H. C. Coffin.
Charles H. Davis.
J. M. Gilliss.
Benj. A. Gould.
Arnold Guyot.
Lewis M. Rutherfurd.
John Rodgers.

### Section IV. *Mechanics.*

J. H. Alexander.
J. F. Frazer.
J. E. Hilgard.
D. H. Mahan.
Fairman Rogers.
Joseph Saxton.

### Section V. *Chemistry.*

Wolcott Gibbs.
Benj. Silliman, Jr.
John Torrey.

## CLASS OF NATURAL HISTORY.

### Section I. *Mineralogy and Geology.*

J. P. Lesley.
Leo Lesquereux.
James Hall.
J. S. Newberry.
Benj. Silliman, Sr.
J. D. Whitney.

### Section II. *Zoölogy.*

Louis Agassiz.
James D. Dana.
Spencer F. Baird.
Augustus A. Gould.
John L. LeConte.

SECTION III. *Botany.*

ASA GRAY.

SECTION IV. *Anatomy and Physiology.*

JEFFRIES WYMAN. JOHN C. DALTON.

SECTION V. *Ethnology.*

# VIII.

## COMMITTEES OF THE ACADEMY.

### I.

*Committee on Weights, Measures, and Coinage.*

(Appointed May 4th, 1863, at the request of the Hon. S. P. Chase, Secretary of the Treasury of the United States, dated April 24th, 1863.)

JOSEPH HENRY, *Chairman.*

J. H. ALEXANDER. ARNOLD GUYOT.
FAIRMAN ROGERS. BENJ. SILLIMAN, JR.
WOLCOTT GIBBS. WM. CHAUVENET.
JOHN TORREY.
A. D. BACHE. (By resolution of the Academy.)
JOHN RODGERS. (Jan. 5th, 1864.)
L. M. RUTHERFURD. (Jan. 5th, 1864.)

And by authority of Art. II., Sec. 4,

SAMUEL B. RUGGLES.

Mr. Henry, Chairman of the Committee on Weights, Measures, and Coinage, reported to the Academy on behalf of the Committee, January 9th, 1864, and offered the following resolution, which was adopted.

*Resolved,* That the Committee on Weights, Measures, and Coinage have leave to continue their labors and business now in progress, with power.

(A copy of the Report was submitted to the Secretary of the Treasury.)

## II.

*Committee on the Subject of Protecting the Bottoms of Iron Ships from Injury by Salt Water.*

(Appointed May 9th, 1863, at the request of the Navy Department, through Rear-Admiral Davis, made May 8th, 1863.)

Wolcott Gibbs, *Chairman.*

Benj. Silliman, Sr. John Torrey.
Robert E. Rogers. Benj. Silliman, Jr.
John Rodgers. (January, 1864.)

The Committee presented a report to the Academy, January 9th, 1864, when the following resolution was passed, and the Committee was discharged.

*Resolved*, That the report of the Committee on the protection of the bottoms of iron ships be adopted, and that a series of experiments on the subject be undertaken by a Committee of the Academy whenever the requisite means are provided therefor.

(A copy of the Report was forwarded to the Navy Department, February 4th, 1864.)

## III.

*Committee to investigate and report upon the Subject of Magnetic Deviations in Iron Ships.*

(Appointed May 20th, 1863, at the request of the Navy Department, made through Rear-Admiral Charles Henry Davis, May 8th, 1864.)

A. D. Bache, *Chairman.*

Joseph Henry. Benj. Peirce.
Wolcott Gibbs. Charles H. Davis.
Fairman Rogers. (May 26th, 1863.)

And by authority of Art. II., Sec. 8,

Wm. P. Trowbridge.

The Committee presented a Report to the Academy, January 7th, 1864, when on motion the Report with the accompanying documents was accepted and the Committee continued.

(A copy of the Report was forwarded to the Navy Department, February 11th, 1864.)

## IV.

*Committee to investigate and report on Saxton's Alcoholometer.*

(Appointed May 25th, 1863, at the request of A. D. Bache, Superintendent of U. S. Weights and Measures, May 25th, 1863.)

J. F. Frazer, *Chairman.*
F. A. P. Barnard. Wm. Chauvenet.
Joseph G. Totten.

The Committee reported to the Academy, January 7th, 1864, when the following resolution was passed: —

*Resolved,* That the words following be added to the close of the Report, viz.: "It being understood that Mr. Saxton places this invention at the disposal of the Government without any view to remuneration."

The report was then accepted, and the Committee was discharged.

## V.

### *Committee on Wind and Current Charts and Sailing Directions.*

(Appointed May 25th, 1863, at the request of the Navy Department, conveyed through Rear-Admiral C. H. Davis, May 23d, 1863, asking for an investigation and report on the subject of discontinuing the publication, in the present form, of the Wind and Current Charts and Sailing Directions.)

F. A. P. Barnard, *Chairman.*

J. H. Alexander. Alexis Caswell.
Wm. Chauvenet. J. H. C. Coffin.
J. F. Frazer. A. Guyot.
J. E. Hilgard. Benj. Peirce.
Joseph Winlock.

J. P. Lesley. (June 2d, 1863.)
J. D. Dana. (July 15th, 1863.)

The Committee on Wind and Current Charts reported January 9th, 1864, when the following resolutions offered by the Committee, were adopted: —

*Resolved*, by the National Academy of Sciences, That in the opinion of this Academy the volumes entitled "Sailing Directions," heretofore issued to Navigators from the Naval Observatory, and the Wind and Current Charts which they are designed to illustrate and explain, embrace much which is unsound in philosophy and little that is practically useful, and that therefore these publications ought no longer to be issued in their present form.

*Resolved*, That the records of meteorological phenomena and of the important facts connected with terrestrial physics, which, under the direction of the Navy Department, have been accumulated at the Observatory, are capable of being turned to valuable account, and that it is eminently desirable that such information should continue to be collected and subjected to careful discussion.

*Resolved,* That the President of the Academy be authorized and requested to communicate to the Secretary of the Navy a copy of the foregoing resolutions and of this report, as a response to the inquiry addressed to the Academy upon this subject by that officer.

The Committee was then discharged.

## VI.

### *A Committee on National Currency.*

(Appointed September 5th, 1863, at the request of the Hon. S. P. Chase, Secretary of the Treasury, made August 17th, 1863.)

John Torrey, *Chairman.*
Joseph Henry.
F. A. P. Barnard.
Joseph Saxton.

And by authority of Article 11, Section 4,
George C. Schaeffer.

January 7th, 1864. — The Committee reported successful progress, and were continued.

The following resolutions were adopted by the Academy: —

*Resolved,* That said Committee be empowered to communicate directly with the Secretary of the Treasury, and to take order in reference to the matters intrusted to them.

*Resolved,* That the President of the Academy communicate the foregoing resolution to the Hon. Secretary of the Treasury.

(Communication made January 14th, 1864.)

## VII.

*A Committee on the Question of Tests for the Purity of Whiskey.*

(Appointed January 14th, 1864, at the request of the Acting Surgeon-General, January 5th, 1864.)

B. SILLIMAN, Jr., *Chairman.*
JOHN TORREY.
R. E. ROGERS.
J. H. ALEXANDER.

March 12th, 1864. A communication was sent from the Committee to Acting Surgeon-General I. R. Barnes, recommending that an appropriation of $ 3,500 be made to meet the expenses of the investigation.

March 25th, 1864. A letter was received from Acting Surgeon-General Barnes, stating that an appropriation of $ 3,500 had been authorized by the Secretary of War, and that Surgeon R. S. Satterlee, U. S. A., Medical Purveyor at New York, would be instructed to pay accounts for necessary purchases, etc., upon approval by the Committee.

## VIII.

*A Committee on the Expansion of Steam.*

February 29th, 1864. The Hon. Gideon Welles, Secretary of the Navy, invited the appointment of a committee of three members of the Academy to act jointly with three members named by the Department and with three members of the Franklin Institute of Pennsylvania, for the promotion of the Mechanic Arts, to conduct, witness, and report upon experiments which may be agreed upon by the Commission on the expansion of Steam. The experiments are to be reported as early as practicable to the Department, and to be submitted also to the National Academy of Sciences for its judgment and suggestions.

March 10. The Committee of the Academy was appointed, to consist of

FAIRMAN ROGERS. F. A. P. BARNARD.
JOSEPH SAXTON.

[The Navy Department named as its members of the joint Commission,

HORATIO ALLEN, *Chairman.*
ADMIRAL C. H. DAVIS. B. F. ISHERWOOD.

The Franklin Institute named as its members of the joint Commission,

J. H. TOWNE. J. V. MERRICK.
R. A. TILGHMAN.]

## IX.

### *A Committee on Cent Coinage.*

(Appointed April 11th, 1864, upon the invitation of the Hon. S. P. Chase, Secretary of the Treasury, March 30th, 1864, to examine and report upon Aluminum bronze, and other materials for the manufacture of cent coins.)

JOHN TORREY, *Chairman.*
JOSEPH HENRY.
WOLCOTT GIBBS.
F. A. P. BARNARD.
A. D. BACHE. (By request of the Department.)

The Committee reported to the Academy, August 6th, 1864. A copy of the Report was transmitted to the Hon. W. P. Fessenden, Secretary of the Treasury, August 25th, 1864.

## X.

### *A Committee on the Explosion of the Boiler of the U. S. Steamer Chenango.*

(Appointed May 2d, 1864, by the President of the Academy, under verbal authority received from the Assistant Secretary of the Navy, G. V. Fox, April 30th, 1864.)

John F. Frazer, *Chairman.*

F. Rogers. L. M. Rutherfurd.

The Committee reported to the Academy, August 5th, 1864, a copy of the Report having been previously forwarded to the Department.

# VIII.

## MEMBERS OF THE ACADEMY.

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| Agassiz, Louis, | Cambridge, Mass. |
| Alexander, John Henry, | Baltimore, Md. |
| Alexander, Stephen, | Princeton, N. J. |
| Bache, Alexander Dallas, | Washington, D. C. |
| Barnard, Frederick A. P., | New York, N. Y. |
| Barnard, John G., | U. S. A., Washington, D. C. |
| Bartlett, Wm. H. C., | U. S. A., West Point, N. Y. |
| Baird, Spencer F., | Washington, D. C. Elected, August 1864. |
| Caswell, Alexis, | Providence, R. I. |
| Chauvenet, William, | St. Louis, Mo. |
| Coffin, John H. C., | U. S. N. Newport, R. I. |
| Dalton, John Call, | New York, N. Y. Elected, August, 1864. |
| Dana, James Dwight, | New Haven, Conn. |
| Davis, Charles Henry, | U. S. N., Washington, D. C. |
| Engelmann, George, | St. Louis, Mo. |
| Frazer, John Fries, | Philadelphia, Penn. |
| Gibbs, Wolcott, | Cambridge, Mass. |
| Gilliss, James Melville, | U. S. N., Washington, D. C. |
| Gould, Benjamin Apthorp, | Cambridge, Mass. |
| Gould, Augustus Addison, | Boston, Mass. |
| Gray, Asa, | Cambridge, Mass. |
| Guyot, Arnold, | Princeton, N. J. |
| Hall, James, | Albany, N. Y. |
| Henry, Joseph, | Washington, D. C. |

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| Hilgard, Julius E., | Washington, D. C. |
| Humphreys, Andrew A., | U. S. A., Washington, D. C. |
| Le Conte, John L., | U. S. A., Philadelphia, Pa. |
| Leidy, Joseph, | Philadelphia, Penn. |
| Lesley, J. Peter, | Philadelphia, Penn. |
| Lesquereux, Leo, | Columbus, Ohio. Elected, August, 1864. |
| Longstreth, Miers Fisher, | Philadelphia, Penn. |
| Mahan, Dennis H., | U. S. A., West Point, N. Y. |
| Newberry, John S., | Cleveland, Ohio. |
| Newton, Hubert A., | New Haven, Conn. |
| Peirce, Benjamin, | Cambridge, Mass. |
| Rodgers, John, | U. S. N., Washington, D. C. |
| Rogers, Fairman, | Philadelphia, Penn. |
| Rogers, Robert E., | Philadelphia, Penn. |
| Rogers, William B., | Boston, Mass. |
| Rutherfurd, Lewis M., | New York, N. Y. |
| Saxton, Joseph, | Washington, D. C. |
| Silliman, Benjamin, Sr., | New Haven, Conn. |
| Silliman, Benjamin, Jr., | New Haven, Conn. |
| Strong, Theodore, | New Brunswick, N. J. |
| Torrey, John, | New York, N. Y. |
| Winlock, Joseph, | Cambridge, Mass. |
| Wyman, Jeffries, | Cambridge, Mass. |
| Whitney, Josiah Dwight, | San Francisco, Cal. |

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There are at present, January 1, 1865, two vacancies in the Academy. Of the fifty members originally appointed by Act of Congress, three have died since the first Session of the Academy, namely, Joseph S. Hubbard, Joseph G. Totten, and Edward Hitchcock. Two members by appointment, namely, Uriah A. Boyden, and John A. Dahlgren, declined to accept membership of the Academy.

# IX.

## FOREIGN ASSOCIATES.

The following Foreign Associates were elected at the January Meeting in 1864: —

Sir Wm. Rowan Hamilton.
Karl Ernst Von Baer.
Michael Faraday.
J. B. Élie de Beaumont.
Sir David Brewster.
G. A. A. Plana.*
Robert Bunsen.
Friedrich Wilhelm August Argelander.
Michel Chasles.
Henry Milne-Edwards.

* Since deceased.

X.

# ANNUAL REPORT OF THE PRESIDENT

## FOR 1863.

# ANNUAL REPORT.

NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., March 28, 1864.

HON. HANNIBAL HAMLIN,
*Vice-Pres. United States, President of the Senate.*
HON. SCHUYLER COLFAX,
*Speaker House of Representatives.*

THE Constitution of the National Academy of Sciences, (Article V, Section 6,) incorporated at the Third Session of the Thirty-seventh Congress, requires that "An Annual Report, to be presented to Congress, shall be prepared by the President, and submitted by him first to the Council, and afterward to the Academy at its January meeting." In accordance with this provision, I have submitted the following report to the Council, and to the National Academy at their first stated meeting, and now present it on their behalf to Congress.

The want of an institution by which the scientific strength of the country may be brought from time to time to the aid of the government, in guiding action by the knowledge of scientific principles and experiments, has long been felt by the patriotic scientific men of the United States. No government of Europe has been willing to dispense with a body, under some name, capable of rendering such aid to the government, and in turn of illustrating the country by scientific discovery and by literary culture.

It is a remarkable fact in our annals that, just in the midst of difficulties which would have overwhelmed less resolute men, the Thirty-seventh Congress of the United States, with an elevated policy worthy of the great nation which they represented, took occasion to bring the scientific men around them in council on scientific matters, by creating the National Academy of Sciences. Such has been the way in which the public mind has been stirred before in the annals of other countries, leading to the organization of great systems of education, science, art, and literature, to be encouraged and perfected when more peaceful and prosperous times recurred. The Bill (marked A) to Incorporate the National Academy of Sciences, was passed in the Senate of the United States in February, in the House of Representatives in March, signed by the President on the 4th of March, and, as if to render it more acceptable to the men of science of the country, without opposition, from the time when unanimous consent was asked and obtained by Mr. Wilson, in the Senate, to bring in the bill, to the signature by the President.

In pursuance of the provisions of that Act, the members of the National Academy met in New York on the 22d of April, 1863, and completed their organization, renewing by their loyal oath their obligations to serve their country and its constituted authorities to the best of their abilities and knowledge, on such subjects as were embraced in their charter, and upon which they might be consulted, and adopting a Constitution and Laws which they supposed would enable them to carry on successfully the plans of Congress as sketched in the charter.

Providing for the full and deliberate consideration and arrangement of their laws by a Committee selected for their capability in such a task, the Academy adopted the laws presented to their discussion, divided into Classes and Sections for the consideration of matters of science, elected officers, (see list marked B,) and adjourned to a stated day, the 4th of January, and to Washington, the National Capital, with which they were henceforth to be connected in their membership of the National Academy of Sciences.

The first trial of the working of the Academy was to be made, and the first effort was to be through the action of a Committee on Weights and Measures, for the appointment of which, to consider the subject of the "Uniformity of Weights, Measures, and Coins, considered in relation to domestic and international commerce," the Academy had been addressed before its adjournment by the Hon. Secretary of the Treasury, S. P. Chase.

It was obvious that the only effective and prompt mode of action by members scattered over the United States, as were the fifty named in the charter, must be through committees. Action must originate with committees, and be perfected by discussion in the general meetings of the Academy, or in the classes or sections. Decisions to be finally pronounced by the entire body.

To avoid delay in reports which might be desired by the government to be promptly furnished, the President of the Academy was authorized to transmit such reports on their reception. It has not appeared to me, except, perhaps, in one case, and in that the conclusions of the Committee had not reached me, that there was occasion to present the reports until they had been discussed in the Academy itself, and the views had been adopted; especially as this was, as I have said before, a first trial of the working of our organization. One of the committees thus acting has been able to meet so often, and with so many members at a meeting, as to show that in important cases, where consultation and discussion must be had, there will be little difficulty in effecting meetings; while in most cases correspondence amply suffices for the settlement of the questions involved, and to bring out the results in the form of a report with suggestions.

It will be seen by the spirit and words of our laws, enacted by the authority of the charter, that the members of the National Academy put their time and talents at the disposal of the country in no small or stinted measure, freely, fully, by the binding authority of an oath; asking no compensation therefor but the consciousness of contributing to judicious action by the government on matters of science. The more the wealth of such men can be drawn out from the treasury of their knowledge, the richer will the nation be; and I for one do not fear that even the suggestions which may be made to Congress of subjects in which that knowledge may be most profitably employed for our country and times, will be subject to any supposed taint of self-seeking as to power or influence. Subject to the taint of supposed desire for remuneration it cannot be, by our charter, and all our laws look away from such a centre.

Since the organization of the National Academy of Sciences in April last, six committees have been appointed under the authority of Article II., Section 4, — two by application from the Treasury Department, one from the Office of United States Weights and Measures, of the same Department, and three by application from the Navy Department, or, under its authority, from the Bureau of Navigation. These applications, referring to physical, chemical, and mathematical subjects generally, have been committed to members of the Physical Class of the Academy, with a few special exceptions only. These subjects are assuredly of eminent practical value; and if the Academy, by the reports of its committees, or by their own discussions, shall give the information asked for, or shall point out the best ways of obtaining it, the members will, at the outset, have returned to the government and country the boon of their organization as a national institution. The importance of a body which can thus put the Departments and Congress on a level with the knowledge of science of the day, and by disinterested advice may keep it out of the hands of schemers, and provide the methods, intelligence, and knowledge for experimental inquiries, will thus, in the earliest days of the organization, be put to a complete test.

The subjects embraced in the references of the Departments are as follows: —

1. From the Treasury Department. Weights, Measures, and Coins, their decimalization, &c.

2. From the Navy Department. Protection of the bottoms of iron vessels from corrosion by sea-water, and from fouling.

3. From the Navy Department. Correction of the compasses of naval vessels, especially of iron vessels and of iron-clads.

4. From the Treasury Department. Saxton's new alcoholometer, intended as a substitute for the hydrometer now in use.

5. From the Navy Department. Inquiry as to the expediency of continuing, in their present form, the publication, by the Navy Department, of the Wind and Current Charts and of the Sailing Directions.

6. From the Treasury Department. Methods of protecting the national currency from being counterfeited.

The subject of weights and measures, and of coins, is undoubtedly one of the most important in the uses of common life; and upon a right or wrong determination in regard to the system depends the convenience of the great mass of the people of a country; and upon international determinations the convenience of all engaged, directly or indirectly, in commerce and kindred pursuits.

In the report of the Secretary of the Treasury (Hon. S. P. Chase), in 1861, occurs the following sentence in regard to weights, measures and coins (page 22): "The Secretary desires to avail himself of this opportunity to invite the attention of Congress to the importance of a uniform system and a uniform nomenclature of weights, measures, and coins, to the commerce of the world, in which the United States already so largely shares. The wisest of our statesmen have regarded the attainment of this end, so desirable in itself, as by no means impossible. The combination of the decimal system with appropriate denominations in a scheme of weights, measures, and coins, for the international uses of commerce, leaving, if need be, the separate systems of nations untouched, is certainly not beyond the reach of the daring genius and patient endeavor which gave the steam-engine and the telegraph to the service of mankind."

This Committee, No. 1, was appointed as follows: Professor Joseph Henry, Chairman, Professor J. H. Alexander, Professor Fairman Rogers, Dr. Wolcott Gibbs, Professor A. Guyot, Professor B. Silliman, Jr., Professor William Chauvenet, Dr. John Torrey, Professor A. D. Bache (appointed by resolution of Academy), Commodore John Rodgers, U. S. N., and L. M. Rutherfurd.

It is not a little strange that in our country, where, notwithstanding the capital error committed in long retaining in use foreign coins which stood in no convenient relation to the established system, the decimal system proved at once so acceptable, nothing of the kind was effected for weights and measures. It is still more strange that the antiquated and cumbrous variety of tables by which articles of different classes were bought and sold should have been retained; that, even in our preparation of a national system intended for practical use, neither the decimalization of the weights and measures, nor the simplicity of one weight of one name, should have been adopted. The influence of great names can alone probably explain this, without justifying it.

The Committee laid out an extended scheme of reports by their members on the weights and measures of the principal countries of the world, a part of which have been already received, and are, for the present, retained in the archives of the Committee.

The discussions in the body of this Committee were very strongly in favor of the adoption of the French metrical system, but more strongly, in fact unanimously, in favor of the effort to arrive at a thorough international system, — a universal system of weights, measures, and coins, available for the general acceptance of all nations.

The Committee has received, through oral communications from the Hon. S. B. Ruggles, delegate appointed by the government of the United States to the International Statistical Congress at Berlin, authentic information as to the propositions made or adopted in that body in regard to weights, measures, and coins.

A communication, marked C, was received from the Hon. Secretary of State, and the following resolution was adopted by the Academy in regard to it: —

"*Resolved*, That the letter of the Secretary of State be referred to the Committee on Weights and Measures, with power to take such order as may in their judgment be necessary."

This Committee had several meetings during the recesses of the Academy, and finally the following report, marked

D, was submitted, and the resolution appended to it adopted by the Academy: —

"*Resolved*, That the Committee on Weights and Measures ask leave to continue their labors and business now in progress, with the power to take action."

The second Committee was appointed at the request of the Permanent Commission of the Navy Department, through the Chief of the Bureau of Navigation, on the highly important practical subject of the protection of the bottoms of iron vessels from corrosion by salt water.

The Committee consisted of Prof. W. Gibbs, Chairman, Prof. B. Silliman, Jr., Dr. John Torrey, Dr. R. E. Rogers, Prof. Benjamin Silliman, and Commodore John Rodgers, U. S. N., who, after an examination of the subject, presented to the Academy a report which was adopted on the 9th of January. They state that the methods hitherto proposed for such protection depend upon one or other of the following principles:

1st. Those which are designed to prevent or arrest, wholly or in part, the corrosion of the metal.

2d. Those intended to avoid the accumulation of living plants and animals upon the bottoms of iron ships, known technically as fouling.

The remedies for these two very distinct classes of injury to iron vessels naturally fall under the following heads: —

*a*. Those in which a metallic coating or alloy is employed, or those in which paints, with or without metallic oxides, are relied on.

*b*. The use of some poisonous substance as an ingredient of a paint or varnish, for the specific purpose of destroying the life of those plants and animals, the accumulation of which constitutes fouling.

These are discussed in the report which is hereto appended, marked E. The Committee points out that no reliable systematic experiments have been made upon the relative power of American irons to resist corrosion by sea-water, which they consider of cardinal importance. They point out also the importance of experiments on the use of oak timber as a backing to the armor of iron vessels, and are of opinion that no method yet proposed can be considered as sufficiently tested to merit a recommendation to the Department; that the question is still an open one, and that the naval and commercial interests of the country would in all probability be materially advanced by a careful and thorough experimental investigation of the whole subject.

The Secretary of the Smithsonian Institution has offered to place the laboratory under his charge at the disposal of the Committee for the purpose of investigation.

The Committee is of the opinion that no proper investigation can be made of these important subjects, unless an appropriation to defray the necessary expenses be made by the Department, or, if necessary, by Congress.

The conclusions of the Committee were adopted by the Academy in the following resolution: —

"*Resolved*, That the report of the Committee on the Coating of Iron Ships be adopted, and that a series of experiments on this subject be undertaken by a committee of the Academy, whenever the requisite means are provided therefor."

The subject, referred by the Chief of the Bureau of Navigation, by instructions from the Navy Department, of investigation of the magnetic deviation in iron ships, and of the correction of the compasses, including the correction of those of naval vessels, was referred to Committee No. 3, whose preliminary report is presented herewith, lettered F. This Committee consists of Prof. A. D. Bache, Prof. Jos.

Henry, Prof. B. Peirce, Prof. W. Gibbs, Admiral C. H. Davis, and Prof. Fairman Rogers, and Prof. W. P. Trowbridge, appointed under Art. II., Sect. 4, of the Constitution of the Academy. It was first named by the Navy Department, and the Chairman was named by the Committee, Admiral Davis having been added when the duty was transferred to the Academy.

Two important practical results have already flowed from the operations of this Committee: one, on the suggestion of the Bureau of Navigation, the taking out one of the two binnacles which were generally used in the pilot-house of the naval vessels, interfering each with the other in its use; and the correction, between April and December, of the compasses of twenty-two iron or iron-clad vessels, or of wooden vessels in which the local attraction was found to be inconvenient, from the presence of engines and boilers, of iron rigging, and other iron works.

The inconvenience and even danger resulting from the derangement of the compasses on board of many of our iron vessels have been loudly complained of to the Navy Department. The Committee adopted Airy's method for these vessels generally, and appointed Mr. A. D. Frye, of New York, who, in former years, had corrected successfully the compasses of the iron Revenue Cutters for the Treasury Department, to make the corrections. The difficulties resulting from the rapid movements to sea and port of these vessels, have sometimes rendered the effort at correction somewhat imperfect on the first trial; but a persevering application of the method has in no case failed to effect the purpose desired. The Committee has also had under successful trial a compass invented by Mr. Ritchie, of Boston, under the especial direction of the Navy Department, and a compass by Charles A. Schott, Assistant in the Coast Survey. These are referred to in the report, lettered F, of Committee No. 3. This report contains also the results of experiments on iron vessels in the course of construction, and of iron-turreted vessels, especially of the three-turreted iron-clad, the Roanoke, and of the monitor Passaic. The five compasses of the Roanoke were compared near Newport News, by swinging the vessel and noting the deviation at different points. With this report are presented nine sub-reports, as follows: —

No. 1. List of Iron-clad Vessels in Commission or Construction, as also of Iron Vessels not armored, either purchased, constructed, or being constructed.

No. 2. Report of Professor F. Rogers on Operations on U. S. Steamer Ticonderoga.

No. 3. Report of Mr. A. D. Frye.

Nos. 4, 5, 6, 7. Report by Charles A. Schott, Assistant U. S. Coast Survey, Magnetic Survey of Roanoke and Passaic.

No. 8. Drawings and Specifications of Ritchie's Fluid Compass.*

No. 9. Drawings and Specifications of Schott's Compass Arrangement.

A Committee, No. 4, on Mr. Saxton's Alcoholometer, was appointed, as follows: Professor Frazer, Chairman, Doctor Barnard, Professor Chauvenet, and General Totten. Professor W. B. Rogers was also appointed, but declined. The report, lettered G, is herewith presented. It gives a lucid description of the instrument, which was itself presented to the examination of the members of the Academy, and concludes, after a candid examination of its advantages and defects, by recommending its use to the government in place of the Tralles hydrometer, which is now employed in the col-

* Omitted by request of Mr. Ritchie, communicated through Admiral C. H. Davis.

lection of the revenue. It is much more simple, more portable, and less liable to breakage than the Tralles instrument. It was approved by the Academy on the discussion of the report, and will therefore be presented to the Treasury Department for adoption. It is so small, that the bulb and chain, which form the measuring part of the apparatus, is contained in a box of three quarters of an inch in diameter and one inch high.

The following resolution, in regard to Mr. Saxton's hydrometer, was adopted by the Academy on the 7th of January: —

"*Resolved*, That the words following be added to the close of the report, viz.: 'It being understood that Mr. Saxton places this invention at the disposal of the government without any view to remuneration.'"

A letter from Mr. Saxton, marked H, is appended to this report.

The next subject, Committee No. 5, was brought before the Academy in the following letter of the Chief of the Bureau of Navigation of the Navy Department: —

Bureau of Navigation, Navy Department,
Washington, May 23, 1863.

Sir: — I transmit herewith a copy of a letter addressed by me to the Honorable Secretary of the Navy, on the subject of discontinuing the publication, in the present form, of the "Wind and Current Charts," and "Sailing Directions" accompanying them; and now, with the approval of the Department, I have the honor to refer the same subject to the National Academy of Sciences, for investigation and report, requesting that, on account of the expense and the public interest, it may receive early attention.

Very respectfully, your obedient servant,

CHARLES H. DAVIS,

*Chief of the Bureau.*

PROFESSOR A. D. BACHE, President National Academy of Sciences.

(Copy.)

Bureau of Navigation, Navy Department,
Washington, May 21, 1863.

SIR: — I have the honor to inform the Department that the Charts and Sailing Directions, published by the late Superintendent of the Observatory, at the expense of the Government, are regarded by hydrographers and scientific men as being prolix and faulty, both in matter and arrangement, to such an extent as to render the limited amount of original information which they actually contain costly and inaccessible.

I am prepared to recommend the discontinuance of the publication of these Charts and Sailing Directions. But, in order that this question of discontinuance may be decided with deliberation, I have to request permission to refer it to the National Academy of Sciences, for investigation, and report to this Department.

I am, sir, very respectfully, your obedient servant,

CHARLES H. DAVIS,

*Chief of the Bureau.*

HON. GIDEON WELLES, Secretary of the Navy.

The Committee appointed on this application consisted of Professor F. A. P. Barnard, Chairman, Professor J. H. Alexander, Mr. J. P. Lesley, Professor A. Caswell, Chancellor Chauvenet, Professor J. H. C. Coffin, U. S. N., Professor J. F. Frazer, Professor A. Guyot, Mr. J. E. Hilgard, Professor B. Peirce, Professor J. D. Dana, and Professor J. Winlock, U. S. N., who came to their conclusions early in October, which were adopted by the Academy after discussion, on the 9th of January, and which are expressed in the following resolutions: —

"*Resolved by the National Academy of Sciences*, That, in the opinion of this Academy, the volumes entitled 'Sailing Directions,' heretofore issued to navigators from the Naval Observatory, and the 'Wind and Current Charts' which they are designed to illustrate and explain, embrace much which is unsound in philosophy, and little that is practically useful, and that, therefore, these publications ought no longer to be issued in their present form.

"*Resolved*, That the records of meteorological phenomena and of other important facts connected with terrestrial physics, which, under the direction of the Navy Department, have been accumulated at the Observatory, are capable of being turned to valuable account, and that it is eminently desirable that such information should continue to be collected, and subjected to careful discussion.

"*Resolved*, That the President of the Academy be authorized and requested to communicate to the Secretary of the Navy a copy of the foregoing resolutions and of this report, as a response to the inquiry addressed to the Academy upon this subject by that officer."

The report of this Committee, marked I, is appended to this Report.

It was, on motion,

"*Resolved*, That a copy of each report made on the application of the Navy Department be forwarded by the President of the Academy to the Hon. Secretary of the Navy."

The sixth Committee, appointed by request of the Treasury Department, was upon the plans presented for preventing the counterfeiting of the national currency, and consisted of Dr. Torrey, Professor Henry, Dr. Barnard, Mr. Saxton, and Professor Schaeffer, the last named being appointed by request of the Department, and under Section 4, Article II. of the Constitution of the Academy. This Committee has labored diligently and successfully in the important matters confided to them. The facts which they have developed will, by direction of the Academy, be presented confidentially to the Secretary of the Treasury. The general resolutions adopted by the Academy are as follows: —

"*Resolved*, That the Currency Committee be empowered to communicate directly with the Secretary of the Treasury, and to take order in reference to the matters intrusted to them.

"*Resolved*, That the President of the Academy communicate the foregoing resolution to the Hon. Secretary of the Treasury."

A Committee was appointed, at the first meeting, on the form of a diploma, on a corporate seal, and a stamp for books and property, which reported progress at the January meeting, and was continued.

Another Committee was appointed, to report a rule prescribing the mode of electing Foreign Associates, which reported at the January session, and was discharged.

I append to this report the minutes of the meeting of organization of the National Academy of Sciences, at New York, marked J, and of the first regular session at Washington, in January, marked K.

The draft of the Constitution and By-Laws of the Academy prepared by the Committee appointed in April, 1863, was presented and discussed in Committee of the Whole, engrossed, and finally passed, as marked L, on the 6th of January.

The following papers were read at the meetings of the January session: —

Prof. Agassiz, "On the Individuality among Animals, with reference to the Questions of Varieties and Species."

Prof. B. Peirce, "On the Elements of the Mathematical Theory of Quality."

Prof. A. D. Bache, "On the Discussion of Magnetic Observations made at Girard College Observatory, in the Years 1840–45. Parts IV., V., and VI. Horizontal Force. Investigation of the Eleven-Year Period, of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon."

Dr. F. A. P. Barnard, "On the Force of fired Gunpowder, and the Pressure to which Heavy Guns are actually subjected in Firing."

Dr. B. A. Gould, "Reduction of the Observations of Fixed Stars made by d'Agelet at Paris during the Years 1783–85, with a Catalogue of the corresponding Mean Places referred to the Equinox of 1800."

Prof. Agassiz, "On the Metamorphoses of Fishes."

Prof. B. Peirce, "On the Saturnian System."

Dr. T. Strong, "Notes on the Parallelogram of Forces, and on Virtual Velocities."

Prof. Agassiz, "On the Geographical Distribution of Fishes, as bearing upon their Affinities and Systematic Classification."

Prof. A. D. Bache, "On the Discussion of Magnetic Observations, &c. Parts VII., VIII., and IX. Vertical Force. Investigation of the Eleven-Year Period, of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon."

Dr. F. A. P. Barnard, "Description of an Anemograph, designed for the University of Mississippi."

Prof. Joseph Henry, "On Materials of Combustion for Lamps in Light-houses."

Mr. L. M. Rutherfurd, "On Photographs of the Solar Spectrum."

General J. G. Barnard, "On Tangencies of Circles and Spheres."

Prof. Stephen Alexander, "On Observations of the Planet Venus, near the Times of her Inferior Conjunction, Sept. 28, 1863, and subsequently."

Prof. Stephen Alexander, "Brief Note on the Forms of Icebergs."

These papers were referred to the Committee of Publication, to take order, and to the Council, to provide the Ways and Means for publication.

The formalities of the Constitution and By-Laws in reference to Foreign Members having been fulfilled, the following were nominated and elected Foreign Members of the National Academy of Sciences: Hamilton, Baer, Faraday, Elie de Beaumont, Brewster, Plana, Bunsen, Argelander, Chasles, Milne-Edwards.

The decease of Mr. Hubbard was announced by the President, and Dr. B. A. Gould appointed to prepare a biographical notice for the next session of the Academy.

The decease of the following scientific men, not members of the Academy, was announced: Dr. Darlington, Mr. Fitz, and Major E. B. Hunt. The following members were appointed to prepare notices of their career: Mr. Torrey, Mr. Rutherfurd, and Mr. F. A. P. Barnard.

After the reading of Dr. B. A. Gould's paper "On the Reduction of the Observations of Fixed Stars made by d'Agelet at Paris, during the Years 1783–85, with a Catalogue of the corresponding Mean Places referred to the Equinox of 1800," the following resolution was unanimously adopted: —

"*Resolved*, That the Academy, impressed with the importance of a new reduction of the observations of Piazzi, presented by Mr. Gould, recommend that such reduction be made by Government at an early period."

The Council for the year was elected, as follows: Messrs. Davis, Torrey, Rutherfurd, and Lesley.

The Academy determined to meet in New Haven, next August, on the first Wednesday, at 10 A. M., at such place as may be fixed by the Committee of Arrangement.

The Committee was appointed, as follows: Messrs. B. A. Gould and Hall, Secretaries of the Classes of Mathematics and Physics; and of Natural History, Messrs. Newton, B. Siliman, jr., and Dana.

A resolution was passed, making the President of the Academy, *ex officio*, a member of all committees.

On Tuesday evening the members of the Academy were presented, by invitation, to the Hon. Secretary of the Treasury, S. P. Chase; on Thursday evening, to the Hon. Secretary of State, Wm. H. Seward; on Friday morning, to the President of the United States; on Friday evening, they came together at the residence of the President of the Academy; on Monday, visited some of the works of fortification near Washington, with Gen. Barnard; and on Tuesday, at 2½ o'clock, adjourned to the next session.

Respectfully submitted.

A. D. BACHE,
*President National Academy of Sciences.*

# XI.

# LIST OF PAPERS PRESENTED TO THE ACADEMY,

## TO JANUARY 1, 1865.

1. On the Individuality among Animals, with reference to the Questions of Varieties and Species, by Louis Agassiz.
2. On the Elements of the Mathematical Theory of Quantity, by Benjamin Peirce.
3. On the Discussion of Magnetic Observations made at Girard College Observatory, in the Years 1840–1845. Parts IV., V., and VI. Horizontal Force. Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon, by A. D. Bache.
4. On the Force of Fired Gunpowder, and the Pressure to which Heavy Guns are actually subjected in Firing, by F. A. P. Barnard.
5. Reduction of the Observations of the Fixed Stars made by J. J. Lepaute d'Agelet at Paris, during the years 1783–1785, with a Catalogue of the corresponding Mean Places referred to the Equinox of 1800, by B. A. Gould.
6. On the Metamorphoses of Fishes, by Louis Agassiz.
7. On the Saturnian System, by Benjamin Peirce.
8. Notes on the Parallelogram of Forces and on Virtual Velocities, by Theodore Strong.

9. On the Geographical Distribution of Fishes, as bearing upon their Affinities and Systematic Classification, by Louis Agassiz.
10. On the Discussion of Magnetic Observations made at Girard College Observatory in the Years 1840 – 1845. Part VII., VIII., and IX. Vertical Force. Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon.
11. Description of an Anemograph designed for the University of Mississippi, by F. A. P. Barnard.
12. On Materials of Combustion for Lamps in Light-houses, by Joseph Henry.
13. On Photographs of the Solar Spectrum, by Lewis M. Rutherfurd.
14. On Tangencies of Circles and Spheres, by J. G. Barnard.
15. On Observations of the Planet Venus near the Times of her Inferior Conjunction, Sept. 28, 1863, and subsequently, by Stephen Alexander.
16. Brief Note on the Forms of Icebergs, by Stephen Alexander.
17. Memoir of the late Henry Fitz, by Lewis M. Rutherfurd.
18. On the Distribution of certain important Diseases in the United States, by Augustus A. Gould.
19. On the Integration of differential Equations of the first Order and higher Degrees, by Theodore Strong.
20. Criticism on the Forms of Ships, by Capt. J. Cole. (Presented by Theodore Strong.)
21. On the Light visible on the Moon's Surface, and that seen adjacent to her Edge, when the Sun is either partially or totally eclipsed, by Stephen Alexander.

22. On the Influence of the Hour of the Day on the Results of Barometric Measurements of Altitudes (not read), by Arnold Guyot.
23. On Shooting Stars, by H. A. Newton.
24. A Method of determining the Errors of a Vertical Divided Circle, by Simon Newcomb. (Presented by Benj. Peirce.)
25. Considerations relative to various Phenomena presented by certain Comets, by Stephen Alexander.

XII.

# EULOGY ON JOSEPH S. HUBBARD.

By B. A. GOULD.

# EULOGY

ON

# JOSEPH S. HUBBARD.

By B. A. GOULD.

[Read before the National Academy at New Haven, 1864, Aug. 5.]

Mr. President and Gentlemen: —

The Constitution of our Academy, like the organic law of most Academies of Science beyond the seas, provides for the tribute of a formal Biographical Notice, pronounced in open session, in commemoration of each of our number who may be removed by death. For it is no unreasonable assumption that public benefit and individual incentives may be derived from the history of any man whose scientific services have rendered him worthy of admittance to your number.

It has been the will of God that the first place in our ranks made vacant by death should be that of Joseph Stillman Hubbard, and in obedience to your instructions I am here to tell the simple story of his life; — not without a doubt of my own ability for the task, yet glad that the lot has fallen to my share, for none outside the narrow limits of his kindred could have held him dearer.

Upon our roll, Gentlemen of the Academy, are the names of venerable men, whose usefulness has extended through a period surpassing the total duration of most human lives, and side by side with these are the names of others, who were not yet cradled when the former were full of honors, and crowned with gray hairs. The years of our eldest and youngest member differ by more than half a century. Yet the first summons came, not to any of the great masters in science who give its lustre to the new gem with which an afflicted but regenerate land would fain crown her aching brows; not to those who might well claim to have finished the work on earth, which their talents and opportunities seemed to mark out for them; — it came to one of the youngest in our ranks, — the forty-sixth of the original fifty in order of age, — to one whose work seemed chiefly in the future, and from whom we expected bright laurels for the Academy and for America.

When in April, 1863, we assembled for the great work of founding a National Academy, none was more hopeful, none more buoyant, none more impressed with the magnitude and import of our new duties, than he. It was the realization of the dream of his maturer years, the new Atlantis of his scientific aspiration, and his heart was full of bright anticipations, tinged with all the hues which a noble enthusiasm could bestow.

"A better Three Days for science were never spent," he wrote to his brother; and to his pastor in Washington, "The inauguration of this Academy marks the most important epoch ever witnessed by Science in America; — *we* say in the world."

In less than four months after that meeting in New York, his generous, fervid heart had ceased to beat. He died 1863, August 16, twenty-one days before the completion of his fortieth year.

The custom has always seemed to me an eminently proper one, which prefaces the history of a life by some mention and notice of ancestry. For, — whether we adopt the European notion that the ancestor ennobles his descendant by good deeds, or the perhaps more equitable Asiatic idea that honor flows in an ascending course, ennobling those whose nurturing care has thus borne fruit, — the bond of lineage may not lightly be disregarded; and each day's experience teaches us anew, that "men do not gather grapes of thorns nor figs of thistles."

I may therefore say that our departed colleague drew his origin from the early founders of our race, from that sturdy stock which gave character to the Colony of Massachusetts Bay, and shaped the civilization of New England.

His first American ancestor, Mr. WILLIAM HUBBARD, came out at the age of forty in the "*Defence*" from London, in the year 1635, and soon established himself in Ipswich, Essex County, Massachusetts; which town he represented for eight successive years, from 1638 to 1646, in the Legislature of the Colony. In 1662, he removed to Boston, where he died in the year 1670, aged seventy-five years, leaving three sons, all born in England.

The eldest of these sons and second in the line of descent was the Rev. WILLIAM HUBBARD, a man of much note in his day. Born in 1622, he was but thirteen years old when his father brought him to the new world. He graduated at Harvard College in 1642, and was in 1658 ordained colleague of Rev. THOMAS COBBETT in Ipswich, where he remained as pastor until his death in 1704; his kinsman, Rev. JOHN ROGERS, son of the President of Harvard College, acting as his colleague during the later years of his life.

This learned and good man was one of the first historians of the early troubles with the Indians. Two works on this subject were published by him in 1677, and subsequently republished in London in one volume under the title, "*The Present State of New England.*" His "History of New England," left by him in manuscript, is preserved in the archives of the Massachusetts Historical Society, and forms volumes V. and VI. of their printed "Collections." In 1688, after the departure of President INCREASE MATHER for England, he was commissioned by Governor ANDROS to officiate as President or Rector at the Harvard Commencement, being the oldest clerical Alumnus in New England; and as there were no graduates in that year, it is recorded in Sewall's Diary that he delivered an oration on the occasion, although this has not been transmitted to us.* His first wife, and the mother of his children, was Margaret, daughter of Rev. NATHANIEL ROGERS, and said to have been the great-granddaughter of that JOHN ROGERS who was burnt at the stake in Smithfield, 1555, — although, according to that accurate investigator, Mr. SAVAGE, this claim is not well substantiated.

* That Rev. WILLIAM HUBBARD was a man of no small independence and decision of character, may easily be inferred from his works; but other indications of his mental and moral force are not wanting. In the ecclesiastical troubles of 1667, connected with the establishment of the "Old South Church" in Boston, he took strong ground and bore an active part; and on the passage of a vote of censure upon himself and his colleagues in 1670, by a committee of the Legislature, he was one of the number who answered with a protest of such ability and convincing force, that the Legislature replied by an ample apology.

John Dunton, who visited him in 1686, gives [Felt, Hist. Ipswich, p. 230] the following description of Mr. Hubbard: "The benefit of nature and the fatigue of study have equally contributed to his eminence. Neither are we less obliged to both than himself; he freely communicates of his learning to all who have the happiness to share in his converse. In a word, he is learned without ostentation and vanity, and gives all his productions such a delicate turn and grace, . . . . that the features and lineaments of the child make a clear discovery and distinction of the father; yet he is a man of singular modesty, of strict morals, and has done as much for the conversion of the Indians as most men in New England."

The several successive generations of our colleague's ancestors seem to have been, without exception, men of moral worth, and of influence in the community.

Rev. JOHN HUBBARD, in the fourth generation, was settled in 1698 at Jamaica, Long Island, where he was distinguished by a Christian charity and tolerance remarkable for those days. His son JOHN settled in New Haven, where he served the community in the various capacities of physician, Colonel, Representative, Judge of Probate, and Judge of Common Pleas; and his descendants have continued to reside in the vicinity of this beautiful and classic city.*

Here our colleague was born, 1823, Sept. 7 (in the ninth generation from the American founder of his family), being

* The line of descent is as follows: —

I. WILLIAM, b. in England, 1595; d. Ipswich, Mass., 1670.

II. Rev. WILLIAM, b. England, 1622 (H. C. 1642); d. Ipswich, 1794, Sept. 14; married Margaret, daughter of Rev. Nathaniel Rogers.

III. JOHN, a merchant of Boston, b. Ipswich, 1648; d. 1710, Jan. 8; married Ann, daughter of Gov. John Leverett.

IV. Rev. JOHN, of Jamaica, N. Y., b. Boston, 1677, Jan. 9 (H. C. 1695); d. 1705, Oct. 5. [See Thompson, Hist. of Long Island, 1st ed., p. 388; also Boston News Letter, No. 79, 1705, Oct. 22.]

V. Dr. JOHN, of New Haven, b. Jamaica, 1703, Nov. 30 (A. M. Yale, 1730); d. 1773, Oct. 30; married 1724, Elizabeth Stevens.

VI. Rev. JOHN, of Meriden, Conn., b. New Haven, 1727, Jan. 24 (Y. C. 1744); d. 1786, Nov. 18; married 1750, Jan. 25, Rebecca Dickerman. [See Meriden Historical Collections.]

VII. ISAAC, of Meriden, b. Meriden, 1752, Nov. 22; married 1782, Dec. 5, Jane, daughter of Thomas Berry.

VIII. EZRA STILES, of New Haven, b. Meriden, 1794, May 13; d. 1861, Aug. 20; married 1820, Dec. 13, Eliza, daughter of Josiah Church.

IX. JOSEPH STILLMAN, of Washington, D.C., b. New Haven, 1823, Sept. 7 (Y. C. 1843).

the second son of EZRA STILES HUBBARD, and ELIZA CHURCH of New Haven, — parents to whom he was more than tenderly attached, and whose declining years were blessed by his thoughtful devotion. Of his father, I may quote his own words written three years ago: "My father has done his life's work well. Unable from feeble health to live the scholar's life to which he had been destined by his uncle, President STILES, and honoring learning next to godliness, he endeavored to give his children every advantage attainable for scholarship, devoting his life, labors, and scanty means to this one object. Precious is his memory."

From a most interesting and touching sketch of his early life, prepared by his admirable mother, I may be permitted to gather some of the incidents of his boyhood illustrative of the peculiar traits of his character, — earnestness, enthusiasm, and self-forgetfulness, modified by a wholesome love of fun and frolic, a tender susceptibility, and an affectionate nature. From the whole account it is manifest that in childhood as in maturer life he made for himself a place in the hearts of all with whom he came in contact; and I think it may be said of him with literal truth, what is so rarely true even of good men endowed with far less force of character, that he had not an enemy in the world.

With him, too, the old and ever new experience came to his parents, of the early yearning of an intellectual child for books and knowledge, and they afterwards lamented that this dangerous tendency was not more carefully held in check. But although the danger of over-stimulating a receptive brain can hardly be exaggerated, and though the precautions of physical education were at that time comparatively disregarded among us, — I see no reason for suspicion of any morbid precocity. I venture to make the following extracts from the interesting accounts kindly furnished me by his mother: —

"In his eighth year he suffered a severe course of lung fever, and for several weeks after the crisis was past seemed vacillating between life and death. After he began to convalesce, it was almost impossible to keep his active mind quiet enough to suffer the weakened frame to recover its tone. Pictures, books, toys, everything we could devise, were put into requisition to amuse him. His father saw one day in a store a curious piece of mechanism, a puzzle which he knew would delight the child, — but it was an expensive article, and he hesitated if he ought to purchase it. But a second thought of the tired, weary boy decided the question. When he put it into Joseph's hand, as he sat bolstered up in bed, the child's eyes fairly flashed with delight. Seeing him so much amused at studying its intricacies, I left him, . . . . and returning after a while found him utterly exhausted. He had taken the toy to pieces to ascertain its construction, and in trying to put it together again, had so used the little strength he had gained as to leave us for many days to fear a fatal result. That was ever one of his peculiarities, — not to rest till he understood the how and why of everything he saw, or at least had learned all that could be learned about it. . . . . It was about his ninth year that he began especially to develop his peculiar taste for mathematical studies and mechanics. Though he loved play dearly, and enjoyed it with zest for a little while, he had far rather spend his hours out of school in trying experiments, endeavoring to make machines, &c. . . . One of his great efforts was to make a clock. He had been attracted by seeing his father wind up the time-piece, and had begged to examine it. A day or two after I found him in his room, surrounded by a quaint collection of bits of board, pasteboard, wire, lead, &c. To the question, 'What is the tinker about now?' he replied: 'Mother, I'm going to make a clock.' I told him we must ask his father for some tools, and perhaps he would succeed; and he did succeed, — constructing a clock in all its parts, with face, hands, &c., and which went for a time, being duly mounted on the kitchen shelf, and for making which his only tools were a pair of scissors and a jackknife.

"After that, his father procured him a small chest of tools, and from that day he had full employment for every leisure hour. The attic was appropriated for his wood-work, and the back piazza for his crucibles, castings, &c. Most of his leisure time before entering college was devoted to making a telescope, which proved to be quite a good instrument, and which he sold to a gentleman from Catskill, soon after he entered college. He made also a camera-obscura, which afforded a fund of amusement to himself and his playmates, and a press for binding books. As long as his father lived he used the blank books with which the boy supplied him at this time.

"When fitting for college, while visiting some mechanic's shop, in pursuit of material or instruction, he came in contact with EBENEZER MASON, who was then one of Yale's enthusiastic astronomers, and at once there sprung up between the young man and the boy a kindly sympathy. MASON introduced the lad to his own chosen associates in study, invited him to their rooms for work, experiments, &c.; and from that day his scientific life began in earnest. Nothing could make him so happy as permission to spend the evening he could spare from daily lessons with MASON and HAMILTON SMITH; and, when in college, to be invited to watch shooting-stars or take observations with Mr. HERRICK, was the greatest boon the world could afford him. His standing in college was above mediocrity, but not what he could easily have made it. His mind was so entirely filled with his own loved department of study, that he did not value college honors enough to give the needful attention to other branches.

"In his sixteenth year Joseph determined to take a pedestrian excursion. He set out to visit an uncle residing twenty or thirty miles north of us, and his father furnished him with all he thought needful for so short a trip. He had always kept us informed of his movements when away; and when six days had passed, and we received no intelligence from him, we began to be seriously uneasy. At length a letter came, mailed in Charlestown, Mass. He had heard MASON and SMITH talk about a mechanic in Ware, who had given them much information about casting mirrors for telescopes, and had long wished to see the man for himself. So, after tarrying one night at his uncle's, he had wended his way up to Ware, and having learned all he could from the man he sought, had proceeded on foot to Charlestown, a distance of 175 miles, in order to visit Bunker Hill."

In 1843, he graduated at Yale College. For a few months he remained at home pursuing his favorite studies, mathematics and astronomy; and in the following winter he taught for a while in a classical school. Early in 1844, he went to Philadelphia, as an assistant of WALKER, who was then beginning his astronomical labors, and whose attention had been attracted by the bright promise of the earnest and gifted youth. Here the contagious zeal of WALKER added fuel to the flame. Removed for the first time from the restraining influence of home, on which he had learned unconsciously to depend, he forgot all prudent care for himself. He observed with WALKER at the High-School Observatory all night, and computed all the day, — and I need not add that his health soon gave way. From that time he was subject to a nervous excitability before unknown to him, and to an irregular action of the heart, from which he suffered much, and which finally exhausted his strength and energies, — depriving him of that vigor of constitution with which he was originally endowed, and which might have arrested the progress of his last disease.

In the autumn of 1844, Lieut. (now Major General) Frémont offered Mr. Hubbard a position in Washington as computer of the observations for latitude and longitude made on his expeditions across the Rocky Mountains, and on the Pacific coast. These completed, and the interest of Prof. Bache, Capt. Frémont, and Col. Benton being enlisted in his behalf by his successful and meritorious labors in Philadelphia and Washington, they obtained a promise from Mr. Bancroft, then Secretary of the Navy, that his appointment should immediately be made out for a vacancy in the corps of Professors of Mathematics in the Navy. He was commissioned 1845, May 7, and immediately assigned to duty at the Washington Observatory, of which he continued an officer during the remainder of his life. He was elected a member of the National Institute of Washington, 1845, January 14; of the Connecticut Academy of Arts and Sciences, 1849, October 24; of the American Academy of Arts and Sciences in Boston, 1850, August 15; and of the American Philosophical Society of Philadelphia, 1852, May 7.

It would be needless, gentlemen of the Academy, did taste not forbid, for me to describe to you at any length, the embarrassments of astronomers, stationed at the Washington Observatory, while under the charge of the late Superintendent. Few of you, if any, can have failed to appreciate the painful conflict between self-respect and official proprieties, — between the emotions of the scientist, jealous of his country's reputation, and of the subordinate, whose duty in an establishment under military organization demanded tacit submission and apparent acquiescence, under a mortifying or atrocious policy. The sensitive nature of WALKER found it impossible to endure the trial; but his pupil, HUBBARD, struggled more successfully.

Would that I might with propriety express my keen sense of the deep debt of gratitude due from American science to those able and disinterested men, some of them, happily, still of our number, who bore the mortifications of their position without flinching, that they might save the national scientific institution, which it was partially within their power to protect, from becoming a source of national disgrace. They toiled earnestly and judiciously for the sake of their hope that some small portion of their labor might bear fruit, though that fruit should not be plucked by them. They struggled against obstacles which would have deterred most men, in order that the noble instruments might render some service to science, or at least fail to be made implements of national disgrace. How well they succeeded, their record bears witness; and it will bear eternal testimony to their honor, when in its own good time history shall break the seals which the present day has necessarily affixed.

A single anecdote from many which might be told, illustrative of the state of things, may perhaps be pardonable now, although it would never have been publicly mentioned by our departed colleague, nor with his permission.

Professor HUBBARD was one morning summoned to the presence of the Superintendent, who handed him a letter just received from Germany, and desired its translation. It contained the announcement of the discovery of a new comet, together with observations of its position on two successive days, — an interval of eighteen or twenty days having of course elapsed since that time.

"I wish an Ephemeris of this comet," said he, "to be prepared without delay, for publication in the newspaper to-morrow morning." HUBBARD respectfully suggested that three observations were requisite for computing the elements, and that even should the comet be found early in the evening, the intervals between the three dates would not be well adapted for the purpose. "Confound the elements, Mr. HUBBARD!" said the Lieutenant, using some rather strong expletives; "I want none of your Elements, I only want an Ephemeris, and I wish you would compute it at once."

What the astronomer did under the embarrassing circumstances, I do not exactly know; but I suspect that the Ephemeris, which went to the *National Intelligencer*, was computed by methods neither of OLBERS nor of BESSEL!

The first published observations of HUBBARD, so far as I am aware, were those by which, on the 4th of February, 1847, he confirmed the prediction of WALKER as to the identity of *Neptune* with one of the stars observed by LALANDE, 1795, May 10. This important discovery was made almost simultaneously by PETERSEN in Altona, and by WALKER and HUBBARD in Washington, and was of the highest importance for the accurate determination of the planet's orbit. By the employment of this ancient observation, and of the perturbations computed by PEIRCE, WALKER was enabled to deduce the orbit of *Neptune* with a precision which leaves even now very little to be desired, and which surpasses that attained by any other computer to this present day.

At the Naval Observatory HUBBARD was at once placed at the Transit-Instrument, with which he observed for four months; and was transferred to the Meridian Circle in September. Nearly nine hundred transit-observations by him may be found in the volume of Washington Observations for

1845; and examination has shown them to possess decided value, in spite of the very unfavorable circumstances under which they were made. During the remainder of the year he was occupied with the adjustments, and in determining the Instrumental errors, of the Meridian Circle. The thorough description of this instrument and discussion of its corrections, in the volume for 1846, is from his pen; as also is the description of the Prime-Vertical Transit. Nearly one thousand observations with the Meridian Circle in 1846, as well as the discussion already cited, give token of his activity; but the equal labor of endeavoring to train and instruct many others, — who were assigned to duty at the several astronomical instruments by the naval routine, although not inclined to astronomical pursuits, and indeed often affected with distaste for them, — does not appear. Nor is any mention made of the careful and laborious organization and inception of a system of zone-observations, admirably devised and arranged by one of our present colleagues in connection with Professor HUBBARD, although no public acknowledgement of their services in this respect was ever made, nor indeed claimed, by either of them. According to the plan of these zone-observations (Washington Observations, 1845, App., p. 32), the micrometers of the Mural Circle, Transit-Instrument, and Meridian Circle were provided with additional declination-threads; additional transit-threads were inserted in the field of the Mural Circle, and the micrometer of the Transit-Instrument was rotated 90°; thus rendering it available for the measure of differences of declination. The several zones were made to overlap by 10′ in declination, and the instruments were to be employed simultaneously upon nearly the same declination, so that a portion of the stars observed by the Mural and Transit should be identical. Thus the Transit-Instrument would give standard observations of right-ascensions for an adequate number of stars in each zone swept by the Mural Circle; while this latter would in its turn give accurate declinations for a sufficient number of stars to determine the zones observed with the Transit. The Meridian Circle, meanwhile, was to go over the same ground independently, and thus all discordances which might arise from inevitable errors of observation would be satisfactorily disposed of.

These zone-observations were begun early in 1846, and continued till 1850, and even later; and a large amount of material was thus collected. The zones observed during 1846 with the Meridian Circle were reduced and published (under the superintendence of Mr. FERGUSON of the Washington Observatory) in 1860; a portion of the Mural zones for 1846 had been reduced under the superintendence of Professor COFFIN before he left the Observatory, and a considerable amount of labor had been given by HUBBARD to the reduction of the Transit-zones for the same year. With these exceptions, nothing had been done toward the reduction, on the accession of the present Superintendent in 1861; although in the mean time a similar investigation had been planned by Professor ARGELANDER, completely executed by him over all the practicable region south of Bessel's limit, and with a single instrument, and the results published in 1852, under the title of "Southern Zones."

But although the great labor bestowed by COFFIN and HUBBARD on the arrangement and execution of this grand scheme proved in a great degree futile, — by reason of the neglect of the observations after they were made, by the loss of some of them, and by the reckless manner in which a large proportion of the work was done, — the value of the plan and ingenuity of the arrangement remain the same. Had the valuable and delicate instruments, and the execution of the work, remained in charge of astronomers, — rather than of gentlemen, who, however gallant and accomplished in their proper calling as lieutenants and midshipmen, could not reasonably be expected to do the work of astronomers without the requisite training, and frequently much to their distaste, — had the large sums annually voted by Congress for the support of the Observatory been in part devoted to the reduction of these observations, and to the detection of the errors lurking in the observing books, — they would have conferred high honor upon American science, and indeed formed by far the noblest achievement of practical astronomy in America. As it is, it has been found necessary to reject all the zone-observations made since 1849; the remainder consist of a curious combination of observations of the most delicate character and conscientious accuracy, with others which are literally beyond criticism; and the disregard of the original plan, and total lack of system in carrying on the work with the different instruments, has in great measure defeated the scheme, which prescribed that the same region should be swept by the Transit and the Mural. Thus the zones, when reduced, do not form a complete catalogue for the region over which they extend. Moreover, it has been found necessary to determine the zero-points, both for right-ascension and for declination, of a large proportion of the zones by observations of stars made during the last two years, at an expenditure of labor quite comparable with that of the original observations of the zones, and yet exposed to all the deleterious influences which may be exerted by the unknown proper motion of the comparison-stars during an interval of from fifteen to eighteen years. The reduction of these zones has been essentially completed, so that their publication may be looked for at no distant day; and of this work a portion of the original excellent organization, a considerable part of the earlier zones observed with the Meridian Circle, and two thirds of all the good work done with that instrument, is due to HUBBARD.

Still, in my desire to do full honor to the generous and gifted man whose loss we mourn, I may not do injustice to the living; and at the hazard of incurring the disapproval of a colleague, happily spared to us, I must add, that for an amount of intellectual labor bestowed upon this work, greater even than HUBBARD's, and for the exquisite elegance with which the observations with the Mural Circle were elaborated and made to give character and finish to the whole work, we are indebted to Professor COFFIN, whose transfer from the Observatory to the Naval Academy was productive of more advantage to the latter institution than to the one from which, unfortunately for its welfare, he was taken away in 1853. Still his influence and example were not lost, and to Professor YARNALL we owe an ample series of admirable observations with the Mural Circle, which, in connection with those of Mr. FERGUSON at the Equatorial, saved the honor of a national institution, at the time when HUBBARD was precluded by his health from observing, and after the departure of COFFIN; and have furnished valuable observations in an unbroken line from this well-equipped establishment down to the time of its resuscitation under the original founder, Capt. GILLISS.

The most valuable of HUBBARD's observations were unquestionably those with the Prime-Vertical Transit Instrument. This is essentially the counterpart of the one originally designed by STRUVE, and which has rendered such service at Pulkowa. It was thoroughly studied and mastered by HUBBARD soon after his appointment at the Observatory, and the scientific portions of the descriptions of the instrument were from the first chiefly from his pen.

It was not, however, till the beginning of 1848, a year and a half after observations with the Prime-Vertical Instrument had been commenced, that he was officially assigned to its charge. The attainment of some definite result concerning the long mooted annual parallax of *a Lyræ*, which passes within 15′ of the zenith of Washington, was an especially cherished problem. For many years he labored towards its solution, in spite of serious and most vexatious obstacles. But the maxima and minima of the annual parallax occur at seasons very unfavorable to observations in the climate and atmosphere of Washington; and it was chiefly due to this fact, that some result was not long since attained. At the regeneration of the Observatory in 1861, he was again full of hopefulness and confidence of an early solution of this favorite problem, as well as sundry others. "Your rejoicing," he wrote, "cannot exceed mine; for it is a constant gratification to see order quenching chaos, energy overriding the old slowness, and above all our own science raising her triumphant head, and banishing the old humbug." Even at that period of his domestic bereavement and loneliness, it needed only the unwonted consciousness that Astronomy might be protected at the only national Observatory in the land, to reanimate his spirits, and give him a new stimulus to exertion. The Prime-Vertical Instrument, like the others, was soon put into complete order, and the traces of early misuse thoroughly removed; and in March, 1862, he began a new series of observations of *a Lyræ*. During the period of this series HUBBARD completed an exhaustive discussion of the influence of irregularity of pivots upon the level-reading at different altitudes; — a determination of the effect and amount of flexure by comparisons of the error of collimation deduced from reversing the telescope on a star with that resulting from reversals on the image of the threads reflected from mercury in the nadir. He had re-determined the value of the level divisions, had removed some serious discordances arising from a faulty construction of the level, and had completed tables for the more convenient reduction of the observations.

This series of observations he intended to continue for several years, but an overruling Providence willed otherwise. His last observation was on the 8th of July, 1863, not sixteen months after the first. Happily he was favored with an able and skilful collaborator in Professor WILLIAM HARKNESS, and found a worthy successor. The series is continued by Professor NEWCOMB, than whom none is more competent to carry out the plans of his lamented associate, with all the success that scientific ability or earnest devotion can insure.

Professor NEWCOMB has investigated the probable error of HUBBARD's observations of *a Lyræ*, and finds that of a single observation to be but 0.″155.

In the early part of the year 1849, it was my privilege to become personally acquainted with Professor HUBBARD, and to begin a friendship which knew no cloud until the last sad severance of all earthly ties. For his affectionate solicitude in time of sickness, his sympathy and support in evil days, his cordial aid in difficulty, and his encouragement in all good works, — a debt is due to his memory which words cannot express, and which, alas! this life affords no opportunity of repaying.

Without HUBBARD's cordial approval, the plan of the *Astronomical Journal* would probably not have been carried into execution; certainly it would not, at the time when it was actually begun. He aided it in every way, — by the promise of investigations for its columns — a promise amply fulfilled; — by stimulating others both to contribute and to subscribe, — by frank criticism, by generous incitement and discriminating commendation. No one could have felt a deeper interest in it than he, and of whatever service it may have rendered, a large proportion is to be credited to him alone. The earliest letter from him in my possession, dated June 8, 1849, is almost wholly devoted to a discussion of the various plans we had previously orally debated.

In the summer of 1849, these plans were essentially matured, and after discussion with BACHE, PEIRCE, HENRY, COFFIN, WALKER, CHAUVENET, and others almost equally interested, though not themselves engaged in prosecuting the same departments of inquiry, (prominent among whom were our two honored Secretaries, and the Editors of the American Journal of Science,) it was decided to give its origin a sort of national character by causing the first public suggestion to emanate from the American Association for the Advancement of Science, which held its second session at Cambridge in August, 1849. This work HUBBARD took cordially and zealously in hand. He prepared a communication, which he laid before the Association [p. 378], representing the importance of the proposed undertaking, and the services which it might render in the development of astronomy and its kindred sciences at that critical period of our national growth. At his suggestion a committee was appointed to consider the subject, and to bring it to the notice of those interested in the advancement of astronomy. He afterwards prepared a Prospectus, and labored earnestly and with effect, for its wide circulation.

The six volumes of the Journal contain more than 210 columns of valuable contributions from his pen, — and twice during the Editor's absence from the country did HUBBARD assume the control and editorship.

The first extended computation of Professor HUBBARD consisted in the determination of the zodiacs of all the known asteroids, except the four previously published in Germany. In November, 1848, he presented to the Smithsonian Institution the Zodiacs of *Vesta*, *Astrea*, *Hebe*, *Flora*, and *Metis;* and to the first volume of the Astronomical Journal, he contributed those of *Hygea*, *Parthenope*, and *Clio*, making the list complete up to that time. That of *Egeria* followed, soon after his satisfactory determination of the elements; and although he published no others, it was his intention as well as endeavor to prepare the zodiac for each successively discovered asteroid. These zodiacs give for each planet, — as suggested by GAUSS, and computed by him for *Ceres*, *Pallas*, and *Juno*, — the northern and southern limits of its geocentric position for each right-ascension, and enable us in many cases to draw immediate inferences as to the possible identity of any recorded star with the planet in question. It is much to be desired that the series of asteroid-zodiacs should be completed, and a key thus furnished for the solution of many interesting questions of identity, which have occurred in the past, and must present themselves hereafter.

None of you, Gentlemen, can fail to recall the magnificent spectacle exhibited by the great Comet of 1843. Through the early evenings of March, it trailed like a gorgeous banner of flame across the Western sky, the first visitant of its kind within the memories of many a full grown man, and rekindling the awe and wonder of those, whose impressions of the cometic glories of 1807, 1811, and 1819 had become dimmed by time. Its magnificent train extended at nightfall nearly parallel with the horizon through an arc of some 40°, rivaling the later, though perhaps equally splendid, manifestation of the great Comet of 1858. So great indeed was its brilliancy while in close proximity to the sun, that it attracted the attention of the public at high noon in various parts of North and South America both on the day of its perihelion, and on the day following. It was seen at 11 o'clock on the morning of the 27th, at Conception, and measurements of its distance from the sun were made on the 28th, both in Maine and in Mexico; the tail being visible to the length of a full degree, at 3 o'clock in the afternoon of that day. The attempts of astronomers to satisfy the observations led to results singularly diverse. Only one characteristic of the orbit seemed beyond question, — the extreme smallness of the perihelion distance. The close resemblance of its parabolic elements to those deduced by HENDERSON for the Comet of 1668, could not fail to attract attention, and the elements obtained by PEIRCE from the very unsatisfactory observations of the Comet of 1689, which have come down to us, exhibit also a decided similarity. Both CAPOCCI and CLAUSSEN, believing in its identity with both, found themselves able to satisfy the observations by an ellipse of seven years period. ENCKE, WALKER, and ANDERSON found that the observations could be closely represented by a hyperbolic orbit, — BOGUSLAWSKI in Breslau advocated a period of $147\frac{1}{3}$ years, — WALKER finally decided in favor of an ellipse of $21\frac{7}{8}$ years, — while LAUGIER and MAUVAIS in Paris, NICOLAI in Mannheim, and others, found the probabilities strongly in favor of the period of 175 years, — which I cannot but believe to be the true one.

This magnificent object fired the zeal of HUBBARD, already fascinated as he was with astronomical study and imbued with the spirit of research. He was within five months of graduation at Yale, and, from that time, he looked forward to a thorough and decisive investigation of the path of this comet, as his most favorite problem. And although some six years elapsed before he found it within his power to begin the long-desired research, he then prosecuted it with an earnestness which showed no loss of interest or of enthusiasm.

In December, 1849, he published the first part of this masterly discussion of the Orbit of the Great Comet of 1843, — an investigation begun only a few months before, but hastened for the sake of an early contribution to the Astronomical Journal. This paper occupied a part of eight numbers, the conclusion appearing in July, 1852. It seems to me safe to say that the orbit of no comet of long period has been more thoroughly and exhaustively treated than this. All observations of the comet, of whatever kind, whether before published or obtained from the manuscripts of astronomers, were subjected to rigorous scrutiny, and were winnowed with a painstaking fidelity which would have surpassed the patience of most men. Especially were the very important sextant-observations, made in the daytime on the 28th of February by Captain Clarke, at Portland, Maine, and by Mr. Bowring, at Chihuahua, discussed with extreme care, and made, after sundry corrections, to exert an important influence upon the resultant orbit.

First forming normal places by the aid of one of the approximate parabolas at hand, Hubbard computed elliptic elements by the ordinary Gaussian method, and thus obtained new normals. Determining for these the coefficients of the variations of the elements relatively to the variations of the geocentric co-ordinates, — and, for the sake of control, both by Bessel's method and by that of Goetze, he deduced the variations required for satisfying the new normals, and thus arrived at a second set of elements.

Repeating the process, and computing ten new equations of condition for new normal places, he obtained a third and fourth ellipse, the latter by the assignment of weights to the several normals. The amount of outstanding error was thus reduced to a very small quantity, and the orbit was sufficiently accurate to correct the sextant-observations, and decide sundry points left ambiguous by the observer. Thus he found which limit of the sun had been compared with the comet at Chihuahua, and was able to make the assumption of an error of two minutes in one of the recorded times of observation, and thus both to render the observations accordant, and to show their value. In a similar way the untrustworthiness of another sextant-observation was made manifest, and thus prevented from vitiating the computations. The errors of two sextant-measurements in each place were thus shown to lie within the limits of good observation, and the aid of these very important auxiliaries secured.

The disturbing forces were computed for each of the six large planets for each fourth day during the period of the comet's visibility, and with the series of osculating elements thus obtained, he determined the discordances of every accessible observation. Here, as everywhere in HUBBARD'S work, we find the indication of his scrupulous care in controlling his computations by the independent employment of different formulas, and of the tact by which he adapted various methods to his purpose; this peculiarity, as well as his exquisite elegance in the mechanical arrangement, and the beauty of his chirography reminding one continually of ENCKE, many of whose scientific characteristics seem equally to have belonged to HUBBARD, — though the fulness of years and opportunities happily accorded to the accomplished astronomer of Berlin were denied to our departed associate. True to his nature, he computed all the anomalies and radius-vectors in duplicate, once by means of a manuscript table to supply the reductions needed for NICOLAI'S formulas, which proved more convenient than BARKER'S table for an orbit of so small a perihelion distance, and then again by means of the Besselian reduction of the parabola to an ellipse.

New equations of condition were now formed, sixty-six in number, — weights were empirically assigned to each, and a fifth system of elements thus found which absolutely represented the Portland observation, and satisfied the two Chihuahua altitudes so admirably that the greatest discordance of the five amounted to but 37″, while the probable error of a normal place amounted to 16″. Separating the observations made with a ring-micrometer from those obtained by the filar micrometer, he was able to assign more accurate weights to the several measurements of each coordinate, and found, as might have been anticipated, that the probable error with the ring-micrometer did not much exceed that with the filar micrometer for differences of right ascension, while it proved to be nearly in the ratio of 7 to 10 for differences of declination.

By a repetition of the process, after assigning carefully computed weights, as above mentioned, to sixty-five normal equations of condition, HUBBARD obtained by the method of least squares a sixth system of elements, which gave the best possible representation to the entire series of observations, and reduced the probable error of a normal place to less than 13″.

Here the investigation might well have rested; for the effect of terms of the second order, both in the perturbations and in the comparisons, might fairly be considered as removed, and the sums of the squares of the residuals were a minimum. But HUBBARD was not content to leave any investigation, where there seemed an opportunity of prosecuting it further with success; and since the incorporation of observations made with the ring-micrometer had increased the probable errors of the results, and since the series with the filar micrometer extended through the whole period of visibility excepting the observations by daylight, he passed on to still another determination from the filar-micrometer observations alone combined with the sextant-observations of February 28. From these he constructed eighty-three new equations of condition, determined a seventh series of elements, reducing the probable error of a single normal to less than 8″.5, and assigned for each element its probable error. The period corresponding to these final elements was somewhat more than five hundred years, and it became a problem of much interest to determine to what extent the resultant period might be varied consistently with the probable limits of errors of observation. This HUBBARD solved most thoroughly by an ingenious method of determining the variations of each of the elements, of the probable errors, and of each normal place, as a function of the variation of the eccentricity. So that by substituting in these expressions the change of eccentricity corresponding to any suspected period, a few minutes of figuring will give us the corresponding elements, the probable error of normal places, and the individual discordances of observations. This substitution he carried out himself for the period of one hundred and seventy-five years, and found that it implied a probable error of 11″$\frac{1}{3}$ for a single observation, and no individual discordances beyond the limit of reasonable error; although, to be sure, a certain "rate" seems indicated on this assumption by the earlier observations. The limits of periodic time consistent with its observed geocentric path were thus shown to be extremely wide; and HUBBARD closed by suggesting that the want of coincidence between the centre of gravity and the centre of apparent condensation, as well as the operation of polar forces in the comet itself, might perhaps modify deductions drawn without consideration of these possible influences.

I have not hesitated, Gentlemen of the Academy, to describe this valuable memoir with a minuteness of detail quite unsuitable for a popular address; both because its masterly completeness and elegance render it a model investigation of its class, and because these qualities were so characteristic of our late colleague that a somewhat minute description seemed well adapted to exhibit his habits of mind and mode of research. Preserved in the Library of Yale College are three quarto volumes containing the actual numerical computations,—all executed with marvellous neatness and a beauty of penmanship approaching the elegance of copperplate engraving, — all arranged in due order, and in the form most convenient for reference, and all bearing the strong impress of the man. Indeed, in every one of his manuscripts we may see the reflection of his own cultivated and tasteful mind, in which there was no slovenly corner, or ill-finished record.

HUBBARD'S next investigation of magnitude was upon Biela's comet. Four quarto volumes, filled with neat figures, lie before me as I write, containing his researches concerning the orbit of this most interesting body. They are a priceless and treasured memento of our departed friend, which I owe to the thoughtful kindness of his family; and it is not improbable that four or five years hence they may facilitate the discovery of the origin and nature of the mysterious transformations which this singular comet has undergone, and may aid in the detection of the unknown laws controlling its physical structure.

It is known to you all that Biela's comet, as it is generally called, is one of short period, performing its entire revolution in about $6\frac{3}{4}$ years. It was first seen in 1772, by MONTAIGNE, who made three or four imperfect and untrustworthy estimates of position, and it was observed four times, quite unsatisfactorily, by MESSIER. In 1806, it was detected by PONS; and the general resemblance of its orbit to the approximate one deduced for the comet of 1772, attracted immediate attention. BESSEL and GAUSS computed elliptic orbits on the supposition of identity. The latter found the apparent path as well represented by an ellipse of $4\frac{3}{4}$ years as by his best parabola, thus suggesting the probability that there had been six intermediate returns. The places observed in 1772 were, however, not so well satisfied by an ellipse of so short a major axis, and therefore while the hypothesis of identity seemed plausible, it could hardly be considered probable. It was not until 1826 that the comet was seen again. In that year it was independently discovered both on the 27th February, by VON BIELA, an Austrian captain, on duty at the fortress of Josephstadt, and by GAMBART in Marseilles, ten days later. Upon the first computation of the orbit, each recognized the identity of the comet with that of 1806, and the true length of the period became manifest.

The next return, in 1832, was successfully predicted by astronomers; at the following one in 1839, it was not discovered; and in the winter of 1845 – 6, a predicted return was for the second time observed. But here an unexpected and anomalous phenomenon was exhibited. The comet, which was detected at the close of November, was before the end of December seen to be double, and the two components became apparently farther and farther apart, until, at the end of March, their distance from one another amounted to more than 14′.

It was of course immediately maintained by some that an explosion had occurred, and it became a question of great interest to all astronomers, when, how, and through what agency the separation had been brought about. And yet another curious circumstance was this: — that whereas the northern and preceding component was at first so decidedly the fainter of the two as to receive the name of the "companion," while the southerly one was regarded as the comet proper; — yet this companion, or northerly component, gradually increased in brilliancy, until about the time of perihelion-passage, surpassing the primary nucleus for several days, and then again diminishing in relative brightness so long as observations could be made.

Hubbard, who had observed this comet at Washington early in January, 1846, had been deeply impressed with these inexplicable phenomena, and no astronomer looked forward to its return in 1852 with more anxious interest than he. Would two independent comets be found traversing the same path? or would the phenomenon of a double nucleus be again exhibited? or would the two components manifest mutual relations analogous to those of satellite and primary, or at least to those of binary stars? Would it be possible for observations of each component at the coming perihelion passage to be combined with those made at the last return, so that an ellipse could be deduced for each, and the point of intersection thus determined? These and many similar queries were often discussed; and immediately on the completion of his paper on the comet of 1843, he began his preparations for an equally thorough investigation of Biela's comet so soon as its approaching return to the sun should have been thoroughly observed.

For a month previous to the detection of the comet, Hubbard had been engaged in the preparation of an ephemeris to insure its discovery at as early a date as possible, and had succeeded in obtaining an orbit decidedly better than SANTINI'S, which was the best existing. But the discovery of the comet rendered the publication of this ephemeris unnecessary.

On the 26th August, 1852, Father SECCHI, at Rome, while searching for Biela's comet in the neighborhood of the place indicated by SANTINI'S ephemeris, discovered a very faint nebulous comet somewhat more than 4½° from the place predicted for Biela's, and was able to fix its position with great accuracy by its transit over a small star of the 9.10 magnitude, which it covered at one time so centrally that the comet could only be recognized by the circumstance that the star seemed enveloped in a faint nebulosity. "I do not know," he adds, "whether this is a new comet or a portion of Biela's which was divided in the beginning of 1846."

There seemed but little room for reasonable doubt that this was really Biela's comet, or one of its component parts; since its position, though varying from the ephemeris, was nearly in the same orbit, and the amount and direction of its motion were what might have been expected. But all doubt was removed three weeks later, when Professor SECCHI detected the other portion of the comet, following its predecessor by about half a degree of right-ascension, and about half a degree farther south, and fainter even than the other. Owing to this extreme faintness of both portions, observations could only be continued for a little more than ten days after the discovery of the second component. The last return to perihelion took place in 1859, but the position of the comet was so unfavorable, that although ephemerides prepared by three independent computers, one of them HUBBARD himself, agreed very closely, and the most powerful telescopes of the world were occupied in the search, the comet was not seen.

With this brief sketch of the history of our knowledge of Biela's comet, I may, without entering into close detail, describe HUBBARD's labors and researches concerning it. His published Memoirs on this subject are three in number, in addition to sundry smaller communications on special points; such as one in which he corrected a serious error, which had found its way into the best European computations of the perturbations in 1845 – 6, and explained its probable origin; and a publication of the valuable manuscript observations made by Professor CHALLIS in Cambridge, England, during the same period, and sent by this distinguished astronomer to Professor HUBBARD for employment in his investigations.

The first of these Memoirs is entitled, "On the Orbit of Biela's Comet in 1845 – 6." In this, as in every other memoir of its author, the same searching thoroughness and scrupulous accuracy are manifest which I have recounted concerning his investigation on the comet of 1843. All known observations were employed, no appreciable refinement of method or computation was neglected; and the materials were so fully and completely discussed that it is improbable that any results can ever be drawn from them which he did not himself deduce. The principal results of this memoir, in addition to the discussion of all the observations, consisted in the definite determination of elements for each component, together with their variations for any variation of the adopted mean motion; and in the discovery that by far the greater part of the difference between the two orbits might be represented by a variation in the mean anomaly alone. The residual errors implied by this assumption are very small, much less than the errors of individual observations, and in no case exceeding 8″; but they are nevertheless too symmetric, and too large for his normal places, and he points out, moreover, that some difference must necessarily exist in the mean motions.

In a letter of about this date (1853, June 8), he writes, jestingly: "Biela slides on smoothly. I don't work now, as on '43, wearily and with a $D\psi$, nor boldly and with $D\phi$ance $D$☊ing a change of Inclination, but $D\mu$rely. An allowable change of 0.″34 in the mean motion will give the places in 1852, within 24″ + the error of SANTINI's perturbations, provided I am right in assigning the nuclei relatively to each other; but it is not so easy to tell which is which, as I had supposed."

HUBBARD's published investigations reached this point in the summer of 1853; and he was leisurely preparing the materials for a continuance of the work, when the Imperial Academy of Sciences of St.-Petersburg, in December of that year, offered its astronomical prize for just such an investigation as that on which he was engaged. The distinguished head of the Observatory at Pulkowa wrote specially to suggest the publication in the United States of the Programme for the prize; and it may well be suspected that the very able discussion which HUBBARD had already given might, at least in some degree, have tended to assure the astronomers of the Imperial Academy that competent men were already enlisted in the investigation, whom the liberal prize might at once stimulate and reward. And in view of the laborious and extended computations, which the solution of the problem would entail, a period of nearly four years was allowed for the preparation of the memoir. Many of HUBBARD's friends desired him to compete for this prize, which I think there is no reasonable doubt would have been won by the memoirs which he subsequently published in America.

But HUBBARD's delicate health, together with his earnest desire that whatever he might do for science should inure to his own country's service, prevented him from yielding to the temptation. He considered the matter for a brief period, and then decided that he "ought not to work against time," and the close of his researches was not reached till 1860.

The second paper, published in July, 1854, is entitled, "Results of additional Investigations respecting the two Nuclei of Biela's Comet." In this short, but very elaborate and important memoir, HUBBARD discussed the observations of each nucleus in 1852, determining elements for each. And he arrived at the very remarkable results which seem now incontestable, "that notwithstanding the increased mutual distance of the two nuclei, their alternation, of relative brilliancy were much greater than those noticed in 1846; so great indeed, for several days, as to amount to alternations of visibility from day to day"; and that the observations at Berlin, 1845, November 29 and December 2, were of the primary nucleus, the second being invisible to the observers; while those of CHALLIS, December 1 and 3, were of the secondary, the first being unseen. So that it is clear, both that we are in possession of observations of the second nucleus, made in the beginning of December, 1845, before the existence of two nuclei was suspected, and that even at that time occurred those singular alternations of light which were repeated in 1852. Furthermore, he made it highly probable that the preceding component, in 1846, was identical with the following one in 1852, and *vice versâ;* and finally, that the separation of the nuclei must have occurred not far from 316° of heliocentric longitude, corresponding to a time about five hundred days before the perihelion passage of 1846.

At the close of 1858, HUBBARD published a short papers containing a condensed notice of the condition of the problem, together with new elements for each nucleus, and an ephemeris for each at the approaching return of the comet to perihelion. This I have not counted as one of the Memoirs. His third and last paper on the subject appeared in May, 1860, under the title, "On Biela's Comet." It consists first of an admirable history of all our knowledge of this comet, with full references to the original sources, and presents an excellent specimen of what might be called condensed detail. Next it contains an elaborate discussion of the observations and orbit for every recorded appearance. And in the discussion of the last appearance in 1852, he brought to light a new illustration of the mysterious alternation of brilliancy between the two nuclei. For he showed, that when, on the 15th of September, SECCHI found both nuclei, and determined the position of one of them, the new one being too faint for observation, this so-called "new one" was the identical nucleus which he had discovered in August, and had been observing ever since; while the brighter of the two had then just become visible. "On the 16th, the southern nucleus alone was visible; on the 17th and 18th, only the northern; and finally, on the 19th, both were observed by SECCHI. The double observation was repeated at Rome and at Pulkowa, on the 20th, 23d, and 25th; while on the 21st only the southern, and on the 22d only the northern, was visible. We thus have a most interesting repetition of the alternations in 1845–6, which now appear more remarkable only in consequence of the extreme faintness of the comets, which was such, that the slightest change of light sufficed to carry them within or beyond the scope of vision." (*Astron. Journal*, VI. 140.)

Finally, a recapitulation of the final elements for each nucleus, and for all the observations and normal places, exhausts the sum of our present knowledge of Biela's comet, and leaves us ready for the new investigations which its return eighteen months hence will require.

Another extended investigation by HUBBARD is that upon the Fourth Comet of 1825. HANSEN had long ago found that the observations before and after perihelion seemed better reconciled by an ellipse than by a parabola; and HUBBARD undertook the collection and discussion of all the observations in the hope of some definite determination of the major axis. This investigation occupied much of his time at irregular intervals for five or six years, and was finally published in the spring of 1859. In this, as in most of these cometary investigations, a leading object was to learn whether the motions of the comets, distinguished by their magnitude or varying aspect, or by any other striking peculiarity, would prove in all cases amenable to the law of gravitation alone. In the case of the comet of 1825, no special fact of general interest was elicited; but negative results, though less interesting, are attained with no less labor and skill than positive ones, and are often scarcely less important. Suffice it to say of this memoir, that it is complete, and apparently exhaustive; that the elliptic character of the comet is fully demonstrated, although its periodic time must be exceedingly long; and the material deducible from past observation lies ready for the hands of the future investigator.

I have now spoken, Gentlemen, at sufficient length of the larger and more extended memoirs of our departed colleague, and have described their characteristic features. Of his minor contributions to astronomy I need say no more than that they resembled the larger ones in thoroughness and neatness of conception. The columns of the Astronomical Journal, and the pages of the Washington Observations, are full of them: — elements and ephemerides of many a comet and many an asteroid, elegant and appropriate suggestions, generally relating to methods of computation, or ingenious devices for attaining a desired end with economy of labor.

In the excellent tables appended by Professor COFFIN and himself to several volumes of the Washington Observations; in the reduction and discussion of the geographical observations made by Lieutenants (now Major-Generals) FRÉMONT and EMORY on their various expeditions; in the thorough investigations of the several instruments successively placed in his charge,—the accuracy and conscientiousness of HUBBARD still bear fruit for us.

One of his latest labors was an unpublished investigation of the magnetism of iron vessels, and its effect upon the compass,—upon which he was employed nearly to the time when a Permanent Commission appointed by the Navy Department undertook the same research upon that more extended scale, which the same gentlemen have continued till the present time in the form of a committee of the National Academy.

No description of HUBBARD'S intellectual character could be regarded as complete, that omitted one predominant trait which pervaded all his opinions, and lay deeply rooted in the very foundations of his nature. I mean that deep love of truth and loathing of all false assumption, which may be said to bear the same relation to honesty that honesty bears to what is called "worldly policy." There were few things which his modest and tolerant spirit could be said to hate; but he did hate sham, humbug, and charlatanism with all the energy of his soul. He never claimed honor, rank, or position for himself, although he hastened to accord all these to others far less worthy than he; but he was restive at the sight of scientific rewards unworthily bestowed by incompetent tribunals; and his sterling patriotism and sense of justice not unfrequently united in paining him, when—

"He saw the holy wreaths of Fame
Profaned to deck ignoble brows."

Thus far, gentlemen, I have endeavored to describe Professor HUBBARD to you as a man of science,—showing you the early efforts of his mind, and the eager pursuit of knowledge which characterized even his boyhood. We have seen what he had accomplished at the age of thirty-nine; and alas! how much more he promised for the future which we hoped for him. But though all this is done, I feel that the more difficult part of my duty to his memory remains undone; and I approach it with yet greater distrust of my ability to do it aright. It is comparatively an easy task to trace the working of his mind, and the results of his studies; but to show him as some of us knew him, as a son, a brother, a friend, a Christian, to do him justice without trespassing on that privacy which none valued more highly than he, requires a hand of equal delicacy and skill. One assistance at least the biographer of HUBBARD may justly feel to be accorded him,—that in that life there is no record to be concealed, no page to be glanced at and quickly closed with pain. His only choice is what to show, not what to hide.

Our colleague had a kindly, gentle nature, and an affectionate regard for all around him. He made his own opportunities to help and cheer others, instead of waiting for them. Was a friend successful, he rejoiced with a cordiality that made him twice happy; in sorrow, he mourned with him, and with a sympathy that half lifted off the burden. One of the strongest affections of his life was for his mother. He showed her not only the natural affection and tenderness of a son, the respect due from youth to honorable age, or the attachment which old and cherished associations awaken, but to the very last he made her his confidante and counselor. His deepest thoughts and highest aspirations, his struggles and his joys, were alike intrusted to her; a precious deposit, which her heart knew how to keep and ponder.

Professor HUBBARD was married at the age of twenty-five to Miss SARAH E. L. HANDY of Washington, on the 27th of April, 1848. Few men were more fitted than he to enjoy the comforts of a home, or could better appreciate the blessings of his new relation; but there were many clouds to overshadow the horizon, as he himself says in one short note, whose pathos only those can understand who know that it was but once or twice in a lifetime that a murmur escaped his lips. Upon the threshold of his home stood always that dreary visitant, Ill-health, whose dominion over both mental and physical content most of us know too well. HUBBARD'S own health was never certain, but his wife was a far greater sufferer; and often, unknown to herself, her troubles weighed too heavily upon his over-tasked mind and sensitive heart. Even pecuniary embarrassments, those petty cares that, unlike deeper sorrows, fail to brace the mind they attack, were not wanting to sting his delicate and generous spirit. Each day their peculiar circumstances compelled new outlays, to be defrayed only from means already too slender. We can appreciate their struggles, without prying too closely into what he might have wished forgotten. We can see the student compelled to forego his cherished pursuits, the man of tender sensitiveness wrung by the sufferings of those nearest him, the invalid whose frail health varied with each new trial. We can see all this; but to a spirit such as his must have come many a compensation, many a blessing won from the dark angels by bitter wrestling.

> "For that high suffering which we dread
> A higher joy discloses;
> Men see the thorns on Jesus' head,
> But angels see the roses."

After eight and a half years of married life, a long desired change came to the little household, and with a new joy he welcomed his child. With what hope and happiness he accepted the new promise, those who knew him well cannot forget; but the happiness was all too short. "The little spirit only fluttered for a while on the threshold of its prison-house, and unconscious of captivity took flight forever." Writing to a near friend at the time, HUBBARD says, "God bless you for the interest you took in my boy. This is all I can say; for I cannot write of him." Nor will I undertake to speak of his grief. Four years later, Mrs. HUBBARD's suffering life terminated; and her husband was left alone, with only the remembrance of a home.

As a friend I knew HUBBARD well, and can bear witness to the loyalty and gentleness of his nature. With a gayety never bordering on excess, a sympathy never exhausted, a kindly tact never forgotten, he was a companion such as we rarely meet. Of his help and encouragement to me personally, I have already spoken; and since I have read the memorials entrusted to my care, I see that what he did for me he did for many others, each according to his need.

During the last few years of our colleague's life, there seems to have been some modification, or at least exaltation, of the views and sentiments which, perhaps more than any others, tend to make each one of us what we are, — I mean our sense of personal relation to the Deity. That high principle and religious fervor which through his life had been a lamp to his feet, showing itself in love to God and man, burnt during these later years with a yet brighter flame. Perhaps, indeed, it may to some of us seem for a moment to have dazzled his vision, and made the shadows which must darken every thoughtful mind seem blacker than those ordained by the hand of a loving Father. In reading these last memorials, we cannot but grieve that his pure and gentle spirit should have passed through those hours of struggle which, to our vision at least, he seemed to need so little. But it is not for us to scan too closely the sacred privacy of these emotions. Let us turn rather to their results.

He was long connected with the religious society of Rev. Dr. GURLEY, in Washington; and his letters to his mother show the reliance which he placed upon this excellent man, and the eagerness with which he sought to know and do his Master's will. He became an elder of the church, and not many months before his death, Superintendent of the Sunday Schools of the Presbyterian denomination in the city. In the affections and lives of his associates and pupils, we find the best tribute to the ability and fidelity with which he discharged these duties.

Among the writings of these later months are various treatises on religious and theological subjects, and critical comparisons and reconciliations of various portions of the Old and New Testaments; to all of which he brought the same power of unwearying research that characterized his scientific labors. He attempted the mastery of the Hebrew language, and labored zealously to fit himself for a more critical study of the Bible. Indeed so earnest was his religious devotion that we find indications of some vague aspiration, or half-formed plan, of renouncing even his scientific pursuits in order to enter upon the labors of the Christian ministry. To each one is intrusted his peculiar gift; and we who knew HUBBARD as a student and minister of science, cannot but feel that his Maker had clearly pointed out the way in which he best might serve Him, by devoting a rare capacity and pure heart to the study and interpretation of His works.

Perhaps, Gentlemen, we may regret that, even for a moment, and from the highest possible motives, he was unfaithful to his earliest choice, and swerved from the path where, as we think, he best served God and man. Yet such questions must be decided by every man for himself, with such light as he may attain; and it may be that these varied experiences and changes of thought were sent him that he might live through the experience of many years during the lapse of a few, and might learn as many as possible of the lessons of this life during the time allotted him. But can we do otherwise than honor a creed which blossoms in such deeds as crowded the last years of HUBBARD's life. His was no bigot's zeal. It led him among the poor, the sick, and the afflicted. It sent him to the hospitals, where he daily spent his hours of official leisure with the soldiers, giving each the needful word of good cheer, or bringing delicacies and comforts to them so far as his own opportunities or those of his friends permitted. It inspired him with a true loyalty to his country, and endowed him with that spirit of self-sacrifice which shone in every action. "The number of letters that he wrote for wounded soldiers," says a friend in writing of him, "was almost incredible. He frequently devoted whole afternoons to this one object. I wonder how many of the soldiers knew whose bright face it was that was so pleasant to them."

With all these self-imposed duties added to his daily and nightly routine of work, who can wonder that his health, always so uncertain, became each month still more impaired; and that when the last summons came it was so quickly answered.

Professor HUBBARD left Washington for the last time on the 30th July, 1863. For a few days previous he had been particularly unwell, owing to severe exposure in a sudden shower. But he had looked forward with peculiar pleasure to a meeting of his college classmates in celebration of the twentieth anniversary of their graduation; and he managed to pursue his original plan, and reached New Haven in time for the meeting. But the delicate instrument had been too much shattered to recover its tone, and its music was to be heard no longer. He suffered severely on the journey, and on being assisted into the well-remembered house where his mother was awaiting him, had only strength to say, "O, how good it is to be at home." His mother pressed forward to meet him, and he added those words, which to our ears seem so full of pathos: "Mother, I am worn out."

And so indeed it proved. To the physician who was instantly summoned, he only said: "Doctor, help me to a little strength to meet my class to-morrow night, and then I will give up." But even this gratification was denied him, and the affectionate greeting that he sent his classmates was almost his last earthly utterance. Gradually, but surely, he sank away; but who could have wished for him a happier dismissal? Soothed by familiar voices and pleasant images, tended as in his infancy by his mother, surrounded by loving faces, the worn-out man may have felt himself a weary child again; and with a childlike confidence he went to rest, on Sunday morning, August 16, — waking, we may be sure, to exclaim once more, "How good it is to be at home." A day or two afterward his mortal part was laid in the quiet cemetery near us, where, two years before, that very week, he had seen his father laid.

"Sleep sweetly, tender heart, in peace;
Sleep, holy spirit, blessed soul,
While the stars burn, the moons increase,
And the great ages onward roll.

"Sleep till the end, true soul and sweet,
Nothing comes to thee new or strange;

Sleep, full of rest from head to feet;
Lie still, dry dust, secure of change."

Here we leave him. But, gentlemen of the National Academy, let not the name of the first who left our ranks be soon forgotten. Others of those ranks may have emblazoned their names more conspicuously, their memory may be yet more secure of perpetuity, in the annals of science. But none of our number can claim to have surpassed him in those qualities which make the highest glory of a man; and well will it be for us if our names can be inscribed near his, on the highest of records.

If our National Academy is to fulfil its loftiest mission, and achieve a work commensurate with our hope and faith, let us emulate the spirit of him whom we have first been called upon to mourn, — the spirit of disinterestedness, of patriotism, and of highest purpose.

Cambridge: Printed by Welch, Bigelow, & Co.

# ANNUAL

OF THE

# NATIONAL ACADEMY OF SCIENCES

FOR 1865.

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# CONTENTS.

I.

# AN ACT

## TO INCORPORATE THE NATIONAL ACADEMY OF SCIENCES.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, St. Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States Navy, Kentucky; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania; J. L. Le Conte, United States Army, Pennsylvania; J.

Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, Jr., Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SECT. 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institutions, and to report the same to Congress.

SECT. 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and re-

ports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

SOLOMON FOOT,
*President of the Senate pro tempore.*

GALUSHA A. GROW,
*Speaker of the House of Representatives.*

APPROVED March 3, 1863.

ABRAHAM LINCOLN, *President.*

# II.

# CONSTITUTION AND BY-LAWS

## OF THE ACADEMY.

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## PREAMBLE.

EMPOWERED by the Act of Incorporation adopted by Congress, and approved by the President of the United States, on the 3d day of March, A. D. 1863, the National Academy of Sciences do enact the following Constitution and By-Laws: —

## ARTICLE I.

### *Of Members.*

SECTION 1. The members of the Academy shall be designated as Members, Honorary Members, and Foreign Associates.

SECT. 2. The Academy shall consist of the fifty members named in the Act of Incorporation, and of such others, citizens of the United States, as shall from time to time be elected to fill vacancies, in the manner hereinafter provided.

SECT. 3. Every member shall, upon his admission, take the oath of allegiance prescribed by the Senate of the United States for its own members, and, in addition thereto, an oath faithfully to discharge the duties of a member of

the National Academy of Sciences to the best of his ability. He shall also subscribe the laws of the Academy.

SECT. 4. The members of the Academy shall be arranged in two Classes, according to their special studies, viz.: A, the Class of Mathematics and Physics, and B, the Class of Natural History. The corporate members may select the Class in which they desire to be arranged.

SECT. 5.* The members of the Classes shall arrange themselves in Sections, by inscribing their names under one of the following heads: — CLASS A. *Mathematics and Physics.* Sections: 1. Mathematics; 2. Physics; 3. Astronomy, Geography, and Geodesy; 4. Mechanics; 5. Chemistry. CLASS B. *Natural History.* Sections: 1. Mineralogy and Geology; 2. Zoölogy; 3. Botany; 4. Anatomy and Physiology; 5. Ethnology.

But the Academy retains the power of transferring a member from one Section to another by a unanimous vote.

SECT. 6.† A member of any Section may be elected a member of any one other Section by a vote of a majority of the members thereof present, subject to the approval of the Academy, but shall thereby acquire no new right of voting as a member of a Class.

The Academy may also, by a vote of three fourths of the members present, appoint a member of any Section a member of any one other Section which is unable to elect for itself. Such member shall acquire no new right of voting as a member of a Class.

SECT. 7. The Academy may elect fifty Foreign Associates, who shall have the privilege of attending the meetings of the Academy, and of reading and communicating papers to it, but shall take no part in its business, and shall not be subject to its assessments.

* Amended January 4, 1865.

† Amended August 25, 1865.

They shall be entitled to a copy of the publications of the Academy.

## ARTICLE II.

### *Of the Officers.*

SECT. 1. The officers of the Academy shall be a President, a Vice-President, a Foreign Secretary, a Home Secretary, and a Treasurer, all of whom shall be elected for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner, at the next stated session after the vacancy occurs.

SECT. 2. The officers of the Classes shall be a Chairman and a Secretary, who shall be elected at each January session. The nominations shall be open, and a majority of votes shall be necessary to elect.

SECT. 3. The officers of the Academy and the Chairmen of the Classes, together with four members, two from each Class, to be annually elected by the Academy, at the January session, by a plurality of the votes, shall constitute a Council for the transaction of such business as may be assigned to them by the Constitution or the Academy.

SECT. 4. The President of the Academy, or, in case of his absence or inability to act, the Vice-President, shall preside at the meetings of the Academy and of the Council; shall name all committees, except such as are otherwise especially provided for; refer investigations required by the Government of the United States to members specially conversant with the subject, and report thereon to the Academy at its next January session; and, with the Council, shall direct the general business of the Academy.

It shall be competent for the President, in special cases, to call in the aid, upon committees, of experts, or men of remarkable attainments, not members of the Academy.

SECT. 5. The Foreign and Home Secretaries shall conduct the correspondence proper to their respective departments, advising with the President and Council in cases of doubt, and reporting their action to the Academy at its January session. It shall be the duty of the Home Secretary to give notice to the members of the place and time of all meetings, and to make known to the Council all vacancies in the list of members.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the Home Secretary.

SECT. 6. The Treasurer shall attend to all receipts and disbursements of the Academy, giving such bond, and furnishing such vouchers, as the Council may require. He shall collect all dues from members, and keep a set of books, showing a full account of receipts and disbursements. He shall present at each stated session a list of the members entitled to vote, and a general report at the January session. He shall be the custodian of the corporate seal of the Academy.

## ARTICLE III.

### *Of the Meetings.*

SECT. 1.* The Academy shall hold two stated sessions in each year, — one in the city of Washington, on the Wednesday next succeeding the third Sunday of January, and one in August, at such time and place as the Academy shall have determined upon, in private meeting, on the last day of the preceding January session.

* Amended August 25, 1865.

Sect. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

Sect. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business closed.

Sect. 4. The Academy may divide into Classes for scientific or other business. In like manner, the Classes may divide into Sections.

Sect. 5. The Classes shall meet during such periods of the stated sessions of the Academy as may be fixed by the Academy. Special meetings of a Class may be called by the Council at the request of five members of the Class.

Sect. 6. The stated meetings of the Council shall be held at the times of the stated or special meetings of the Academy. Special meetings shall be convened at the call of the President and two members of the Council, or of four members of the Council.

Sect. 7. No member who has not paid his dues shall take part in the business of the Academy.

## ARTICLE IV.

### *Of Elections, Resignations, and Expulsions.*

Sect. 1. All elections shall be by ballot, unless otherwise ordered by this Constitution; and each election shall be held separately.

Sect. 2. Whenever any election is to be held, the presiding officer shall name a Committee to conduct it, to collect the votes, count them, and report the result to the Academy. The same law shall apply in the Classes.

Sect. 3. Nominations for officers shall be made at the close of the first daily meeting of a stated session; and no candidate shall be voted for unless thus nominated.

Sect. 4.* For election of members, the Council shall first decide the Class in which the vacancy shall be filled. Each Section of that Class may then select one or more candidates, after a discussion of their qualifications, and present their claims to the Class, who shall select three to be presented, in the order of their preference, to the Academy; from these three the Academy shall elect by a majority of the members present. The member elect shall be assigned to the Section in which he has been proposed. The Academy may nominate candidates in any Section which fails to propose them for itself, provided that it shall first be decided by a vote of two thirds that such nomination is proper and advisable.

Sect. 5. Every member elect shall accept his membership personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the Secretary has formally notified him of his election, his name shall not be entered on the roll of members.

Sect. 6. Elections of Foreign Associates shall be conducted as follows: —

Each Section shall report to its Class, nominating a candidate whose special researches need not belong within the province of the Section, but must be comprised within the range of the Class.

From these candidates each Class shall select one name to be presented to the Academy, and from these two names the Academy, after full discussion, shall make the election, at such time as it may have previously appointed for the purpose.

* Amended August 25, 1865.

Sect. 7. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate Secretary to each member on his acceptance of his membership.

Sect. 8. Resignations shall be addressed to the President and acted on by the Academy. No resignation of membership shall be accepted unless all dues have been paid.

Sect. 9. Members resigning in good standing will retain an honorary membership; being admitted to the meetings of the Academy, but without taking part in the business. Honorary members will not be liable to assessment.

Sect. 10. If any member be absent from four consecutive stated sessions of the Academy, without communicating to the Academy a valid reason for his absence, his name shall be stricken from the roll of members.

Sect. 11. Members and officers habitually neglecting their duties shall be impeached by the Council, and at once notified thereof in writing by the Home Secretary.

Sect. 12. Impeachments of members or officers shall first be tried before the Council; which may be convened specially for such purpose. If it decides that the impeachment is proper, such impeachment shall be tried in private session before the Academy at its next stated meeting.

Sect. 13. The expulsion of a member shall be formally and publicly announced by the President at the stated session during which such expulsion shall take place.

## ARTICLE V.

*Of Scientific Communications, Publications, and Reports.*

Sect. 1. Papers on scientific subjects may be read at the meeting of the Academy or of the Classes or Sections to which the subject belongs.

SECT. 2. Any member of the Academy may read a paper from a person who is not a member; and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

SECT. 3. The Academy shall provide for the publication, under the direction of the Council, of Proceedings, Memoirs, and Reports.

SECT. 4. Propositions for investigations or reports shall originate with the Classes to which the subjects belong, and be by them submitted to the Academy for approval; except requests from the Government of the United States, which shall be acted on by the President, who will in such cases report, if necessary, at once to the Government, and to the Academy at its next stated session.

SECT. 5. The judgment of the Academy shall be at all times at the disposition of the Government, upon any matter of Science or Art within the limits of the subjects embraced by it.

SECT. 6. An Annual Report to be presented to Congress shall be prepared by the President, and before its presentation submitted by him, first to the Council, and afterwards to the Academy at its January meeting.

SECT. 7. Medals and Prizes may be established, and the means of bestowing them accepted, by the Academy, upon the recommendation of the Council; by whom all the necessary arrangements for their establishment and award shall be made.

## ARTICLE VI.

*Of the Property of the Academy.*

SECT. 1. All investments shall be made by the Treasurer, in the corporate name of the Academy, in stocks of the United States.

SECT. 2. No contract shall be binding upon the Academy which has not been first approved by the Council.

SECT. 3. The assessments required for the support of the Academy shall be fixed by the Academy on the recommendation of the Council.

## ARTICLE VII.

### *Of Additions and Amendments.*

Additions and Amendments to the Constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change may be given at any stated session, and shall be referred to the Council, which may amend the proposition, and shall report thereon to the Academy at its next stated session, with a recommendation that it be accepted or rejected. Its report shall be considered by the Academy in Committee of the Whole, and immediately thereafter acted on. If the addition or amendment receive two thirds of the votes present, it shall be declared adopted, and shall have the same force as the original law.

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## EXPLANATORY CLAUSE.

In consequence of differences of opinion in relation to the interpretation of Section 4 of Article IV. of the Constitution of the Academy, the following resolution was passed August 5, 1864: —

"*Resolved*, That the Academy is of opinion that Section 4 of Article IV. of the Constitution is to be interpreted to mean, that any Section of either Class making a nomination shall be restricted in the choice to persons eminent in the branch or branches of science understood to be included in the title of the Section."

# BY-LAWS.

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## OF THE OFFICERS.

I. In the absence of the Chairman or Secretary of a Class, a member shall be chosen to perform his duties temporarily, by a plurality of the *viva voce* votes, upon open nomination.

II. The accounts of the Treasurer shall be referred to an Auditing Committee of three members, to be appointed by the Academy at the meeting at which the accounts are presented; which committee shall report before the close of that session, and shall then be discharged.

## OF THE MEETINGS.

III. A Committee of Arrangements for each stated session of the Academy, of five members, shall be appointed by the President, the Class Secretaries to be *ex officio* two of the members of the Committee. This Committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings, to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, etc.; and to arrange the order of reading, and in general to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be as follows: —

1. Chair taken by the President, or, in his absence, the Vice-President.
2. Roll of members called by Home Secretary.
3. Report by Treasurer of members entitled to vote.
4. Minutes of the preceding meeting read and approved.
5. Stated business.
6. Reports of President, Secretaries, Treasurer, Classes, and Committees.
7. Business from Council.
8. Other business.
9. Communications from members.
10. Communications from persons not members.
11. Announcements of the death of members. Biographical notices read.
12. Rough minutes read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless otherwise directed.

VI. It shall be in order for twelve members to require that any matter of business be discussed in Committee of the Whole, for amendment; the vote upon amendments to be taken in the whole Academy; and the amended proposition or propositions to be similarly voted on.

VII. The scientific meetings shall be convened at twelve o'clock, M., in order to allow time for the business meetings of the Academy, and for the meetings of Classes, Sections, and Committees.

### OF ELECTIONS AND OBITUARIES.

VIII. No more than ten Foreign Associates shall be elected at any one stated session.

IX. The death of members shall be announced by the President on the last day of each stated session, when a

member shall be selected by the Academy to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member shall be selected by the Academy in place of the first, and so on until the duty is performed.

X. The deaths of such eminent scientific men of the country as have taken place since the last session of the Academy shall be announced by the President. The names shall be selected by the Council.

XI. All discussions as to the claims and qualifications of candidates, whether at meetings of the Sections, the Classes, or the Academy, will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the Academy at the time of the discussion.

## OF SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

XII. An analysis of the memoirs and reports read in the meetings of the Classes shall be given by the Secretaries of the Classes to the Home Secretary for publication in the proceedings of the Academy. For any failure in this duty, the delinquent officer shall be impeached by the Home Secretary.

XIII. The Secretaries shall receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy, Class, or Section, and ordered to be published by the Academy. Papers shall be published in the order in which they were registered, but papers which have not been sent to the Secretary within a month from the time of their reading shall not be published without a special vote of the Academy.

XIV. Memoirs shall date in the records of the Academy from the day of their presentation to the Academy, and the order of their presentation shall be that on which they were registered, unless changed by consent of the author.

XV. The publication of any communication to which objection is made by the Section to which the subject belongs shall be suspended until a second time authorized by a vote of the Academy.

XVI. Papers from persons not members, read before the Academy, Classes, or Sections, and intended for publication, shall be referred, at the meeting at which they are read, to a Committee of members competent to judge whether the paper is worthy of publication. Such Committees shall report to the Academy as early as practicable, and not later than the next stated session. If they do not then report, they shall be discharged, and the paper referred to another Committee.

XVII. Abstracts of papers published in the transactions of other societies or in journals may be communicated orally to the Academy; and if, on submitting any such communication to a Committee, its publication be approved, it may be ordered for publication on a vote of the Academy.

XVIII. Short communications or abstracts of memoirs may be sent by any member to the Home Secretary, who shall, if requested by the author, without delay circulate them among the members.

XIX. An Annual of the Academy shall be prepared by the Secretaries, and published on the first day of each year.

XX. The printing of the Academy shall be under the charge of the Secretaries and the Treasurer, as a Committee of Publication, who shall report in relation thereto at each January meeting of the Academy.

XXI. The Annual Report of the Academy may be accompanied by a memorial to Congress, in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XXII. The Home Secretary shall present to the Council estimates for books and stationery, binding, &c., required for the use of the Academy.

## OF THE PROPERTY OF THE ACADEMY.

XXIII. The proper Secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session.

XXIV. The books, apparatus, archives, and other property of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles deposited shall be kept by the Home Secretary, who is authorized to employ a clerk to take charge of them.

XXV. A stamp corresponding to the corporate seal of the Academy shall be kept by the Secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels or other proper marks, of similar device, shall be placed upon objects not admitting of the stamp.

## CHANGES IN THE BY-LAWS.

XXVI. Any By-Law of the Academy may be amended or repealed on the written motion of any two members, signed by them, and presented at a stated session of the Academy; provided the same shall be approved by a majority of the members present at the next stated session.

# III.

## ORGANIZATION OF THE ACADEMY.

1865.

ALEXANDER DALLAS BACHE, *President.*
JAMES DWIGHT DANA,* *Vice-President.*
LOUIS AGASSIZ, *Foreign Secretary.*
WOLCOTT GIBBS, *Home Secretary.*
FAIRMAN ROGERS, *Treasurer.*

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### COUNCIL FOR 1865.

The Officers of the Academy and the Chairmen of the Classes *ex officio.*

BENJ. A. GOULD.
J. L. LE CONTE.
LEWIS M. RUTHERFURD.
J. PETER LESLEY.

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## OFFICERS OF THE CLASSES.

1865.

### CLASS OF MATHEMATICS AND PHYSICS.

BENJAMIN PEIRCE, *Chairman.*
J. E. HILGARD, *Secretary.*

* Resigned August 23, 1865.

## CLASS OF NATURAL HISTORY.

LOUIS AGASSIZ, *Chairman.*
SPENCER F. BAIRD, *Secretary.*

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# SECTIONS.

## CLASS OF MATHEMATICS AND PHYSICS.

### SECTION I. *Mathematics.*

J. G. BARNARD.
H. A. NEWTON.
THEODORE STRONG.
WILLIAM CHAUVENET.
BENJAMIN PEIRCE.
JOSEPH WINLOCK.
And under Art. I., Sect. 6,
BENJ. A. GOULD.
J. H. C. COFFIN.

### SECTION II. *Physics.*

A. D. BACHE.
F. A. P. BARNARD.
JOSEPH HENRY.
W. H. C. BARTLETT.
A. A. HUMPHREYS.
OGDEN N. ROOD.
And under Art. I., Sect. 6,
WOLCOTT GIBBS.

### SECTION III. *Astronomy, Geography, and Geodesy.*

STEPHEN ALEXANDER.
J. H. C. COFFIN.
ARNOLD GUYOT.
JOHN RODGERS.
ALEXIS CASWELL.
CHARLES H. DAVIS.
BENJ. A. GOULD.
LEWIS M. RUTHERFURD.
And under Art. I., Sect. 6,
WILLIAM CHAUVENET.
JOSEPH WINLOCK.
HUBERT A. NEWTON.

### Section IV. *Mechanics.*

J. H. Alexander. J. F. Frazer.
J. E. Hilgard. D. H. Mahan.
Fairman Rogers. Joseph Saxton.
Montgomery C. Meigs.

And under Art. I., Sect. 6,
Benjamin Peirce. J. G. Barnard.
Joseph Henry. F. A. P. Barnard.

### Section V. *Chemistry.*

Wolcott Gibbs. Benj. Silliman, Jr.
John Torrey.

## CLASS OF NATURAL HISTORY.

### Section I. *Mineralogy and Geology.*

J. P. Lesley. Leo Lesquereux.
James Hall. J. S. Newberry.
J. D. Whitney.

And under Art. I., Sect. 6,
Arnold Guyot.

### Section II. *Zoölogy.*

Louis Agassiz. James D. Dana.
Spencer F. Baird. Augustus A. Gould.
Jared P. Kirkland. John L. Le Conte.

### Section III. *Botany.*

George Engelmann. Asa Gray.
And under Art. I., Sect. 6,
John Torrey. Leo Lesquereux.

Section IV. *Anatomy and Physiology.*

S. Weir Mitchell. John C. Dalton.

Section V. *Ethnology.*

Wm. D. Whitney.

# IV.

## COMMITTEES OF THE ACADEMY.

### I.

*Committee on Weights, Measures, and Coinage.*

(Appointed May 4, 1863, at the request of the Hon. S. P. Chase, Secretary of the Treasury of the United States, dated April 24, 1863.)

JOSEPH HENRY, *Chairman.*

J. H. ALEXANDER.
ARNOLD GUYOT.
FAIRMAN ROGERS.
BENJ. SILLIMAN, JR.
WOLCOTT GIBBS.
WM. CHAUVENET.
JOHN TORREY.

A. D. BACHE. (By resolution of the Academy.)
JOHN RODGERS. (Jan. 5, 1864.)
L. M. RUTHERFURD. (Jan. 5, 1864.)

And by authority of Art. II., Sect. 4,

SAMUEL B. RUGGLES.

Mr. Henry, Chairman of the Committee on Weights, Measures, and Coinage, reported to the Academy on behalf of the Committee, January 9, 1864, and offered the following resolution, which was adopted: —

*Resolved*, That the Committee on Weights, Measures, and Coinage have leave to continue their labors and business now in progress, with power.

(A copy of the Report was submitted to the Secretary of the Treasury.)

## II.

### *A Committee on the Question of Tests for the Purity of Whiskey.*

(Appointed January 14, 1864, at the request of the Acting Surgeon-General, January 5, 1864.)

B. Silliman, Jr., *Chairman.*
John Torrey.
R. E. Rogers.
J. H. Alexander.

March 12, 1864. A communication was sent from the Committee to Acting Surgeon-General J. K. Barnes, recommending that an appropriation of $ 3,500 be made to meet the expenses of the investigation.

March 25, 1864. A letter was received from Acting Surgeon-General Barnes, stating that an appropriation of $3,500 had been authorized by the Secretary of War, and that Surgeon R. S. Satterlee, U. S. A., Medical Purveyor at New York, would be instructed to pay accounts for necessary purchases, etc., upon approval by the Committee.

Committee reported Jan. 6, 1865, and were discharged. A copy of the report was transmitted to the Surgeon-General.

## III.

### *A Committee on the Expansion of Steam.*

February 29, 1864. The Hon. Gideon Welles, Secretary of the Navy, invited the appointment of a committee of three members of the Academy, to act jointly with three members named by the Department and with three members of the Franklin Institute of Pennsylvania for the promotion of the Mechanic Arts, to conduct, witness, and report upon experiments which may be agreed upon by the Commission on the Expansion of Steam. The experiments are to be reported as early as practicable to the Department, and to be submitted also to the National Academy of Sciences for its judgment and suggestions.

March 10. The Committee of the Academy was appointed, to consist of

Fairman Rogers. F. A. P. Barnard.
Joseph Saxton.

[The Navy Department named as its members of the joint Commission,

Horatio Allen, *Chairman.*
Admiral C. H. Davis. B. F. Isherwood.

The Franklin Institute named as its members of the joint Commission,

J. H. Towne. J. V. Merrick.
R. A. Tilghman.]

## V.

## MEMBERS OF THE ACADEMY.

| | |
|---|---|
| Agassiz, Louis, | Cambridge, Mass. |
| Alexander, John Henry, | Baltimore, Md. |
| Alexander, Stephen, | Princeton, N. J. |
| Bache, Alexander Dallas, | Washington, D. C. |
| Barnard, Frederick A. P., | New York, N. Y. |
| Barnard, John G. | U. S. A., Washington, D. C. |
| Bartlett, Wm. H. C., | U. S. A., West Point, N. Y. |
| Baird, Spencer F., | Washington, D. C. |
| Caswell, Alexis, | Providence, R. I. |
| Chauvenet, William, | St. Louis, Mo. |
| Coffin, John H. C., | U. S. N., Newport, R. I. |
| Dalton, John Call, | New York, N. Y. |
| Dana, James Dwight, | New Haven, Conn. |
| Davis, Charles Henry, | U. S. N., Washington, D. C. |
| Engelmann, George, | St. Louis, Mo. |
| Frazer, John Fries, | Philadelphia, Penn. |
| Gibbs, Wolcott, | Cambridge, Mass. |
| Gould, Benjamin Apthorp, | Cambridge, Mass. |
| Gould, Augustus Addison, | Boston, Mass. |
| Gray, Asa, | Cambridge, Mass. |
| Guyot, Arnold, | Princeton, N. J. |
| Hall, James, | Albany, N. Y. |
| Henry, Joseph, | Washington, D. C. |
| Hilgard, Julius E., | Washington, D. C. |
| Humphreys, Andrew A., | U. S. A., Washington, D. C. |
| Kirtland, Jared P., | Cleveland, Ohio. |

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|---|---|
| LE CONTE, JOHN L., | Philadelphia, Pa. |
| LEIDY, JOSEPH, | Philadelphia, Penn. |
| LESLEY, J. PETER, | Philadelphia, Penn. |
| LESQUEREUX, LEO, | Columbus, Ohio. |
| LONGSTRETH, MIERS FISHER, | Derby, Penn. |
| MAHAN, DENNIS H., | U. S. A., West Point, N. Y. |
| MEIGS, MONTGOMERY C., | Washington, D. C. |
| MITCHELL, S. WEIR, | Philadelphia, Penn. |
| NEWBERRY, JOHN STRONG, | Cleveland, Ohio. |
| NEWTON, HUBERT A., | New Haven, Conn. |
| PEIRCE, BENJAMIN, | Cambridge, Mass. |
| RODGERS, JOHN, | U. S. N., Washington, D. C. |
| ROGERS, FAIRMAN, | Philadelphia, Penn. |
| ROOD, OGDEN N., | New York, N. Y. |
| RUTHERFURD, LEWIS M., | New York, N. Y. |
| SAXTON, JOSEPH, | Washington, D. C. |
| SILLIMAN, BENJAMIN, JR., | New Haven, Conn. |
| STRONG, THEODORE, | New Brunswick, N. J. |
| TORREY, JOHN, | New York, N. Y. |
| WHITNEY, JOSIAH DWIGHT, | San Francisco, Cal. |
| WHITNEY, WM. DWIGHT, | New Haven, Conn. |
| WINLOCK, JOSEPH, | Cambridge, Mass. |

HONORARY MEMBER (Sect. 9, Art. 4).

| | |
|---|---|
| JEFFRIES WYMAN, | Cambridge, Mass. |

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There are at present, January 1, 1866, two vacancies in the Academy. Of the fifty members originally appointed by Act of Congress, five have died since the first Session of the Academy, namely, Joseph S. Hubbard, Joseph G. Totten, Edward Hitchcock, Benjamin Silliman, Sr., and James M. Gilliss. Two members have been stricken from the roll in accordance with Sect. 10 of Art. IV. One member has resigned.

# VI.

## FOREIGN ASSOCIATES.

Sir Wm. Rowan Hamilton.*
Karl Ernst Von Baer.
Michael Faraday.
J. B. Elie de Beaumont.
Sir David Brewster.
G. A. A. Plana.*
Robert Bunsen.
F. W. A. Argelander.
Michel Chasles.
Henry Milne-Edwards.
Alexander Braun.
George B. Airy.
Richard Owen.
Friedrich Wöhler.
Sir Roderick I. Murchison.
Victor Regnault.

* Since deceased.

# VII.

# ANNUAL REPORT OF THE PRESIDENT

## FOR 1865.

# ANNUAL REPORT.

WASHINGTON, D. C., February 13, 1865.

SIR: I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year, in conformity with the requirements of the act of incorporation, approved March 4, 1863.

Very respectfully,

A. D. BACHE,

*President National Academy of Sciences.*

HON. SCHUYLER COLFAX, *Speaker of the House of Representatives.*

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NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., February 11, 1865.

SIR: In accordance with the provisions of the Constitution of the National Academy of Sciences, (Article V., Section 6,) the following report of the proceedings and labors of the Academy during the year 1864 is respectfully submitted to Congress:

Since the presentation of the first annual report, (March 28, 1864,) three Committees have been appointed by the President of the Academy, to examine into and report upon subjects submitted to the Academy by different departments of the government of the United States.

On the 5th of January, 1864, a letter was received from the Acting Surgeon-General, J. K. Barnes, inviting the Academy to investigate and report upon the best methods of testing the purity of whiskey employed for medicinal purposes. A Committee was in consequence appointed, consisting of the following members: —

B. SILLIMAN, JR., *Chairman.*

| | |
|---|---|
| JOHN TORREY, | J. H. ALEXANDER, |
| R. E. ROGERS, | J. L. LE CONTE. |

On the 12th of March, 1864, the Committee addressed a communication to the Acting Surgeon-General, recommending that an appropriation of three thousand five hundred dollars ($ 3,500) be made to meet the expenses of the investigation. The recommendation of the Committee was promptly adopted by the Acting Surgeon-General, and the sum asked for placed in the hands of R. S. Satterlee, United States Army, Medical Purveyor at New York, subject to the order of the Committee. On careful examination of the subject, however, the Committee became satisfied that no money was needed, and presented to the Academy, January 6, 1865, a report, a copy of which is herewith submitted.

The report of the Committee was adopted by the Academy, and a copy was transmitted to the Surgeon-General.

On the 29th of February, 1864, a communication was received from the Hon. Gideon Welles, Secretary of the Navy, inviting the appointment of a committee of three members of the Academy, to act jointly with three members named by the department, and with three members of the Franklin Institute of Pennsylvania for the Promotion of the Mechanic Arts, to conduct, witness, and report upon experiments, which may be agreed upon by the committee, on the expansion of steam. The experiments are to be reported as early as practicable to the Navy Department, and to be submitted also to the National Academy of Sciences for its judgment and suggestions. The President of the Academy appointed a Committee, consisting of the following members:

Fairman Rogers, F. A. P. Barnard,
Joseph Saxton.

The Navy Department named as members of the joint commission, —

Horatio Allen, *Chairman.*
C. H. Davis, *Rear-Admiral U. S. N.*
B. F. Isherwood, *Chief of Bureau of Steam Engineering.*

The Franklin Institute named as members of the joint commission, —

J. H. Towne, J. V. Merrick,
R. A. Tilghman.

On the 5th of January, 1865, the Committee of the Academy, through Mr. Saxton, reported progress. It is believed that the results of this investigation will be of great value in a scientific as well as practical point of view. (Appendix B.)

On March 30, 1864, the Honorable S. P. Chase, Secretary of the Treasury, invited the appointment of a Committee for the examination of aluminum bronze and other alloys for the manufacture of cent coins. The Committee appointed by the President consisted of the following members: —

John Torrey, Wolcott Gibbs,
Joseph Henry, F. A. P. Barnard.

At the request of the department, A. D. Bache was added to this Committee.

On the 6th of August, 1864, the Committee presented a report to the Academy, which was adopted and ordered to be transmitted to the Secretary of the Treasury. A copy of this report is herewith submitted.

On April 30, 1864, the President received oral authority from the Assistant Secretary of the Navy to appoint a Committee to examine and report on the explosion of the United States steamer Chenango, which occurred in the harbor of New York on the 15th of April, 1864.

The Committee appointed consisted of

J. F. Frazer, *Chairman.*
Fairman Rogers, L. M. Rutherfurd.

The Committee presented to the Academy, on the 5th of August, 1864, a very elaborate report accompanied by drawings, a copy of which had been previously transmitted to the Navy Department. The report and a drawing are herewith submitted.

In addition to the above-mentioned reports, which belong to the year 1864, it is proper to mention in this place the report of the Committee on National Currency, appointed September 5, 1863, upon the application of the Honorable S. P. Chase, Secretary of the Treasury. The Committee reported progress on the 7th of January, 1864, when the following resolutions were adopted: —

*Resolved*, That said Committee be empowered to communicate directly with the Secretary of the Treasury, and to take order in reference to the matters intrusted to them.

*Resolved*, That the President of the Academy communicate the foregoing resolution to the honorable Secretary of the Treasury.

On January 5, 1865, the chairman of the Committee reported that the Committee had made reports to the Secretary of the Treasury, as directed by the Academy. From the nature of the subject intrusted to the consideration of the

Committee, it will be readily understood that the reports submitted to the Secretary of the Treasury were strictly confidential in their character. They were therefore not read to the Academy, and for the same reasons are not appended to this report.

Since the presentation of the first report the Annual of the National Academy for the years 1863–64 has been prepared and published. Copies of the Annual have, in accordance with a formal vote of the Academy, been distributed to the members of both houses of Congress, and also to the heads of the departments under the government of the United States.

At the two sessions of the Academy held during the year 1864, twenty-five original memoirs were read, making in all about forty which have been presented to the Academy during the three stated sessions which have been held since the meeting for organization.

The following list gives the titles of the memoirs read during the past year: —

1. On the Individuality among Animals, with reference to the Questions of Varieties and Species, by Louis Agassiz.

2. On the Elements of the Mathematical Theory of Quantity, by Benjamin Peirce.

3. On the Discussion of Magnetic Observations made at Girard College Observatory in the Years 1840–1845, Parts IV., V., and VI.; Horizontal Force; Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon, by A. D. Bache.

4. On the Force of Fired Gunpowder, and the Pressure to which Heavy Guns are actually subjected in firing, by F. A. P. Barnard.

5. Reduction of the Observations of the Fixed Stars made

by J. J. Lepaute d'Agelet at Paris, during the Years 1783–1785, with a Catalogue of the corresponding Mean Places referred to the Equinox of 1800, by B. A. Gould.

6. On the Metamorphoses of Fishes, by Louis Agassiz.

7. On the Saturnian System, by Benjamin Peirce.

8. Notes on the Parallelogram of Forces and on Virtual Velocities, by Theodore Strong.

9. On the Geographical Distribution of Fishes, as bearing upon their Affinities and Systematic Classification, by Louis Agassiz.

10. On the Discussion of Magnetic Observations made at Girard College Observatory in the Years 1840–1845, Parts VII., VIII., and IX.; Vertical Force; Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon, by A. D. Bache.

11. Description of an Anemograph designed for the University of Mississippi, by F. A. P. Barnard.

12. On Materials of Combustion for Lamps in Lighthouses, by Joseph Henry.

13. On Photographs of the Solar Spectrum, by Lewis M. Rutherfurd.

14. On Tangencies of Circles and Spheres, by J. G. Barnard.

15. On Observations of the Planet Venus near the times of her Inferior Conjunction, September 28, 1863, and subsequently, by Stephen Alexander.

16. Brief Note on the Forms of Icebergs, by Stephen Alexander.

17. Memoir of the late Henry Fitz, by Lewis M. Rutherfurd.

18. On the Distribution of certain important Diseases in the United States, by Augustus A. Gould.

19. On the Integration of Differential Equations of the first Order and higher Degrees, by Theodore Strong.

20. Criticism on the Forms of Ships, by Captain J. Cole. (Presented by Theodore Strong.)

21. On the Light visible on the Moon's Surface, and that seen adjacent to her Edge, when the Sun is either partially or totally eclipsed, by Stephen Alexander.

22. On the Influence of the Hour of the Day on the Results of Barometic Measurements of Altitudes, by Arnold Guyot.

23. On Shooting Stars, by H. A. Newton.

24. A Method of determining the Errors of a Vertical Divided Circle, by Simon Newcomb. (Presented by Benjamin Peirce.)

25. Considerations relative to various Phenomena presented by certain Comets, by Stephen Alexander.

None of these memoirs have been published, in consequence of the want of funds; and it is feared that a longer delay in publication will prevent the Academy from receiving valuable communications which would be presented in case the Academy should be able to commence the publication of its memoirs.

The current expenses of the Academy, and the cost of publishing the Annual, have been defrayed from the contributions of members.

The Academy, through the courtesy of the chairman of the Pacific Railroad Committee of the Senate, has been permitted to occupy rooms in the Capitol during each of the sessions held at Washington.

The vacancies in the Academy have been filled by the election of Professor Leo Lesquereux, Dr. John C. Dalton, and Professor S. F. Baird.

The Academy at the session of January, 1865, elected as

Foreign Associates, Alexander Braun, G. B. Airy, Richard Owen, Friedrich Wöhler, R. I. Murchison, and Victor Regnault.

The Council for the year 1865 consists of Messrs. B. A. Gould, Lewis M. Rutherfurd, J. L. Le Conte, and J. P. Lesley.

The next session of the Academy will be held at Northampton, Mass., on the 23d of August, 1865.

Respectfully submitted.

A. D. BACHE,

*President National Academy of Sciences.*

Hon. Schuyler Colfax, *Speaker of the House of Representatives.*

# VIII.

# LIST OF PAPERS PRESENTED TO THE ACADEMY,

## TO JANUARY 1, 1866.

1. On the Individuality among Animals, with reference to the Questions of Varieties and Species, by Louis Agassiz.
2. On the Elements of the Mathematical Theory of Quantity, by Benjamin Peirce.
3. On the Discussion of Magnetic Observations made at Girard College Observatory, in the Years 1840–1845, Parts IV., V., and VI.; Horizontal Force; Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon, by A. D. Bache.
4. On the Force of Fired Gunpowder, and the Pressure to which Heavy Guns are actually subjected in firing, by F. A. P. Barnard.
5. Reduction of the Observations of the Fixed Stars made by J. J. Lepaute d'Agelet at Paris, during the Years 1783–1785, with a Catalogue of the corresponding Mean Places referred to the Equinox of 1800, by B. A. Gould.
6. On the Metamorphoses of Fishes, by Louis Agassiz.
7. On the Saturnian System, by Benjamin Peirce.
8. Notes on the Parallelogram of Forces and on Virtual Velocities, by Theodore Strong.

9. On the Geographical Distribution of Fishes, as bearing upon their Affinities and Systematic Classification, by Louis Agassiz.
10. On the Discussion of Magnetic Observations made at Girard College Observatory in the Years 1840 – 1845. Parts VII., VIII., and IX.; Vertical Force; Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon.
11. Description of an Anemograph designed for the University of Mississippi, by F. A. P. Barnard.
12. On Materials of Combustion for Lamps in Light-houses, by Joseph Henry.
13. On Photographs of the Solar Spectrum, by Lewis M. Rutherfurd.
14. On Tangencies of Circles and Spheres, by J. G. Barnard.
15. On Observations of the Planet Venus near the Times of her Inferior Conjunction, September 28, 1863, and subsequently, by Stephen Alexander.
16. Brief Note on the Forms of Icebergs, by Stephen Alexander.
17. Memoir of the late Henry Fitz, by Lewis M. Rutherfurd.
18. On the Distribution of certain important Diseases in the United States, by Augustus A. Gould.
19. On the Integration of Differential Equations of the first Order and higher Degrees, by Theodore Strong.
20. Criticism on the Forms of Ships, by Captain J. Cole. (Presented by Theodore Strong.)
21. On the Light visible on the Moon's Surface, and that seen adjacent to her Edge, when the Sun is either partially or totally eclipsed, by Stephen Alexander.

22. On the Influence of the Hour of the Day on the Results of Barometric Measurements of Altitudes, (not read), by Arnold Guyot.
23. On Shooting Stars, by H. A. Newton.
24. A Method of determining the Errors of a Vertical Divided Circle, by Simon Newcomb. (Presented by Benjamin Peirce.)
25. Considerations relative to various Phenomena presented by certain Comets, by Stephen Alexander.
26. Memoir of Lieut. E. B. Hunt, by F. A. P. Barnard.

*Papers presented to the Academy at the January Session,* 1865.

27. On a Chronograph for measuring the Velocity of Projectiles, by J. E. Hilgard.
28. On the Homologies and Classification of the Cephalopods, by L. Agassiz.
29. On the Geographical Distribution of North American Birds, by S. F. Baird.
30. Note on the Changes that have taken place in the Bar of Charleston Harbor since the sinking of Obstructions in the Main Channel, as developed by the United States Coast Survey, by J. E. Hilgard.
31. On the Tables of the Moon, by Benjamin Peirce.
32. On the Metamorphoses of some Malacopterygians, by L. Agassiz.
33. On Chemical Classification, by Wolcott Gibbs.
34. On the Dimensions and Proportions of American Soldiers, by B. A. Gould.
35. On a Method of exhibiting certain Statistics of Hospitals, by J. L. Le Conte.
36. On the Glacial Phenomena and Present Configuration of the State of Maine, by L. Agassiz.

37. On a Regulator for maintaining Uniform Motion, and an Apparatus for recording Time-Observations in Type, by J. E. Hilgard.
38. On the Progress of the Geological Survey of California, by J. D. Whitney.
39. On the Mineral Lands of the United States, and the Relations of the Government to their Management, by J. D. Whitney.
40. On the Origin and Formation of Sedimentary Rocks, by J. S. Newberry.
41. On the Origin and Distribution of Petroleum in the United States, by J. S. Newberry.
42. The Theory of the Sling, by Benjamin Peirce.
43. The Fucoids of the Coal Measures, by Leo Lesquereux.
44. Letter from Mr. Agassiz.
45. Observations of the Right Ascensions of Stars within one degree of the North Pole, by B. A. Gould.
46. On Observations of Tides at the Island of Tahiti, made for the United States Coast Survey, by J. E. Hilgard.
47. Discussion of Magnetic Observations made at Eastport, Maine, during the Years 1861–1864, by the United States Coast Survey, by J. E. Hilgard.
48. On Rifled Guns, by W. H. C. Bartlett.
49. A New Theory of the First Principles of the Differential Calculus, by Theodore Strong.
50. On the Ages of United States Volunteer Soldiers as deduced from the Statistical Bureau of the Sanitary Commission, by B. A. Gould.
51. On a Photometer, by O. N. Rood.
52. On the Structure of the Moon, by S. Alexander.
53. On the Systems of Mountain Upheaval to which the Continent of North America owes its present Configuration, by J. D. Whitney.

54. Abstract of Geological Investigations made in China and Mongolia, by Raphael Pumpelly. (Communicated by J. D. Whitney.)
55. Examination of Shells obtained by the Sounding-Lead in the Coast Survey of New York and New Jersey, with some Nautical Hints, by Augustus A. Gould.
56. On the probable immediate Cause of the Glacial Epoch of the Post-Tertiary, by A. Guyot.
57. On the Lower Silurian Oils of Kentucky and Tennessee, by J. S. Newberry.
58. Suggestions relative to the Annular Eclipse of the Sun, of October next, by S. Alexander.
59. On Certain Converging Series expressing the Ratio of the Diameter to the Circumference of the Circle, by William Ferrel. (Communicated by Benjamin Peirce.)
60. On a Tide-Meter, by J. M. Batchelder. (Communicated by Benjamin Peirce.)

IX.

# BIOGRAPHICAL NOTICE

OF

# JOSEPH GILBERT TOTTEN.

By J. G. BARNARD.

# BIOGRAPHICAL NOTICE

OF

# JOSEPH GILBERT TOTTEN.

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Mr. President and Gentlemen of the Academy: —

In conformity with a clause of the Constitution of this Academy, and in obedience to your instructions, I am here to render the tribute of a formal biographical notice in commemoration of one who was numbered among our most venerable and most honored associates. If, in the language of one of our body, on a previous and similar occasion, "it is no unreasonable assumption that public benefit and individual incentives may be derived from the history of any man whose scientific services have rendered him worthy of admittance to your number," that assumption must have a peculiar force when it applies to one who has "finished his course," and has filled a life, protracted beyond the usual term, with scientific labors of no ordinary variety and magnitude.

It is but little more than two years since we first met for the great and important work of organizing this National Academy, and with us — of our number, if not personally present — were "both the gray-headed and very aged men." But, alas! these, like autumnal leaves, are rapidly falling away, and already the places of a Totten, a Hitchcock, and a Silliman know them no more, save in the records of their lives and deeds, and in the grateful memories of their associates. What a trio of names, glorious in the annals of science, is this! Well may they be incentives to us who yet remain to strive that we may worthily replace them, and establish for this Academy a reputation for usefulness and science which their honored bearers have acquired for themselves.

Although there may be many among us more capable than myself of doing justice to the memory of our departed colleague, I feel grateful that the lot has fallen to me. Placed under his command on my first entrance into the military service, — almost in my boyhood, — my relations with him, both personal and professional, have ever since been continuous and intimate. Under obligations to him of no ordinary nature, I could not do otherwise than regard him with reverence and affection. If I fail, therefore, it shall not be because my heart is unmoved, nor because I am insensible to the magnitude of my task.

Joseph Gilbert Totten was born in New Haven, Connecticut, on the 23d of August, 1788. His grandfather, Joseph Totten, came from England before the war of the Revolution, and engaged in mercantile pursuits in New York. Attached to the cause of the mother country, he left that city, after the acknowledgment of our independence, for Annapolis, Nova Scotia. It would appear that his two sons remained in this country, since one of them, Peter G. Totten, married in 1787 Grace Mansfield of New Haven, a very beautiful woman, who died a few years after her marriage, leaving two children, — the subject of this memoir and a daughter, Susan Maria, who married Colonel Beatty, an English officer, and who is still living, a widow, in London. After the death of Mrs. Totten, which occurred when her infant son was but three years old, the father, having been appointed United States Consul at Santa Cruz, West Indies, took up his future abode on that island, leaving his son under the care of his maternal uncle, Jared Mansfield, a graduate of Yale College, 1777, and a learned mathematician. The boy continued to be a member of Mr. Mansfield's family until the latter removed to West Point, having been appointed Captain of Engineers and a teacher in the United States Military Academy, then just organized by act of Congress of 1802. Young Totten's first teacher was Mr. Levi Hubbard, brother to the Rector (at that time) of Trinity Church, New Haven; afterwards his education was carried on under the personal superintendence of his uncle. Of the period of his school-boy life we have some glimpses, through the recollections of an old friend and schoolmate, Mr. Ralph Ingersoll of New Haven, who speaks of him as a bright, noble youth, of fine mind, fond of study, and always at the head of his compeers, gentlemanly in his deportment, and greatly beloved.

Young Totten went to West Point with the family of his uncle in 1802. He was soon after appointed a cadet. He remained at West Point one term, that of 1803, and perhaps part of that of 1804. He was promoted to a second lieutenancy in the corps of Engineers, July 1, 1805.

The venerable General J. G. Swift, recently deceased, his brother engineer officer and life-long friend, describes him at West Point as "a flaxen-headed boy of fourteen years of age, a good scholar, and to me a most interesting companion."

Captain Mansfield, having been appointed Surveyor-General of Ohio and the Western Territories, November 4, 1803, induced his nephew to accompany him to the West as an assistant on that first systematic survey of any of the new States of the Union. Here that faculty which so distinguished him through life, of keen observation of whatever was most interesting connected with or incidentally brought under his notice by his professional pursuits, displayed itself at this early age in a noteworthy manner. The vestiges of an earlier race than the red man, which have since been made the subject of the researches of a Squier and a Davis, of a Lapham and of a Haven, and to which, during recent times, fresh attention has been directed by the developments of the high antiquity of the human race in Europe as shown by similar relics over the surface of that country and by the lacustrine remains in Switzerland, attracted his notice and were made the subjects of survey. Although these investigations were not published, they are, I believe, the first we have record of; those of Caleb Atwater, who is called by Squier and Davis "the pioneer in this department," not having been published until 1819. Full descriptions and measurements of several of these mounds, particularly that of Circleville, were made and sent to his friend, J. G. Swift. To most youths of his age those remains of structures, built

> "while yet the Greek
> Was hewing the Pentelicus to forms
> Of symmetry, and rearing on its site
> The glittering Parthenon,"

would have been passed over with vague curiosity or listless indifference. Not so with young Totten. Although not able, perhaps, to perceive all the ethnological importance which has since been attached to them, he could yet appreciate them as objects of high interest, as vestiges of the races which had inhabited the country, and give his time to their examination and measurement.

During the two years which he passed in the office of his uncle at Ludlow's station near Cincinnati, he was a companion of several young men who subsequently became conspicuous, among whom were Nicholas Longworth, Samuel Perry, Daniel Duke, Thomas Pierce, and Peyton

Symmes, all of whom are now dead. His tastes, however, led him back to the army (from which he had resigned shortly after his promotion), and, February 23, 1808, he was reappointed a Second Lieutenant of Engineers, his commission bearing the same date as that of his subsequent friend, brother engineer officer, and professional associate, Sylvanus Thayer, of national fame as for so many years Superintendent of the Military Academy, and as the officer to whom is mainly due its present high grade among the military and scientific institutions of the world. Lieutenant Totten commenced his career as a military engineer under Colonel Jonathan Williams, the first chief of the corps, and was engaged on the construction of Castles Williams and Clinton, New York harbor.

At the commencement of the war with England Lieutenant Totten was assigned to duty as Chief Engineer of the army under Brigadier-General Van Rensselaer, in the campaign of 1812, on the Niagara frontier, and in that capacity took a conspicuous part in the battle of Queenstown. He was subsequently Chief Engineer of the army under the command of Major-General Dearborn, in the campaign of 1813, and of the army under Major-General Izard and Brigadier-General Macomb, in the campaign of 1814, on Lake Champlain. Having been promoted to a Captaincy in 1812, he was in June, 1813, brevetted Major, for "meritorious services," and September 11, 1814, Lieutenant-Colonel, for "gallant conduct at the battle of Plattsburg"; his efficient services as an engineer in the defensive arrangements of that field having contributed powerfully to the successful issue.

The termination of the war may be considered as the close of one period in the life and services of General Totten, and the commencement of another; or rather it may be said, that the events of which we have traced a faint outline were but the preparation and training of his mind for the real work of his life. Reared under the eyes and guardianship of a relative distinguished for his mathematical attainments, receiving as extensive a military and scientific education as West Point at that early day could give, called by his position in Surveyor-General Mansfield's office, not only to exercise the science which the duties involved, but to take extended views of our country as to the interconnection of its parts, and their relations to commerce or war, then practically taught the duties of a military engineer in what concerns the defence of harbors, and finally carried through the ordeal of actual war in the campaigns of armies in the field, he was now prepared for the great work of his life, — the fortification of our seaboard frontier. When I call this the great work of his life, I am not unaware that it is but a *part* of that work, — still the most important part, and one to which his other labors may be considered incidental.

A brief reference to the condition and progress of sea-coast defence at that period is here appropriate. Previous to the Revolution, our seaport towns had not grown into large cities, nor were there great naval establishments or military depots to invite the enterprises of an enemy. During that contest, the harbors of Boston, New York, Philadelphia, Charleston, &c. had been, to a certain extent, "fortified" against naval attack, by slight earthen batteries, or in some few cases by small and (as we would now call them) insignificant earthen forts. A work of palmetto logs and sand on Sullivan's Island, Charleston harbor, mounting but 30 guns, decisively repulsed, early in the Revolutionary war, the attack of the British fleet under Sir Peter Parker, consisting of two frigates and six sloops-of-war, carrying about 270 guns, destroying four of the smaller vessels, and inflicting a loss of 205 in killed and wounded (eleven times as many per gun employed against them as the English lost at Trafalgar); thus decisively demonstrating the value of fortifications, and the superiority of land batteries to ships. But with an immense sea-coast line and sparse population, it was impossible to hold our seaports against the great naval power of the mother country, and the war of the Revolution was mainly a contest of land forces. After the attainment of our independence, the importance of fortifying our harbors impressed itself on the mind of General Washington, and the political agitations which grew out of the French revolution, and which threatened to involve the new-born Power of the West, prompted early action in this direction. In that day war, though a science, had not grown into one which makes tributary to it all other sciences, as it has since done. Fortification, indeed, had reached a high degree of perfection, but the elaborate treatises on that subject scarcely touched the subject of harbor defence, so little art was apparently supposed to be involved in throwing up batteries to defend the entrances of ports. The art of a Vauban and Cormontaigne was little concerned in the war from which we had just emerged, and the circumstances were too dissimilar, the theatre too large and too thinly populated, the armies engaged too small, to afford to the precepts of a Lloyd or a Templehoff much apparent applicability. While the war developed generals of unquestionable ability in the spheres in which they acted, it seemed to be conceded, that for military science, and especially for the art of fortification, we must look to Europe. Hence we find so many of the early harbor defences of our principal seaport towns to have been built under the direction of foreign officers who had found employment among us, and who did not always possess the knowledge of the art to which they laid claim.

The importance of a Military Academy for the training of officers for the military service, and especially for the engineers and artillery, had been acknowledged even from the very outset of the struggle for independence. We find even the Continental Congress appointing a committee "to prepare and bring in a plan of a Military Academy," and the first Secretary of War, General Knox, in an official report to the President, discusses the subject at much length. The establishment of such an institution is known to have been a favorite object of General Washington, and in his annual message in 1793 he suggests the inquiry, "whether a material feature in the improvement" of the system of military defence "ought not to afford an opportunity for the study of those branches of the art which can scarcely ever be attained by practice alone"; and in 1796 he states that "the desirableness of this institution had constantly increased with every new view he had taken of the subject."

An act of Congress of 1794 had provided for a Corps of Artillerists and Engineers, to consist of four battalions, to each of which eight Cadets were to be attached, and made it the duty of the Secretary of War to procure books, instruments, and apparatus for the benefit of said corps; and in 1798 Congress authorized the raising of an additional regiment, increased the number of Cadets to fifty-six, and empowered the President to appoint four teachers of the arts and sciences necessary to the efficiency of this "Corps." Of the four teachers, none were appointed prior to January, 1801, at which time Mr. George Barron was appointed teacher of Mathematics, and the institution, "which was nothing more than a mathematical school for the few Cadets then in the service," was nominally established.

It was soon discovered that the regiment of Artillerists and Engineers could not combine with effect the two duties assigned to its members, and a law was therefore framed separating them into two corps, and declaring that the Corps of Engineers should be stationed at West Point, New York, and should constitute a Military Academy. This act of March 16, 1802, which is the organic law of the Corps of Engineers and of the Military Academy, provided for the appointment of a certain number of officers and Cadets,* (not to exceed twenty in all,) and declared that "the principal Engineer, or, in his absence, the next in rank, shall have the superintendence of the Military Academy, under the direction of the President of the United States."

It is not my purpose here to follow further the history of that institution; I have alluded to its initiation as a step taken to provide for an acknowledged want of the period, — an institution for teaching the military sciences to young men entering the army, and for creating a competent *Corps of Engineers*. It was soon found, however, that the duties of Engineer officers were inconsistent with their remaining at West Point, and themselves constituting "a Military Academy." Most of them were soon called to duties along the seaboard, in constructing our fortifications, while, as the wants of the service and of the Academy have been more clearly seen, the number of Cadets has been increased, to supply not only the Engineers and Artillery, but officers of all arms of the service, and the various professorships and departments of instruction now existing have been established.

As the duties of the Corps became more and more extensive, its chief, though charged with the administration of its

* Besides ten Cadets of Engineers, forty Cadets "of Artillery" were authorized by this law; making fifty Cadets in all.

affairs, could not be constantly present at the Academy, and it ultimately became apparent that the immediate superintendency of such an institution was incompatible with his proper functions. In 1817, an officer selected from the corps (Brevet-Major Sylvanus Thayer, to whom allusion has already been made) was appointed permanent Superintendent of the Academy, and made subject only to the orders of the President of the United States.

Major (afterwards Colonel) Jonathan Williams, a near relative of Dr. Franklin, whom he accompanied, as secretary, to France, where he studied the military sciences, and made himself acquainted with the standard works on fortification, was the first Chief Engineer of the United States under the law of 1802. He was an officer of decided merit, much beloved by his subordinates, and is justly styled the father of the Corps of Engineers and of the Military Academy.

While exercising his superintendence of the Academy, he devoted himself personally to the fortification of New York harbor, and most of the forts which constitute the inner line of defence of that harbor — Fort Columbus, Castles Williams and Clinton (Castle Garden), and a work similar to the last named, located two or three miles higher up the river (Fort Gansevoort) — were planned by him, and built under his immediate supervision.

Castle Williams was the first "casemated" battery erected in this country (built in 1807 – 10), and was planned after the system of Montalembert, with which, as we have seen, Colonel Williams had made himself acquainted in France. This and other works of Colonel Williams, though they have been superficially and ignorantly criticised, were really meritorious, and do not suffer by comparison with European structures of the same or even much more recent dates.

The indications of an approaching war with England, and the obvious inadequacy of existing fortifications, had led to renewed exertions, and prompted the works just mentioned and others at all our seaports, so that when the war broke out there was not a town of any magnitude upon the coast not provided with one or more batteries. But most of the works so thrown up before the subject had been studied and systematized as a whole were defective in design, small, weak, and being built, for present economy, of cheap materials and workmanship, very perishable. In the main, however, they answered their purpose, — more, perhaps, through an undue respect for them on the part of our foe than through their intrinsic strength. It was not till after the close of the war with England that a permanent system of coast defence was entered upon by our government. Indeed, without the experience of that war it is doubtful whether a measure, always so unpopular, and generally so little understood as a national system of fortifications, could have gained the support of Congress, and of the people. A "Board of Engineers" was constituted in 1816, with instructions to make examinations of the sea-coast, and to prepare plans for defensive works, subject to the revision of the Chief Engineer and the sanction of the Secretary of War.

Up to this period the Military Academy had maintained a sort of embryo existence, without definite form or a prescribed system. The annual term of study lasted from April to November, all the intermediate months being vacation. No fixed number of terms was necessary to graduation, nor was it prescribed what should be studied. Some Cadets remained but a single term before being commissioned; others, several years. Although this period produced officers who afterwards became highly distinguished in engineering (as well as in other branches of military art), it is not surprising that the government yet entertained the common notion that only in Europe, and especially in France, could high military science be found; nor that, in undertaking so vast and costly a work as the fortification of our sea-coast, distrust should have been felt in the unaided abilities of our own engineer officers. A distinguished French engineer, General Simon Bernard, was invited to this country, and as "Assistant" in the Corps of Engineers, (an office created for the purpose by Congress,) made a member of the board which, as first constituted, November 16, 1816, consisted of himself as President, Colonel William McRee, and Lieutenant-Colonel J. G. Totten. In 1817, Colonel Totten was relieved, and appears to have been stationed at Rouse's Point, Lake Champlain, in charge of fortifications at that place, and the board to have been composed of Brigadier-General J. G. Swift, Chief Engineer, Brigadier-General Bernard and Colonel McRee; but Colonel Totten was again made a member in 1819, and (both General Swift and Colonel McRee having resigned) the permanent board came to consist of Bernard and Totten alone, and the labor of working out the fundamental principles of the system, and of elaborating the projects of defence for the great seaports thus devolved mainly upon these two officers, though naval officers of rank and experience were associated with them whenever their examinations included positions for dock-yards, naval depots, or other objects which concerned the naval service.

Though the advent of a foreign officer, and his assignment to this duty, under the anomalous designation of "Assistant" in the Corps of Engineers, naturally caused some feeling, yet it can scarcely be doubted that the influence of the proceeding was beneficial. If in Swift, McRee, Totten, Thayer, and many others, were found high engineering abilities and acquirements, it is no less true that professional association with such a man as Bernard was calculated to stimulate to higher attainments and more zealous exertion. The spirit of emulation alone would induce our own officers to prove to the country that they were not inferior to others. To high military and scientific acquirements and great experience in his professional duties, General Bernard united to the qualities of an amiable and accomplished gentleman the tact to adapt himself to his peculiar position without wounding the pride of those with whom he was thus associated. The prestige of his name aided powerfully in sustaining, with the administration and with Congress, the measures which the board found necessary to recommend, and in establishing firmly, as a part of our national policy, the system of sea-coast defence by fortifications. In recounting the origin and growth of the system, it is but just to give that name an honorable mention.

By the Board of Engineers of which I have been speaking a series of reports was drawn up, which, mostly from the pen of our departed associate, form his best memorial, and exhibit in a masterly manner the principles of sea-coast and harbor defence, and their application to our own country. In a paper of this kind it will not be out of place to give some idea, at least, of the arguments and views contained in these documents. An elaborate report of 1826, from which I quote, gives a general *résumé* of the principles which have guided the labors of the board, and of the results arrived at.

"The means of defence for the seaboard of the United States, constituting a system, may be classed as follows: First, a navy; second, fortifications; third, interior communications by land and water; and fourth, a regular army and well-organized militia.

"*The navy* must be provided with suitable establishments for construction and repair, stations, harbors of rendezvous, and ports of refuge, all secured by fortifications defended by regular troops and militia, and supplied with men and materials by the lines of intercommunication. Being the only species of offensive force compatible with our domestic institutions, it will then be prepared to act the great part which its early achievements have promised, and to which its high destiny will lead.

"*Fortifications* must close all important harbors against an enemy, and secure them to our military and commercial marine; second, must deprive an enemy of all strong positions where, protected by naval superiority, he might fix permanent quarters in our territory, maintain himself during the war, and keep the whole frontier in perpetual alarm; third, must cover the great cities from attack; fourth, must prevent as far as practicable the great avenues of interior navigation from being blockaded at their entrances into the ocean; fifth, must cover the coastwise and interior navigation by closing the harbors and the several inlets from the sea which intersect the lines of communication, and thereby further aid the navy in protecting the navigation of the country; and sixth, must protect the great naval establishments.

"*Interior communications* will conduct with certainty the necessary supplies of all sorts to the stations, harbors of refuge, and rendezvous and the establishments for construction and repair, for the use both of the fortifications and the navy; will greatly facilitate and expedite the concentration of military force and the transfer of troops from one point to another; insure to these also unfailing supplies of every description, and will preserve unimpaired the interchange of domestic commerce even during periods of the most active external warfare.

" *The army and militia*, together with the marine, constitute the vital principle of the system.

" From this sketch it is apparent that our system of defence is composed of elements whose numerous reciprocal relations with each other and with the whole constitute its excellence; one element is scarcely more dependent than the whole system is on any one. Withdraw the navy, and the defence becomes merely passive; withdraw interior communications from the system, and the navy must cease in a measure to be active for want of supplies, and the fortifications can offer but a feeble resistance for want of timely reinforcements; withdraw fortifications, and there only remains a scattered and naked navy."

The relation of the navy to fortifications is one of those subjects not always well appreciated, and hence the cause of mischievous notions and much misrepresentation. No pains is spared in these reports to make this subject clearly understood. After the quotation just given, Colonel Totten remarks:—

"It is necessary to observe, in the first place, that the relations of fortifications to the navy in a defensive system is that of a sheltering, succoring power, while the relation of the latter to the former is that of an active and powerful auxiliary; and that the latter ceases to be efficient as a member of the system the moment it becomes passive, and should in no case (we allude to the navy proper) be relied on as a substitute for fortifications. This position may be easily established.

" If our navy be inferior to that of the enemy, it can afford, of course, unaided by fortifications, but a feeble resistance, single ships being assailed by whole fleets; if it be equal, or superior, having numerous points along an extended frontier to protect, and being unable to concentrate, because ignorant of the selected point of attack, every point must be simultaneously guarded: our separate squadrons may therefore be captured in detail by the concentrated fleet of the attacking power. If we attempt to concentrate under an idea that a favorite object of the enemy is foreseen, he will not fail to push his forces upon the places thus left without protection. This mode of defence is liable to the further objections of being exposed to fatal disasters, although not engaged with an enemy, and of leaving the issue of conflict often to be determined by accident, in spite of all the efforts of courage and skill. If it were attempted to improve upon this mode by adding temporary batteries and field works, it would be found that besides being weak and inadequate from their nature, the most suitable positions for these works must often be neglected, under a necessary condition of the plan, that the ships themselves be defended; otherwise they must either take no part in the contest, or be destroyed by the superior adversary."

It is hardly to be expected that a system affording so much room for discussion, and by its importance inviting it, should, especially in this country, escape adverse judgment. Military and naval men, congressmen, and even cabinet officers have assailed it, called in question the principles on which it is based, or denied the judiciousness of their application. The forms and sources of assault have been varied, but there has been really no great difference in the substance, of which, perhaps, as good an expression as any may be found in these dogmas, forming the pith of a criticism from no less a source than the Secretary of War, Mr. Cass, approved by the President, General Jackson: —

"1st. That for the defence of the coast, the chief reliance should be on the Navy.

"2d. That in preference to fortifications, floating batteries should be introduced wherever they can be used.

"3d. That we are not in danger of large expeditions, and consequently

"4th. That the system of the Board of Engineers comprises works which are unnecessarily large for the purposes which they have to fulfil."

Owing to these strictures, the House of Representatives, by resolutions of April 9, 1840, called upon the War Department for a report of a full and connected system of national defence. The duty was committed by the Secretary of War to a board of officers of the army and navy, among whom was Colonel Totten, and by whom the report was drawn up. It was entirely approved by the Secretary of War, Mr. Poinsett, and is universally admitted to be one of the most able and comprehensive expositions of the whole subject of sea-coast defence extant, and a complete refutation of the objections made to our existing system. The discussion of the first and principal proposition — that of defence by the Navy — is so interesting and instructive, that, though long, I venture to quote it: —

"The opinion that the navy is the true defence of the country is so acceptable and popular, and is sustained by such high authority, that it demands a careful examination.

"Before going into this examination, we will premise that by the term 'navy' is here meant, we suppose, line-of-battle ships, frigates, smaller sailing vessels and armed steamships, omitting vessels constructed for local uses merely, such as floating batteries.

"For the purpose of first considering this proposition in its simplest terms, we will begin by supposing the nation to possess but a single seaport, and that this is to be defended by a fleet alone.

"By remaining constantly within this port, our fleet would be certain of meeting the enemy, should he assail it. But if inferior to the enemy, there would be no reason to look for a successful defence; and as there would be no escape for the defeated vessels, the presence of the fleet, instead of averting the issue, would only render it the more calamitous.

"Should our fleet be equal to the enemy's, the defence might be complete, and it probably would be so. Still, hazard, some of the many mishaps liable to attend contests of this nature, might decide against us; and in that event, the consequences would be even more disastrous than on the preceding supposition. In this case the chances of victory to the two parties would be equal, but the consequences very unequal. It might be the enemy's fate to lose his whole fleet, but he could lose nothing more; while we in a similar attempt would lose not only the whole fleet, but also the object that the fleet was designed to protect.

"If superior to the enemy, the defence of the port would in all respects be complete. But instead of making an attack, the enemy would, in such case, employ himself in cutting up our commerce on the ocean; and nothing could be done to protect this commerce without leaving the port in a condition to be successfully assailed.

"In either of the above cases, the fleet might await the enemy in front of the harbor, instead of lying within. But no advantage is apparent from such arrangement, and there would be superadded the risk of being injured by tempests, and thereby being disqualified for the duty of defence, or of being driven off the coast by gales of wind; thus for a time removing all opposition.

"In the same cases, also, especially when equal or superior to the enemy, our fleet, depending on having correct and timely notice as to the position and state of preparation of the enemy's forces, might think proper to meet him at the outlet of his own port, or intercept him on his way, instead of awaiting him, within or off our own harbor. Here it must be noticed that the enemy, like ourselves, is supposed to possess a single harbor only ; but having protected it by other means, that his navy is disposable for offensive operations. If it were attempted thus to shut him within his own port, he, in any case but that of decided inferiority, would not hesitate to come out and risk a battle ; because if defeated, he could retire under shelter of his defences to refit, and if successful, he could proceed with a small portion of his force — even a single vessel would suffice — to the capture of our port now defenceless, while, with the remainder, he would follow up his advantage over our defeated vessels, not failing to pursue into their harbor, should they return thither.

"Actual superiority on our part would keep the enemy from volunteering a battle; but it would be indispensable that the superiority be steadily maintained, and that the superior fleet be constantly present. If driven off by tempests, or absent from any other cause, the blockaded fleet would escape, when it would be necessary for our fleet to fly back to the defence of its own port. Experience abundantly proves, moreover, that it is in vain to attempt to shut a hostile squadron in port for any length of time. It seems, then, that whether we defend by remaining at home, or by shutting the enemy's fleet within his own harbor, actual superiority in vessels is indispensable to the security of our own port.

"With this superiority, the defence will be complete, provided our fleet remains within its harbor. But then, all the commerce of the country upon the ocean must be left to its fate; and no attempt can be made to react offensively against the foe, unless we can control the chances of finding the enemy's fleet within his port, and the still more uncertain chance of keeping him there; the escape of a single vessel being sufficient to cause the loss of our harbor. Let us next see what will be the state of the question on the supposition of numerous important ports on either side, instead of a single one; relying on our part still exclusively on a navy.

"In order to examine this question, we will suppose our adversary to be fortified in all his harbors, and possessed of available naval means, equal to our own. This is certainly a fair supposition; because what is assumed as regards his harbors is true of all maritime nations, except the United States; and as regards naval means, it is elevating our own strength considerably above its present measure, and above that it is likely to attain for years.

"Being thus relatively situated, the first difference that strikes us is, that the enemy, believing all his ports to be safe without the presence of his vessels, sets himself at once about making our seas and shores the theatre of operations, while we are left without choice in the matter; for if he thinks proper to come, and we are not present, he attains his object without resistance.

"The next difference is, that while the enemy (saving only the opposition of Providence) is certain to fall upon the single point, or the many points he may have selected, there will exist no previous indications of his particular choice, and, consequently, no reason for preparing our defence on one point rather than another; so that the chances of not being present and ready on his arrival are directly in proportion to the number of our ports, that is to say, the greater the number of ports, the greater the number of chances that he will meet no opposition whatever.

"Another difference is, that the enemy can choose the mode of warfare as well as the plan of operations, leaving as little option to us in the one case as in the other. It will be necessary for us to act, in the first instance, on the supposition that an assault will be made with his entire fleet; because, should we act otherwise, his coming in that array would involve both fleet and coast in inevitable defeat and ruin. Being in this state of concentration, then, should the enemy have any apprehensions about the result of a general engagement, should he be unwilling to put anything at hazard, or should he, for any other reason, prefer acting by detachments, he can, on approaching the coast, disperse his force into small squadrons and single ships, and make simultaneous attacks on numerous points. These enterprises would be speedily consummated, because, as the single point occupied by our fleet would be avoided, all the detachments would be unopposed; and after a few hours devoted to burning shipping, or public establishments, and taking in spoil, the several expeditions would leave the coast for some convenient rendezvous, whence they might return, either in fleet or in detachments, to visit other portions with the scourge.

"Is it insisted that our fleet might, notwithstanding, be so arranged as to meet these enterprises?

"As it cannot be denied that the enemy may select his point of attack out of the whole extent of coast, where is the prescience that can indicate the spot? And if it cannot be foretold, how is that ubiquity to be imparted that shall always place our fleet in the path of the advancing foe? Suppose we attempt to cover the coast by cruising in front of it, shall we sweep its whole length? — a distance scarcely less than that which the enemy must traverse in passing from his coast to ours. Must the Gulf of Mexico be swept as well as the Atlantic? or shall we give up the Gulf to the enemy? Shall we cover the Southern cities, or give them up also? We must unquestionably do one of two things; either relinquish a great extent of coast, confining our cruisers to a small portion only, or include so much that the chances of intercepting an enemy would seem to be out of the question."

The report then goes on to discuss the uses for defensive purposes of gunboats, floating batteries and steam batteries, as distinguished from the navy proper. Admitting their usefulness, and, even in some cases, their necessity, it argues with great force, that they are not a substitute for, and cannot supersede fortifications, and it sums up its argument concerning naval defence with the following broad propositions, to which it challenges opposition: —

"1st. If the sea-coast is to be defended by naval means exclusively, the defensive force at each point deemed worthy of protection must be at least equal *in power* to the attacking force.

"2d. As from the nature of the case there can be no reason for expecting an attack on one of these points rather than on another, and no time for transferring our state of preparation from one to another after an attack has been declared, each of them must have assigned to it the requisite means; and,

"3d. Consequently this system demands a power in the defence as many times greater than that in the attack as there are points to be covered.

"There has been but one practice among nations as to the defence of ports and harbors, and that has been a resort to fortifications. All the experience that history exhibits is on one side only; it is the opposition of forts or other works, comprehended by the term fortification, to attack by vessels, and although history affords some instances wherein this defence has not availed, we see that the resort is still the same. No nation omits covering the exposed points upon her seaboard with fortifications, nor hesitates in confiding in them."

The most prominent cases of such successful attacks, viz. Copenhagen, Algiers, San Juan de Ulloa, &c., are then described and discussed, to show that the deductions drawn from them are erroneous, or that they are not cases in point, or that the disastrous result has been owing to the neglected condition, imperfect armament or unskilful and inadequate defence of the forts.

The report, of which I have given some of the main points, may be said to have silenced opposition to our system of fortifications for the next ten years; but, in a form modified by the alleged changes in the condition of the country, increase of population, construction of railroads, &c., it again found expression in a resolution of Congress in 1851; and the Secretary of War, to enable himself to respond, called upon numerous distinguished army and navy officers for an expression of their opinions. The following questions were addressed to several of the principal Engineer officers, among whom the Chief of Corps, General Totten: —

"1st. How far the invention and extension of railroads have superseded or diminished the necessity of fortifications on the seaboard?

"2d. In what manner and to what extent the navigation of the ocean by steam, and particularly the application of steam to vessels of war, and recent improvements in artillery, and other military inventions and discoveries, affect this question?

"3d. How far vessels of war, steam batteries, ordinary merchant ships and steamers, and other temporary expedients, can be relied upon as a substitute for permanent fortifications for the defence of our seaports?

"4th. How far the increase of population on the northern frontier and of the mercantile marine on the northern lakes obviates or diminishes the necessity of continuing the system of fortifications on these lakes?"

General Totten's response to these critical interrogations is, as usual with him when this great subject has to be dealt with, full and exhaustive. The following pithy paragraphs exhibit his views on the influence of railroads.

"Suppose a hostile fleet to lie in front of the city of New York, — which nothing would prevent, if the channels of approach were not fortified, — in what way could the 100,000 or 200,000 new men poured into the city and environs by railroads, although armed with muskets and field-pieces, aid the half-million of people already there? It seems to me very clear that these additional forces would, like the population of the city, be utterly powerless in the way of resistance, with any means at their command; and, if resistance were attempted by the city, would but serve to swell the list of casualties, unless they should at once retreat beyond the range of fire. If the enemy's expedition were intended, according to the second supposed mode of attack, for invasion, or occupation for some time, of a portion of the country, then, in many places, this resource of railroads would be of value, because then the duty of defence would fall upon the army and militia of the country; and these communications would swell their numbers.

"But of all circumstances of danger to the coast, this chance of an attempt by an enemy to land and march any distance into a populous district is least to be regarded, whether there be or be not such speedy mode of receiving reinforcements, and our system of fortifications has little to do with any such danger. In preparing against maritime assaults, the security of the points to be covered is considered to be greatly augmented whenever the defence can be so arranged as to oblige an enemy to land at some distance; for the reason that opportunity is thereby allowed, in the only possible way, for the spirit and enterprise of the people to come into play.

"Instead of being designed to prevent a landing upon any part of the coast, as many seem to suppose, and some allege in proof of extravagant views on the part of the system of defence, the system often leaves this landing as an open alternative to the enemy, and aims so to cover the really important and dangerous points as to necessitate a distant landing and a march towards the object through the people. It is because the expedition would easily accomplish its object without landing, and without allowing the population to partake in the defence, that the fortifications are resorted to. For instance, without Fort Delaware, or some other fort low down on Delaware Bay, an enemy could place his fleet of steamers in front of Philadelphia by the time his appearance on the coast had been well announced throughout the city. And in spite of all New Jersey, Delaware, and lower Pennsylvania, he could levy his contributions, and burn the navy-yard and shipping, and be away, in a few hours. But being obliged, by the fort above mentioned, to land full forty miles below the city, the resistance to his march may be safely left to the courage and patriotism that will find ample time to array themselves in opposition."

Concerning the application of steam to vessels of war he says: —

"The application of steam to vessels of war acts upon the question of sea-coast defence both beneficially and injuriously. It acts injuriously in several ways; but chiefly, first, by the suddenness and surprise with which vessels may fall upon their object, and pass from one object to another, in spite of distance, climate, and season; and, secondly, by their ability to navigate shallow waters.

"The first property, by which squadrons may run into our harbors, outstripping all warnings of their approach, affords no chance for impromptu preparations; accordingly, whatever our preparations are to be, they should precede the war. It seems past all belief that a nation having in commission — as France and England always have — a large number of war-steamers, ready for distant service in twenty-four hours, receiving their orders by telegraph, capable of uniting in squadrons, and in two or three days at most speeding on their several paths to fall upon undefended ports, — it is not to be expected, I say, that they should delay such enterprises until temporary resorts could be got ready to receive them. And yet there are those who insist that we should leave defensive measures to a state of war, — that we should let the day supply the need!

"Inadequate as all such measures must prove, there would not be time to arrange even these. By the second property, due to their light draft of water, these vessels will oblige the defence to be extended in some form to passages or channels or shoals that were before adequately guarded by their shallowness. The bars at the mouth of the Mississippi formerly excluded all but small vessels of war, and the strong current of the river made the ascent of sailing vessels exceedingly uncertain and tedious. Now these bars and currents are impediments no longer. And all the armed steamers of Great Britain and France might be formed in array in face of the city of New Orleans before a rumor of their approach had been heard.

"Had the English expedition of 1814, attended by a squadron of armed steamers, arrived at the mouth of the Mississippi, a few transports might have been taken in tow, and in a few hours the whole army would have been before the city. Or twelve or fifteen such steamers could have carried the whole army up in half a day, without the delay of transports. Will it be contended that the attack in that form would have been repulsed with the means then in General Jackson's hands? Would the landing, or even the presence on board these steamships, of the British troops have been necessary to burn the city or put it under contribution? Is there anything now, but the existence of forts on the river, to prevent the success of such an attack by fifteen or twenty steamers of war, allured there by the vastly increased magnitude of the spoil?" *

While the enemy's means of attack are thus enhanced by the use of war-steamers, General Totten contends that they cannot be relied upon, as a substitute for fortifications, for defence.

"I do not assert," he says, "that armed vessels would not be useful in coast defence. Such an idea would be absurd. I shall even have occasion to show a necessity for this kind of force, in certain exceptional cases. It is the general proposition, viz. that armed vessels, and not fortifications, are the proper defences for our vulnerable points,—a proposition the more dangerous, because seemingly in such accordance with the well-tried prowess and heroic achievements of the navy that we have now to controvert.

* The experience of the Rebellion has proved the truth of General Totten's words. The moment the *forts* were passed, the city of New Orleans was, notwithstanding the land forces under Lovell, at Commodore Farragut's mercy. I have alluded elsewhere to the failure of the forts.

"Boston, New York, Philadelphia, Baltimore, Charleston, and New Orleans are, we will suppose, to be guarded, not by forts, but by these vessels, on the occurrence of a war with a nation possessing large naval means. We know that it is no effort for such nations to despatch a fleet of twenty line-of-battle ships and frigates, or an equal number of war steamers, or even the combined mass, — both fleets in one.

. . . . .

"What, then, shall we do at the above-named ports severally? Each is justly felt to be an object worthy of an enemy's efforts, and each would be culpable in sending elsewhere any part of the force required for its own defence. Each, therefore, maintains a naval force equal, at least, to that the enemy is judged to be able to send promptly against it. Omitting any provision for other places scarcely less important, what is the result? It is, that we maintain within the harbors of, or at the entrance to, these places, chained down to this passive defence, a force at least six times as large as that of the enemy.

"He does not hesitate to leave his port, because it will be protected in his absence by its fortifications, which also afford him a sure refuge on his return. He sails about the ocean, depredating upon our commerce with his privateers and small cruisers, putting our small places to ransom, and in other ways following up appropriate duties; all which is accomplished without risk, because our fleet, although of enormous magnitude, must cling to ports which have no other defence than that afforded by their presence. They cannot combine against him singly, for they cannot know where he is; and must not, moreover, abandon the object which they were expressly provided to guard.

"It would really seem that there could not be a more impolitic, inefficient, and dangerous system, as there could not certainly be a more expensive one."

I have thus extensively quoted from the reports of General Totten, because they are themselves the best expressions of the life labors and services of the subject of our memoir, and because I think they treat of matters which should be, in an eminent degree, interesting to the members of this National Academy, and which, moreover, should demand its attention.

To preserve the continuity of my subject, I have followed these reports down to a late date. It is necessary now to revert to an earlier period. It has already been observed, that, as soon as the original Board of Engineers had sufficiently matured the general system of defence, and completed plans for the works first required, its members applied themselves to the duty of construction. In 1828, General (then Colonel) Totten took charge of the construction of Fort Adams, Newport harbor, and continued on this duty, making his residence in the town of Newport, until December, 1838, the date of his appointment as Chief of the Corps of Engineers. This work, the second in magnitude of the fortifications of the United States, is one of the best monuments of his genius as a military engineer. From its peculiar relations to the land defence, it called for the application of most of those rules of the art, and many of those special arrangements which form the themes of treatises upon "fortification," and which, generally, have but a very limited application to works of harbor defence. In these respects it has no parallel with us, and in the treatment of the case and happy adaptation of means to the end, Colonel Totten exhibited a mastery of all the details of the art, which proves his technical skill and minute knowledge to be fully equal to the power of broad generalization I have already endeavored to illustrate. But Colonel Totten found here yet another field for professional usefulness, — another track to explore. The art of the civil engineer (I use the phrase in its application to mere *construction*, whether it be of a military or civil work) was yet in its infancy in this country. Our resources in building materials were almost unknown, their qualities and adaptabilities to different purposes of construction undeveloped. Thus far the matter had excited little attention ; the building material, whether brick or stone, lime or timber, nearest at hand was indiscriminately used, and its aggregation left much to the skill of the mechanic. In commencing constructions on so great a scale, it was of the first importance that the work should be both durable and economical ; a result only to be attained by the most careful selection of materials, and the most skilful manipulation. Besides, our forts called for arrangements unknown in other branches of building, — arrangements for which the execution and the most suitable materials had to be studied out *ab initio*, since on many of these points there were neither experience nor extant rules to guide.

In the years 1830 and 1831 a series of experiments was instituted by Colonel Totten at Fort Adams, on the expansion and contraction of building stone by natural changes of temperature, and the effects of these variations on the cements employed to secure the joints of stone copings. An account of them was prepared under his direction by Lieutenant (now Professor) W. H. C. Bartlett, a member of this Academy, and published in the American Journal of Science for July, 1832. The methods employed were at once simple and ingenious, and the result was such as to leave no doubt that in this climate the joints of copings formed of stone of four or five feet in length will always be insecure, no matter what description of cement may be employed to close them.

This result is one of great practical importance. Previously to the experimental examination of the subject by Colonel

Totten, the walls of our most expensive works of masonry were protected by copings cemented at their joints; and while the failure of the cement was constantly noticed, the cause of the failure was not understood. The experiments showed that the changes of longitudinal dimensions of granite coping-stones, five feet only in length, under the extreme temperatures to which they were exposed at Newport, would be sufficient to pulverize the hardest cement between them, or to leave cracks in it thicker than common pasteboard. With marble as a material, these destructive effects are considerably increased, and with sandstone, nearly doubled.

About the same time, Colonel Totten caused some experiments to be made to ascertain the relative stiffness and strength of the following kinds of timber, viz. White Pine, (*Pinus strobus*), Spruce (*Abies nigra*), and Southern Pine (*Pinus australis*), also called Long-leaved Pine.

These experiments, made by his assistant, Lieutenant T. S. Brown, of the Corps of Engineers, were published in the American Journal of Science and Art, and afterwards, having been revised by the author, in the Journal of the Franklin Institute, a note being added, the calculations extended, and practical inferences drawn therefrom. This memoir and additions are found in Vol. VII., new series, Journal of the Franklin Institute, 1831. Lieutenant Brown's account concludes with the following remarks: —

"In Tredgold's carpentry, and other similar works, may be found the constant numbers (a) and (c) for nearly all the kinds of wood useful in the arts; but besides that the numbers are in many instances calculated from insufficient experiments, most of the specimens used in the trials were of European growth, and of course the results obtained are inapplicable to American timber, though bearing the same name. It is much to be desired that numerous and accurate experiments be made in this country by those having the requisite zeal and opportunities; our architects will then know with certainty the qualities of the different kinds of woods they are using, and instead of working at hazard and in the dark, as they now too often do, they will be guided by the sure light of practical science to certain and definite results. If these experiments contribute ever so little to the attainment of so important a result, the object of their publication will be fully accomplished."

A subject of such vital importance in the art of construction as the composition of mortars could not fail to invite, or rather compel, the researches of Colonel Totten. No species of masonry is subject to such severe deteriorating influences as the walls and arches of fortifications, especially in our climate; so severe, indeed, that they almost drive the engineer to despair. Next only to the importance of having the building stones or bricks of a suitable character, is that of uniting them by a strong and durable mortar. Few persons whose attention has not been called to the subject conceive its magnitude, the variety of materials it embraces, and the laborious investigations to which it has given rise. Colonel Totten commenced his researches at an early date, and continued them actively during the whole period of his connection with Fort Adams.

His work on "Hydraulic and Common Mortars" was published in 1838 by the Franklin Institute of Philadelphia. It contains, besides original experiments and observations on mortars, hydraulic cements and concretes, translations of essays by Treussart, Pitot, and Courtois, the best French writers on the same subject, and constitutes to this day an authority relied on by American engineers. Colonel Totten's experiments extend over the period from 1825 to 1838; they are especially valuable for the variety of limes and cements, and the tests of different modes of slaking the lime, mixing the mortars, and preparing the cements and concretes. The mortars were tested, after periods ranging from five months to four years and five months, for tenacity, by the force required to separate two bricks joined together by means of them, and for hardness by the weight which they would support, applied over a small circular area. The experiments on concretes or factitious stones are equally comprehensive, being directed to the composition and consistency of the cement, whether best used as a stiff mortar or a semi-fluid grout; to the effect of additions of common lime and sand or rounded pebbles and gravel, and to ascertaining the proportion of each that would be used to the best advantage. The results developed by these investigations are of the greatest value, and having been applied in the construction of the fort, have now had the test of many years' experience.

It would be almost impossible to enumerate the various objects of Colonel Totten's researches while at Newport. There is scarce a subject connected with the art or science of the engineer, civil or military, which did not engage his attention, and of which he has not left some record. The thickness of sustaining walls, the thrust of arches, among the more important, and the composition of stuccoes, of paints, lackers, washes for stone or brick work, among the less so, may here be mentioned.

Perhaps no period of his life is so interesting and so affectionately remembered by his professional associates. Indeed, a large proportion of the young officers of the corps of those days passed a portion of their time under his command, and acquired their first professional experience in the performance of duties under his eye and direction. The disposition to cultivate science, physical and natural, led him to original researches, while his influence stimulated and led to improvement the educated young men who from time to time came into his military family. Fond of exercise, bodily and mental, he sought in natural history, as in geology, mineralogy, and conchology, objects for the long walks and drives conducive to health, while the arrangement of the specimens, their care and classification, and the study of the habits of the animals which occupied the shells, gave scope to his wonderful powers of observation. Instead of finding his young officers a trouble, he was fond of their companionship, suggesting modes and objects of experiment, and encouraging them to do so likewise, thus cultivating originality of thought. His laboratory was at their service, and his companionship and example at their disposal. After a day's labor he retired to this laboratory, glad to have with him such of the young companions of the day as desired to join him. The honored President of this Academy can recollect, year after year, the computations, under Colonel Totten's direction, of the thickness of revetments, the analysis of minerals collected in the field, classifications of shells gathered in days' walks on the sea-shore, discussions of the curious structure of geological specimens in the neighborhood of Newport, and of the curious mineralogical specimens of the upper portion of Rhode Island, which he encouraged them to find. So upon the fort itself, the various researches which I have described were marked out for successive experimenting, with a generosity to his assistants which almost persuaded them that they were original with them. The determination of the measures used in laying out the fort and the practical apparatus employed in the measurements, received his careful study. The practical character of these works impressed themselves upon the minds of the young officers, and furnished the fitting complement to the theoretical training received at West Point.

Not least pleasant among the memories of this period of Colonel Totten's life, to those who had the good fortune to be associated with him, is the recollection of the social enjoyments of his house. Married in 1816 to Catlyna Pearson, of Albany, he was surrounded by a young family, among whom his happiest moments were spent, and to whom he was everything that such a relation can imply. None could be happier in his social intercourse. Genial and eminently hospitable, he cultivated as a duty those smaller amenities of society by which the cares of life are lightened, and its joys augmented. His house was the home of his friends, and was seldom without some one of them. Though dignified and courteously reserved in his intercourse with the external world, few more highly enjoyed real humor, or could with more true *bon-hommie* give themselves up to the gayety of the moment. In his relations to his young officers he was kind and affable, encouraging freedom of expression, and inviting inquiry in everything that related to professional matters, while there was always that in his manner which inspired the most profound respect and forbade undue levity of conduct in his presence.

Before quitting the scene of so important a portion of Colonel Totten's official labors, it is proper to remark that, in addition to the duties of his particular charge, he as a member, and for the last six years President of the Board of Engineers, was engaged in the planning of the new works for which Congress from time to time made the necessary appropriations.* To this duty he usually devoted the win-

* By the Regulations, the local engineer officer, upon whom the construction of the proposed work was to devolve, was *ex officio* a member of the board. This brought together during the winter months engineer officers from various parts of the country, — from the shores of the Gulf, from the seaboard of North and South Carolina

ter months, during which all construction on Fort Adams was suspended. In the execution of his designs he was usually assisted by young officers of the corps, who found therein a practical application of the theoretical knowledge acquired at West Point instructive and useful.

The works of harbor improvement on the seaboard and on the lakes were likewise under the control and direction of the Engineer Bureau; and Colonel Totten, though not directly engaged therein, was not infrequently called on to inspect and advise concerning them. Most of these, and especially those of the Lake shores, afforded curious and interesting problems in this branch of civil engineering, and his reports and notes on these subjects, yet extant, are additional proofs of the wide range of his professional knowledge and of his powers of accurate observation and of skilful deduction from the phenomena of nature.

Colonel Totten was appointed Colonel of the Corps of Engineers and Chief Engineer, Dec. 7, 1838. At this time the construction of Fort Adams was so far advanced towards completion as to need no longer his personal supervision, and the city of Washington became thenceforth his home and the seat of his official duties. Identified as we have seen with the origin and growth of the great system of sea-coast defence of the United States, it was eminently proper that he should become the head of that bureau of the War Department to which its execution was committed, and no one could be more eminently fitted for that important station.

At the date of his appointment the system of coast defence had been for about twenty years in progress of construction, and during that period most of those ports and

and Georgia, as well as from nearer points, and added not a little to the charm of the professional and social life of the young engineer officers at Newport.

harbors of the United States deemed most important to ourselves or most assailable by a naval foe had been, at least, partially fortified. At many such points, indeed, no new work had been as yet constructed, owing to the existence of forts or batteries more or less adequate built before or during the war of 1812. These works, where possible, were absorbed into the new system with some repairs and alterations. Among such points may be mentioned the harbors of Portland, Portsmouth, New London, Philadelphia, Baltimore, and Charleston. New and powerful works had, however, been built or far advanced to completion, for the defence of Boston, Newport, New York, Hampton Roads, the Savannah River, Pensacola, Mobile, and New Orleans. But the strictures on the system, to which we have before made reference, proceeding from such an authority as the Secretary of War and sanctioned by the President, had not failed to shake the confidence of Congress and of the people. For several years the annual appropriations had been wholly denied or made so inadequately that the work had languished and at some points had been wholly suspended. But however much opposition may grow up in time of profound peace, no sooner is there a probability of seeing a foe at our doors than all eyes are turned to these protecting works, and the most urgent demands are made that our seaport towns shall be speedily put "in a state of defence." Such an impulse was given by the Maine boundary and McLeod questions, soon after the advent of Colonel Totten to the Chief Engineership. In fulfilling the urgent duty which thus devolved upon him, he did not content himself with the mere issuing of orders from his office at Washington. He made it his business to inspect personally the works, and in less than two years, besides the enormous office labor he found necessary to attend to on the first assumption of charge of the bureau, he had visited every fort and battery on the sea-coast of the United States. His inspections were not superficial and hasty; they were most thorough and searching. His investigations embraced, at the same time, the general scope and purpose of the work, its adaptability to its great objects, and the minutest detail in its construction. It was now that the country derived the full benefit of his indefatigable researches while at Newport.

I have already alluded to the lack of knowledge and experience in this country of the art of construction, especially in its applications to the peculiarities of fortification. To supply this lack was a great end of Colonel Totten's labors at Fort Adams. At few other points did the locality or circumstances of the construction render practicable such researches. This remark will apply particularly to the works on the Gulf of Mexico. The regions bordering the Gulf were, at the close of the war of 1812, but recent acquisitions to the territory of the United States. Sparsely populated and isolated from the rest of the Union as (before the application of steam to the navigation of the Mississippi) they were, they would be defended, if defended at all, only by the aid of fortifications. The fact that New Orleans had been almost wrenched from our grasp, and the impression then everywhere felt that if it had been captured it would not have been relinquished, stimulated the government to secure the possession of this important place and of other strategic points on the Gulf by immediate fortification. Accordingly designs for works — mostly prepared by General Bernard — were among the first labors of the Board of Engineers, and the forts on the river and lake approaches to New Orleans, at the entrances to Mobile Bay and Pensacola harbor, were almost simultaneously commenced.

Around New Orleans especially the Engineers had to contend with formidable difficulties. The deadly climate, the treacherous soil, on which no art could build a structure so massive as a fortification that should not sink one or more feet, warping and dislocating the walls and arches, the difficulties of procuring the services of mechanics and laborers, the want of building materials, &c., all combined to make construction exceedingly difficult, to forbid any of its niceties, and to hinder all research or experiment. Some of these works had been entirely finished at the period we have arrived at, others nearly so, and left to "settle" before the weight of the earthen parapets was added.

Considering all these unfavorable circumstances, these works had been built in a manner creditable to the energy and skill of the engineers; but a few years' neglect, aided by a damp and tropical climate, had given many of them an appearance which, to the superficial observer, promised anything but efficiency. Indeed, it was a popular belief in New Orleans at this time that Fort Jackson on the Mississippi had sunk so much that its guns could not be brought to bear on the river, — a belief doubtless due to the unnecessarily high *levees* by which it had been surrounded to protect its site from inundation, and to the rapid growth of vegetation on and about the fort. Such was the condition of this work when Colonel Totten first visited it in 1841, and the author of this paper, who had but recently taken charge of it, has yet a vivid recollection of the thorough inspections of this and other works, the tedious voyages in open boats through the intricate "bayou" navigation about New Orleans, in company with his chief, as well as the copious and most minute instructions which he received. Destitute of American experience on such points, the designer had followed European precedents, or the constructing engineer had been left to his own devices as to much that relates to the interior arrangements. The wood-work of magazines, inadequately ventilated, had rotted and fallen in ruins; the covering of the bombproof casemates, imperfectly understood, had failed to exclude water, which percolated through the piers and arches or gathered in muddy pools on the floors. The work to be done to bring the forts to speedy efficiency was vast; embrasures and floors of casemates were to be raised to compensate the settlement the works had undergone; earth to be removed from the arches, in order to repair or renew the roofing; magazines and quarters to be refitted, and all this before a gun could be mounted in a proper manner. On all these points Colonel Totten was rich in the experience of his long researches, and ready at once to give the proper directions. Following his detailed instructions, the works speedily reached such a condition of efficiency as to permit the mounting and service of their guns.*

What the writer here relates from his own experience at New Orleans serves but to illustrate the indefatigable labors and personal agency of Colonel Totten at this period, along the whole seaboard of the United States, in bringing all its ports and harbors into a defensible condition. Nor should I confine these attributes to any particular period. During the whole time of his Chief Engineership he continued the same laborious supervision. Generally, once in about every two years, he inspected every fort of the United States, and scarcely was the local engineer officer more thoroughly familiar with each detail of his own particular works than

* When Forts Jackson and Philip on the Mississippi were attacked by the fleets of Commanders Farragut and Porter, they were not provided with the armaments intended for them, and the garrisons were demoralized by a long bombardment. It is not in place to discuss this subject here.

was the Chief Engineer with those of all under charge of the Engineer Bureau. Besides attending to the routine duties of his office at Washington, he found time to design plans for new works, as well as for alterations or enlargement of old ones. An admirable draughtsman, executing his work with a delicacy and finish that defied competition on the part of his subordinates, he would be usually found, if visited at his office, engaged at his drawing-table. Indeed, if he had a fault as Chief Engineer, it was the habit of doing everything himself. It was contemplated by the Regulations that all plans of fortifications should be made by a Board of Engineers, and General Totten, in one of his reports, alludes to the fact that this has *not* always been the case in these words: "In rare cases it has happened that plans have been made under the particular direction of the Chief Engineer, owing to the difficulty, at moments, of drawing the widely dispersed members of the board from their individual trusts." It may be said too, in justice to him, that when he assumed the control of the bureau, it was almost indispensable to take much upon himself, in the direction of the repairs and prosecution of many of the works, owing to the great pressure thrown upon the corps by the circumstances of the period, and the want of a sufficient number of experienced officers.

The excitement produced by the anticipation of war with England was followed by an actual war with a weak neighbor, — a war inaugurated by the same influences which, in a more potent form, produced the Rebellion, or rather of which the Rebellion was but the legitimate and natural sequel. Called on by General Scott, who reposed in his professional skill the most unbounded confidence, Colonel Totten assumed, in 1847, the immediate control of the engineering operations of the army destined to invade the Mexican capital, directing in this capacity the siege of Vera Cruz. For his successful services he was brevetted a Brigadier-General, March 29, 1847, "for gallant and meritorious conduct at the siege of Vera Cruz." Having thus successfully accomplished the special task for which he had been selected, he left the army and resumed his station at Washington.

In addition to the onerous duties of his office, involving, besides the labors described, the Inspectorship and Supervision of the Military Academy, his position and high reputation subjected him to calls for incidental labors, by the government, by the States, or by municipal bodies. A few months prior to his appointment as Chief Engineer, 1838, he was, at the invitation of the Secretary of the Navy, ordered to visit the Navy-Yard at Pensacola, and to prepare plans for dry-docks, wharves, sea-walls, and other improvements. Save a wretched failure in the shape of a wharf, the place — a navy-yard in name — had been, up to this period, destitute of everything that characterizes such an establishment, except an imposing row of officers' quarters, and some few storehouses. A board of naval officers had been convened two years previously to consider the wants of the yard, and had recommended an extensive system of improvements, involving, among other things, no less than four dry-docks. Such constructions, reaching thirty or more feet below the level of low water in the loose sand of the bay shores, were difficult, demanding all the resources of the engineer, and it was on account of General Totten's eminent abilities and high authority in such matters that the Navy Department had recourse to his services. He made a report on the manner of construction, with plans which, if I mistake not, have been a guide in the subsequent operations. Unfortunately, to this day no permanent dry-dock exists, a floating wooden one having, through some influence, been substituted, at enormous expense, for the intended masonry structure.*

The Legislature of the State of New York having, March 30, 1855, passed "An Act for the appointment of a Commission for the preservation of the harbor of New York from encroachments, and to prevent obstructions to the necessary navigation thereof," the commission so appointed invited and obtained the co-operation, as an "advisory council," of General Totten, Professor Bache, and Commander Davis, U. S. Navy. The nature of the services thus rendered is best understood by reference to the reports of the Commissioners themselves.

"The distinguished reputation of General Totten, Professor Bache, and Commander Davis for scientific attainments, their diversified experience in the construction of hydraulic works, and long observation of the influence of tidal currents in the formation and removal of shoals, indicated them as the best qualified to assist the Commissioners in the discharge of their duties, while their high personal character precluded the possibility of their advice being affected by other than the single purpose of arriving at a just decision on the questions submitted to them"; and again, after a particular allusion to the services of Professor Bache: "It is the gratifying duty of the Commissioners to present to the notice of the Legislature the important services which have been gratuitously rendered to the State by General Joseph G.

* The "questionable shape" and suspicious object of this novel craft — set afloat and towed out into the bay by the Rebels in 1861 — caused anxious surmises on the part of Colonel Brown and the gallant garrison of Fort Pickens, reminding us of the famous "Battle of the Kegs" of the Revolution. The probable object was to sink it in the channel to prevent the entrance of our gunboats. But Colonel Brown's interference prevented the accomplishment of the design. It was abandoned by the rebels, and set fire to by Colonel Brown's orders.

Totten, Chief Engineer of the United States Army, and Commander Charles H. Davis, of the United States Navy, who, with Professor Bache, formed the advisory council of the Commissioners. Animated by the single desire of preserving the port of New York in all its usefulness, they brought to the consideration of the subjects referred to them the diversified experience of many years spent in the examination and improvement of harbors. The several reports they have made on the exterior lines, on the improvement of Hell Gate, and on the preservation of Gowannus Bay, are profound dissertations on the forces and actions of currents, and, while they evince, in some degree, the extent of the labors of those gentlemen, they demonstrate how just is the public estimate of their scientific attainments."

Following the example of New York, Massachusetts soon organized a similar Commission for the port and harbor of Boston, on which the same gentlemen were invited to serve, receiving similar testimonials of the high value of their services.

Of the many scientific men of the country who were associated with him in such duties (of whom most usually was our eminent President), none exhibited greater zeal and assiduity, few took a more prominent and useful part. The resolutions of the Lighthouse Board, on the occasion of his decease, which are appended to this memoir, would be, with slight modifications, applicable in reference to all his connections of a similar nature. Inflexible in his integrity, uncompromising in his notions of duty, and watchful to the highest degree for all the interests of the government in all that concerned his charge, it is not strange that the shameless Floyd soon found him an obstacle to his peculiar operations. He was virtually banished from his office, or at least relieved from its duties, which he did not resume until Floyd left the War Department. He took this opportunity — perhaps the very first and only release during his lifetime from the unceasing demand of duty — to visit Europe in company with Mrs. Totten, travelling through France, Italy, Germany, and England. Endued with those keen perceptions and that harmonious adjustment of faculties which render the mind susceptible to the beautiful, whether in nature or art, he was, in the true sense of the term, an artist. For music, for painting, for sculpture, he had a high relish and a most accurate and discriminating judgment. By such a one the treasures of art and antiquity of Europe can only be adequately appreciated and enjoyed, as we know they were appreciated and enjoyed by General Totten. He did not fail, however, to take the opportunity to examine, as far as he was able, the fortifications of Europe, of the character and peculiarities of which, however, he had little to learn. On his return he was sent by Floyd to the Pacific coast, with directions to inspect the fortifications in construction, and to report on the defensive requirements of that region. This duty and the report thereon he executed in his usual thorough and exhaustive manner. It furnished him with the opportunity to acquire the same personal knowledge of all that concerned the seaboard defence of our newly acquired territories on the Pacific which he already possessed, beyond any other man, in reference to the Atlantic and Gulf coasts.

In the year 1851 General Totten inaugurated and continued through the years 1852, 1853, 1854, and 1855 a series of experiments at West Point, "on the effects of firing with heavy ordnance from casemate embrasures," and also "on the effects of firing against the same embrasures with various kinds of missiles." It will be interesting, and conducive to a better understanding of the objects and results of these experiments to say a few words as to the origin and meaning of the term "casemate," and to give an account of General Totten's previous labors in connection with the "casemate embrasure." The word is from the Spanish *casa-mata* (a compound, most likely, of *casa*, house, and *matar*, to kill; though it is said also to mean a low or hidden house; but the etymology is not settled), and seems to have been used to signify a countermine as well as a concealed place, arranged in connection with a fortification, for containing and using a piece of artillery. According to Bardin* it appears to have been applied to the double or triple tier of uncovered gun platforms used by the early Italian and German engineers for flanking the ditch, as well as to vaulted galleries along the scarp wall. The term finally came to mean, in fortification, any vaulted room under the earth work of the rampart or glacis, whether intended for service of guns or for quarters of troops or for containing stores. A *gun casemate* is such a vault abutting against the scarp or counterscarp wall through which an "embrasure" is pierced to permit the discharge of the gun; and in the naval service the term has been adopted to signify the part of an iron-clad vessel containing the guns, and which is, for that reason, especially protected by the iron-plating. Hence the essential notion of the word seems to involve one or more of the attributes of concealment, shelter, and destructive purpose.

The use of the casemate, in some of its forms, for flanking purposes goes back to Albert Durer and San Micheli, in the early part of the sixteenth century, and it was resorted to by Vauban in his second and third systems, of which the tower-bastions are casemated throughout. But it was reserved for the Marquis de Montalembert, in the latter part

* Dictionnaire de l'Armée de Terre, &c.

of the eighteenth century, to give it an extraordinary development, and to make the casemate the essential element of a system of fortification. This "most intrepid of authors upon fortification" (as he is styled by Chasseloup) boldly attempted to apply to his art the same principles by which Napoleon won his victories, — the concentration of superior forces upon the decisive points. In his projects we find upon all parts where there must be a decisive contest of artillery an extraordinary concentration of guns, amounting in some cases to ten times those of the attacking batteries, the construction of which it is intended to prevent, or which shall be promptly overpowered, if constructed. This concentration he effected, and could only effect, by the use of casemates, upon which, numerous and well constructed, he bases all the strength of his fortifications.

No author on this art has displayed greater genius or a greater affluence of resources, and no author has given occasion for so much acrimonious discussion. Rejected by the French, the principles of Montalembert have been made the basis of the modern German, or "Polygonal," system.

For sea-coast fortification the casemates of Montalembert had a singular applicability, and he has the merit, at least, of being the first writer who has seen in this branch of the art a subject of particular treatment, and who had given special designs for forts and batteries "for the defence of ports."

In no warlike structure was there so great a concentration of artillery as in a ship of war, such as it was fifty or even twenty years ago. And as there is no limit to the number of ships which may be brought to bear upon a shore battery save that of the range of artillery and the area of navigable water, it is easy to see to what overwhelming hostile fire such a work may be subjected. On the other hand, it frequently happens that the site otherwise most advantageous for a battery is low and contracted, rendering any accumulation of guns impracticable, if mounted on an ordinary rampart, and exposing the unprotected gunners to the fire of the sharp-shooters with which the enemy's topmasts are filled.*

It is no small merit of Montalembert to have devised a method of mounting guns which should meet this case. Notwithstanding that the French Corps of Engineers rejected the system in its intended application, and disclaimed, as an engineer, its author, it nevertheless constructed, in 1786, for the defence of the roadstead and harbor of Cherbourg, forts which are in reality almost copied from his designs.† Following the example of the French, other European nations have adopted, for the defence of their seaports, works of the same character, of which the forts of Cronstadt and Sebastopol, once made familiar to us, in their outward appearance, by the Pictorials, are recent specimens, and, as we have already seen, Colonel Williams introduced them into our country in 1807, by the construction of Castles Williams and Clinton, and Fort Gansevoort, New York harbor.

An objection urged against casemates, and a grave one, since it is aimed at one of their most important attributes, is, that the embrasures of masonry are dangerous to the gunners, from their outward flaring surfaces reflecting into the interior the enemy's missiles. Montalembert was well aware of this objection, calling the embrasure, in its ordinary form, a "murderous funnel," (*entonnoir meurtrière,*) and his saga-

* The topmasts of many of the vessels of Commodore Farragut's fleet in the attack on Forts Jackson and St. Philip contained boat-*howitzers*, destined to fire canister at the gunners of the low batteries of those works.

† The celebrated Carnot, then an officer of French engineers, but who adopted the views of Montalembert, writes to him, "You have wrung from your adversaries the admission that well-constructed casemates are a good thing," &c. (Zastrow, *Histoire de la Fortification.*)

city did not fail to prescribe the best remedy by rules intended to reduce to a minimum the external opening. He directed that the throat should be no larger than necessary to receive the muzzle of the gun and to endure the shock of its discharge, that it should not be more than two feet from the exterior surface of the wall, that the cheeks should be parallel to the sides of the sector of fire; and to render practicable these arrangements, he invented the "*affut à aiguille*" (carriage with tongue), which has served as the type of nearly all subsequent casemate gun-carriages. It is strange, that, even while adopting the plans of Montalembert, European engineers should have almost wholly overlooked these maxims, and that it was reserved for our own illustrious engineer to make their application, and, in perfecting the casemate and the embrasure, to become a co-worker with Montalembert, by bringing the casemated water-battery to its highest degree of perfection.

I now revert to General Totten's labors in this connection, and in reference thereto I quote from his report to the Secretary of War: —

"The first casemated battery was completed in 1808. It has two tiers of guns in casemates, and one in barbette. The exterior openings of the lower embrasures are 4′ 8″ by 6 feet, giving an area of 28 square feet; and of the second tier, 3′ 8″ by 5 feet, area $18\frac{1}{3}$ square feet, the horizontal traverse of the guns being limited to 44 degrees.

"Within three or four years of the time just mentioned two other casemated batteries were built, each having a single tier of guns in casemates, with exterior openings of 4′ 5″ by 5 feet, area 22 square feet; one with horizontal scope of about 42 degrees, and the other of about 45 degrees.

"In 1815 the author of this report was called on to prepare a project for the defence of an important channel; and having been convinced, while employed as an assistant in the construction of two of the batteries just mentioned, that the principles and the details by which the embrasures and the dependent casemates had thus far been regulated were erroneous and defective, set about a careful study of the conditions to be fulfilled in providing for the heavy guns of that period, mounted on a casemate carriage that had already been approved and adopted. The result was an embrasure, having an exterior opening of 4 feet wide by 2′ 6″ high at the outside line of the cheeks, and three feet high at the key of the covering arch, the throat being 1′ 10″ wide. This provided for all the depression and elevation of the gun that the carriage permitted, and also for a horizontal scope of full 60 degrees. Covered with a lintel instead of an arch, the height of the exterior opening might be a little less than three feet.

"The plan of this embrasure shows that the interior opening is 5′ 6″ wide, and that the plane of the throat is within 2 feet of the outside of the wall, which just at the embrasure is five feet thick.

"A slight modification fitted this embrasure, when applied to flanking or interior defence, to receive at first a carronade of large calibre, and of later years, a howitzer instead. When these latter were liable to be assailed by musketry, the outer cheeks were made *en cremailliere* (notched), — a long-known device.

"It was with timidity and hesitation that the cheeks and this embrasure were placed so near the track of the ball, when fired from the casemate, with the maximum obliquity, and the results of an early trial with experimental embrasures at Fort Monroe gave some sanction to the doubt. The first two under trial were built of lime mortar, and were soon shaken to pieces by the blast of the gun. Another one, however, constructed of bricks laid in cement-mortar, sustained without injury several hundred discharges. These last results have been confirmed wherever there has been practice from our embrasures, which, with immaterial differences, have since 1815 been constructed in all our casemated batteries according to the preceding description."

It will be seen from the foregoing quotations how thoroughly General Totten, in adopting the casemated battery, was imbued with the spirit of its illustrious originator. If, as is likely, he was aware of the latter's rules on this subject, he was the first to appreciate their essential importance, and to prove the practicability of their application. It is probable, however, that the close study of the subject, critical observation and keen sagacity which so distinguished him on all occasions, and which taught him to accept nothing as the best which was susceptible of improvement, led him to recognize as "murderous funnels" the embrasures of routine, — to create anew the rules of Montalembert, and to make, for the first time, a successful application of them. He reduced the throat to nearly an absolute minimum: he placed it at two feet from the outer face of the wall, diminishing the external openings from eighteen, twenty-two, and twenty-eight, down to about ten square feet, while he increased the sector of fire of the gun from forty-five to sixty degrees; thus adding one third to its field of fire, and consequently to its value.

The embrasures, thus modelled in 1815, remained unchanged until the year 1858, but the casemate continued a subject of study and experiment during most of his life. The perfecting of ventilation, the determination of the dimensions and height of the piers, of the span and rise of the arches, their thickness and manner of covering, so as to obtain perfect drainage and to avoid the injurious effects of frost, &c., were problems of prolonged research and skilful solution, establishing for General Totten the right to be considered the author of the American casemate.

In connection with these researches may be mentioned those also which were directed to the determination of the manner of mounting guns "en barbette." * As the dimensions of sea-coast ordnance increased, more and more elaborate structures became necessary for their mounting and management. The planning and construction of the carriages belonged to the Ordnance Bureau, but it was General Totten's task to adapt the platforms and parapets thereto. None but the engineer or artillerist can thoroughly understand the difficulty and complexity of the problems therein involved. To provide a platform which shall support, without the slightest deflexion, the weight, and resist the shock of discharge, while it provides for the training or pointing of the gun, — which is so adapted to the parapet as to allow the maximum horizontal sector of fire and to afford the most perfect cover to the gunners consistent with allowing all the depression demanded by the circumstances of the case, — such are the conditions to be fulfilled, separately, for each calibre of gun. After years of experience, and after our sea-coast ordnance had attained its highest development prior to the introduction of the rifled gun and fifteen-inch columbiad, General Totten embodied his results in a lithographic sheet exhibiting to the eye of the engineer for every kind of gun and for every probable case the particular solution. This single sheet exhibits strikingly the characteristics of the author's mind, — the profound study which he brought to bear on every subject, the scrupulous accuracy

* A barbette gun is one which is fired over a parapet.

of his determinations, which neglected no appreciable magnitude, and the thoroughness and generality of his solutions.

When the embrasure of 1815 was designed, ships' armaments contained no gun heavier than a twenty-four or thirty-two pounder. As the calibres increased it became a matter of doubt whether the five feet thickness of wall immediately about the embrasure was sufficient. At the same time the progress made in the art of forging large masses of iron had suggested that by its use the funnel form of the mouth might be entirely done away with, and the exterior opening reduced to an absolute minimum. Nothing but *experiment* could lead to sound conclusions, and the experiments referred to on a former page were instituted, the principal objects of which were (in General Totten's own language) : —

I. "To ascertain the effects of firing with solid balls, with shells, and with grape and canister, from heavy ordnance at short distances, upon various materials used in the construction of casemate embrasures.

II. "To determine whether these embrasures might have a form that would shut out most of these missiles, and resist for a time the heaviest, without lessening the sector of fire, horizontal and vertical, of the casemate gun.

III. "To determine the degree to which, without injury from the blast of the gun, or lessening its scope of fire, the throat of the embrasure, and also the exterior opening, might be lessened.

IV. "To determine whether all smaller missiles might not be prevented from passing through the throat into the battery; and whether the smoke of the blast might not also be excluded by simple and easily managed shutters."

Targets were constructed, representing the wall of a fortification pierced with its embrasures. All varieties of materials were employed in the walls, and every suggested method of constructing the embrasure was tried. General Totten's report shows that the minutest detail of construction was directed by himself, and that he personally superintended the experiments. They were carried on at intervals during four successive years, the results of each year suggesting the object of experiment for the next.

It would be out of place here to follow the report through its detailed accounts of the firings, or even to attempt to sum up the conclusions arrived at, referring as they do to such a variety of subjects; but those concerning the thickness of the scarp-wall and the use of wrought-iron may be properly quoted as among the most important.

"The general conclusion from these trials is, that, whether of cement concrete, of bricks, or of hard stones, the portion of the wall at and around each embrasure having the thickness of five feet only should be no larger than is indispensable for the adaptation of the gun and carriage to the embrasure; if restricted to a small area, this thickness will suffice, — not otherwise.

"The thickness of five feet will resist a number of these balls, impinging in succession on that space, provided the bond expand promptly above, below, and on each side, into a thickness greater by some two and a half feet or three feet or more. Were the wall no thicker generally than five feet, being reinforced only by piers some fifteen feet apart, it would soon be seriously damaged by battering at short distances."

And in reference to iron it is stated: "First, It may be fairly assumed, that a plate eight inches thick of wrought-iron of good quality, kept in place by a backing of three feet of strong masonry, will stop a solid ball from an eight-inch columbiad, fired with ten and a quarter pounds of powder from the distance of two hundred yards. The plate of iron will be deeply indented at the point of impact, the ball carving for itself a smooth bed of the shape and size of one hemisphere, in which it will be found broken into many pieces easily separable, and it will besides be somewhat bent generally. The masonry behind will be much jarred, and, unless strongly bonded, be considerably displaced; moreover, unless the thickness of three feet is well tied into thicker masses immediately adjacent on the sides and above and below, the general damage will be severe.

"Second, This plate will be much the stronger for being in a single mass, and not made up of several thinner plates. The continuity effected by bolts and rivets of the made-up plates is broken even by weak assaults, so that afterwards the stronger, instead of a joint opposition, finds only a succession of feeble resistances.

"Third, A thickness of two inches is ample for shutters designated to stop the largest grape-shot. With this thickness they will be neither perforated nor deformed by anything less than cannon-balls or shells. These shutters also, for the reason just given, should be made of a single thickness. The firings show the necessity of concealing entirely, even from the smallest iron missile, their hinges and fastenings.

"Fourth, A wrought-iron plate of half an inch in thickness is adequate to protect the outer margins and the offsets of embrasures from injury by grape or canister shot."

These facts established, the effect of the form and dimensions of the embrasures in carrying in the smaller missiles was investigated; the recorded results will enable us to appreciate the force of Montalembert's expression, "murderous funnels," as even its author could not do.

"Suppose a hundred-gun ship to be placed within good canister range of a casemated battery of about the ship's length and height, to the fifty guns of the ship's broadside there would be opposed about twenty-four guns in two tiers in the battery. The ship would fire each gun once in three minutes or ten times in half an hour; the fifty guns would therefore make five hundred discharges within that time.

"With one hundred and fifty-six balls in each thirty-two-pound canister (weighing in all thirty-one and a half pounds) there would be thrown seventy-eight thousand balls in thirty minutes. Supposing one half to miss the fort,— which, considering the size of the object, and the short distance, is a large allowance,—there would still remain the number of thirty-nine thousand balls to strike a surface of (say) six thousand square feet, that is,—

"On each square foot, . . . . $6\frac{1}{2}$ balls.

"Or within the exterior opening of one of the embrasures of our second target, of which the area is 8.9 square feet, there would fall . . . . . . . 58 balls.

"Within the European embrasure above mentioned, having fifty-four square feet of opening,* there would be received in half an hour . . . . . . 351 balls."

And if the ship carried modern eight-inch guns, and fired canister of musket-balls, these figures would be in the three cases fifty-one, four hundred and fifty-three, and two thousand seven hundred and fifty-four. These theoretical conclusions were verified by the experimental firing with grape and canister, and it is thus seen how greatly superior General Totten's embrasure of 1815, which is but little larger

* Reference is made to the embrasure of an European work built within the last twenty-five years.

than that of the second target, is to the European one, and how thoroughly he had, at that early day, mastered the subject. He had indeed perfected the embrasure so far as it could be done with masonry alone.

But the quantity of small missiles which even that embrasure would receive is dangerously great, and would be much diminished if the funnel form of the mouth could be done away with, and the throat reduced to an absolute minimum. This could be accomplished only by the use of iron, and the conclusions I have just quoted furnish the data necessary to its successful application.

The throat (still placed two feet back from the outer face of the wall) being formed of iron plates, it became practicable to cut away the flaring surfaces of masonry, so as to present others parallel or perpendicular to the face of the wall, and by this change of form to exclude all missiles not directed within the limits of the throat itself. Still more completely to accomplish the object, wrought-iron shutters of two inches thickness (as determined by the experiments) were applied, by which, except at the moments of aiming and firing, the embrasure was entirely closed.

Such is the history of the casemated battery and casemate embrasure in the United States. We have seen that the perfection to which they have been brought is due to General Totten, and to General Totten alone. Nor is it to the experiments which I have been describing, laborious, skilful, and thorough as they were, that we may solely attribute such results. We must look back to the time when, a First Lieutenant of Engineers, he saw and aided in the construction of our first casemated fort, and when he, fully appreciating its merits and recognizing the defects which a disregard and want of appreciation of the illustrious projector's own principles had entailed upon it, set himself to the task of enhancing the one and correcting the other.

The ten years which have elapsed since 1855 have witnessed changes in the character of sea-coast and naval artillery, and an increase in the calibres and weight of their projectiles, which no one at that date would have anticipated; hence some doubt may be entertained whether our casemated masonry works are adequate to contend with iron-clad vessels armed with the modern artillery. This is a question which it remains for experiment or experience to decide. It has, as yet, not been demonstrated that a masonry fort, constructed as our more recent works are, will not, armed with the powerful guns now being introduced, endure the contest quite as long as its iron-clad antagonist can protract it.

In this connection it is due to General Totten to say, that he has himself been ever the most strenuous advocate of "big guns," the most urgent instigator of their production. The writer well remembers when, seated with him on the piazza of the officers' quarters at Fort Jackson, our eyes resting on the mighty stream flowing past us, upon the defence of which our thoughts and conversation had been turning, he exclaimed, "We must have a twenty-inch gun." The idea was novel to me at that time, and I exhibited some surprise. He went on to say, that, thoroughly to prevent the passage or attempted passage of an armed steamship, there must be not only danger, but almost a certainty of destruction. "Let us have guns such that (to use his own phrase) 'every shot shall be a bird.'" The invention of armored ships, not then foreseen, has increased the necessity of having such guns as he, on other grounds, so strongly advocated. He expressed the greatest confidence that a gun of the dimensions he named would yet be made and introduced into our batteries, and added the interesting statement, that in his earlier days he had found much difficulty in impressing upon the members of boards on which he had served the necessity of having guns in our harbor defences larger than twenty-four pounders. To the labors and genius of a Rodman we owe the actual invention of the art of constructing fifteen and twenty inch guns; but without the unceasing stimulus of General Totten's known and urged views, it is doubtful whether Rodman's labors would have been called for or sustained.

The preceding pages have been mainly devoted to the illustration of our departed associate's career as an officer and as the Chief Engineer of the United States; before turning our attention to other spheres of his usefulness, it seems fitting to quote from one of his eulogists the following summary of his official characteristics.

"In wielding the influence of his office as Chief Engineer, the prominent traits exhibited by General Totten were strict justice and scrupulous integrity. No sophistry, no blandishments, no arbitrary exercise of superior authority, could turn him in the least from his steadfast adherence to his own sense of duty. Avoiding all useless collisions with his official superiors, showing due respect to their station, he never failed to call their attention to any errors committed by them with respect to the department under his charge; nor did he ever leave them any excuse for wilful wrong-doing by remaining silent; even when he knew that his suggestions would not only be ill-received and of no use, but might be visited by the exercise of those petty vexations which official superiors can employ against those under them who thwart their misdoings.

. . . . .

"The individual traits of General Totten were strongly marked. Powerfully built, of a constitution of the most vigorous stamp, cool, potent, and persevering, of sound judgment and variety of intellectual capacity, Nature seemed to have endowed him for the profession that he had chosen. His attention to the performance of his professional duties amounted to a devotion.

. . . . .

"Whilst steadily adhering to what had been well settled by experience, and withstanding the ill-directed efforts of that class of men, of whom some are to be found in all bodies, who seize upon every novelty and press it into the service of their own crude notions, he was far from rejecting well-reasoned projects of improvement, and encouraged, as his own immediate works show, every step towards real progress. Although not belonging to the class of mere inventors, he had that invaluable faculty to one holding a position of so great public responsibility, of detecting the fallacies with which this class too frequently deceive themselves as well as others."

In 1863, under the law uniting into one the two Corps of Engineers and Topographical Engineers, General Totten was advanced to the full grade of Brigadier-General. A few days before his death the Senate unanimously confirmed his nomination by the President to be "Major-General by brevet, for long, faithful, and eminent services." Never were such distinction and such commendation more fitly bestowed.

Giving the precedence in order to duties most intimately connected with his profession, I now turn to General Totten's important labors in establishing and maintaining our present lighthouse system.

The attention of Congress having been called to the pressing necessity for introducing certain reforms, administrative and executive, into the lighthouse system of the United States, that body, after full discussion of the subject, passed an act (approved March 3, 1851) stipulating that, from and after that date, in all new lighthouses and all lighthouses requiring illuminating apparatus, the lens or Fresnel system should be adopted.

Another chapter of the same act provided for the appointment of a commission to be composed of two officers of engineers of the army, and such civil officers of high scientific attainments as might be under the orders or at the disposition of the treasury department and a junior officer of the navy as secretary, whose duty it should be to inquire into the condition of the lighthouse establishment of the United States, and to make a general detailed report and programme to guide legislation in extending and improving our present system of construction, illumination, inspection, and superintendence.

The board, as constituted by the President, consisted of Commander W. B. Shubrick, General J. G. Totten, Colonel James Kearney, Captain S. F. Dupont, U. S. N., Professor A. Dallas Bache, Superintendent U. S. Coast Survey, and Thornton A Jenkins, U. S. N., as Secretary.

Its labors were directed first to demonstrating the evils, irregularities, and abuses which had crept into the lighthouse service under the management of the Fifth Auditor of the Treasury, (the late venerable and highly respected Stephen Pleasonton,) among which were found to be those arising from defective principles of construction, renovation, and repair of lighthouses, inadequate protection to sites and badly planned and poorly constructed sea-walls. It may readily be understood how the peculiarly practical mind of General Totten, brought to bear upon these and kindred subjects of inquiry, developed and demonstrated the necessity of at once employing proper scientific systems and plans of construction. His assistance in collecting data was found invaluable, and his lucid, clear mind was equally to be trusted in detecting faults and in devising the remedy.

Without entering into a detailed account of the labors of this Board of Inquiry it is sufficient to state that the mass of evidence collected by it was so irresistible in proof of existing errors, that Congress, under date of August 31, 1852, passed an act which created a permanent Lighthouse Board, to which was confided all the duties of the establishment. General Totten was appointed to this board, and served as a valued and honored member, with but a short interruption, until his decease. Its early labors were arduous and onerous. A new system was to be founded where before had been none; — order should come from chaos, error was to vanish before science, economy to succeed to wastefulness, darkness to give place to light. The task, great as it was, fell upon no shrinking hearts or feeble brains. The work was accomplished; and long before his lamented death General Totten had the satisfaction of witnessing the labors of himself and his associates crowned with full success. The board in its deliberations derived great benefit from his presence and participation, and relied with entire assurance upon the correctness of his judgment upon all subjects concerning which he would express an opinion. He served almost continuously as chairman of the Committee of Finance, and the decisions of that committee owe not a little of their sound wisdom to the searching scrutiny joined to the generous and liberal views of its chairman. He was also a member of the Committee on Engineering, in which department his peculiar merit was most conspicuous. The principal works with which his name is associated and which claim our attention, are the lighthouses on Seven-Foot Knoll, near Baltimore, Md., and on Minot's Ledge, off Cohasset, Mass.

The former is an iron pile structure standing in some ten feet of water. It was erected at a time when the science of iron pile construction was in its infancy, and was one of the first works of the kind undertaken by the board. Hence it was a matter of deep interest and solicitude. It was successfully completed, and the lighthouse stands to-day a signal reward for the thought and labor bestowed upon its conception and construction.

The lighthouse at Minot's Ledge was a work of far greater difficulty, and to its proper location and plan General Totten lent the resources of his great experience and exhaustless knowledge. As his intimate acquaintance with the whole coast of the United States, acquired while acting as a member of the Board of Engineers, and during his annual inspections as Chief Engineer, enabled him, with the aid of the Coast Survey, to indicate with almost unerring certainty the proper location and character of all new lighthouses, so his practical knowledge of construction, in laying the foundation of our sea-coast fortifications and the sea-walls by which the sites of many of them had to be protected, prepared him to grapple with the difficulties of constructing a masonry tower in this exposed situation, and to bring to their solution all the known and tried resources of engineering.

Minot's Ledge is situated about twenty miles southeast of Boston. It is the outer rock of a very dangerous group called the "Cohasset Rocks," lying at the very wayside of navigation to the harbor of Boston. A lighthouse of iron had been erected here a few years previous to the organization of the Lighthouse Board, but it was carried away in a fearful storm which swept along the coast of New England on the 16th of April, 1851.

Not only the commercial interests of the country, but humanity demanded that it should be replaced, and Congress promptly made an appropriation for this purpose, stipulating that the tower should be erected on the outer Minot, and confiding its construction to the Topographical Bureau. This bureau, having publicly advertised, received sixteen distinct proposals to erect the proposed structure, but finally recommended, in view of the difficulties to be overcome, and the fearful fate of its predecessor, that it should be located on one of the inner rocks. In accordance with this recommendation, an act of Congress was passed authorizing the Secretary of the Treasury to "select instead of the outer Minot's Ledge, any more suitable site." Before further action had been taken, the whole subject fell into the hands of the newly created Lighthouse Board. A joint resolution of Congress was then passed (1854) giving to this board the decision as to the location and the mode of construction.

The question of location being thus widely reopened, a committee of the board was sent to make a personal examination of the locality. General Totten was, of course, a member of this committee, and was not long in making up his mind that the outer and not the inner Minot was the proper site. His arguments on this subject proved conclusive with the board. He urged that if the light were placed on any of the inner rocks the desired object would be but partially accomplished, since in a dense fog or thick snow-storm vessels might approach within a few hundred feet, without being able to see it, and thus be lost upon the outer ledge.

When the question of practicability was broached, his professional pride seemed to be roused. He argued that, after what had been done on the coast of England in the erection of the Eddystone lighthouse a century ago, and more recently of the Bell-rock and Skerryvore lights, it would be a humiliating admission that the requisite science and skill were not to be found in this country to erect a similar structure where, as all admitted, one was so much needed.

He carefully studied the accounts of the construction of the Eddystone, Bell-rock, and Skerryvore lighthouses, by Smeaton, Robert Stevenson, and Allan Stevenson, but the fact that the Eddystone was begun at high-water mark, that the ledge of the Bell-rock was extensive and elevated several feet above low-water, and that the Skerryvore presented still less difficulties, while the surveys show that the outer Minot's ledge was very contracted and that the proposed structure must commence even below low-water, did not deter him from advocating and designing a work for this formidable position more difficult to accomplish than anything which had ever preceded it.

The plans which he prepared were drawn with his usual minuteness of detail. The problem was one peculiarly fascinating to engineers, — the uniting into a single mass the several component stones of the structure so that no one can be detached from the rest, that each shall be a bond of connection to those adjacent, that the whole shall be an integral, having a strength ample to defy the most powerful foe to human structure, the fury of the ocean's winds and waves. Though not himself the constructor of the work, yet to have insisted against authoritative adverse opinion on its practicability, to have planned the building and selected the engineer who should rear it, and to have overlooked the work from its commencement to its completion, entitles him, even were this his only work, to recognition among the Smeatons and Stevensons and Brunells, as one of the great engineers of the age.

For the execution, he selected Captain (now Brevet Brigadier-General) Barton S. Alexander, of the Corps of Engineers, an officer whose experience, energy, boldness, and self-reliance eminently fitted him for the task. It is for him to recount the history of the work, to give to the world the interesting narrative of difficulties met and overcome, of patience requited and energy triumphant. General Totten watched its progress with unflagging interest, making frequent visits to the superintending engineer, aiding him with his counsels and encouraging him in his difficulties. He lived to enjoy the proud satisfaction of inspecting the finished structure; and when at last from its towering summit flashed o'er the troubled waters the beacon-light of safety to the tempest-tossed mariner, he might well exclaim, with the Latin poet, though in a nobler sense and in a less boastful spirit, — " Exegi monumentum ære perennius."

General (then Colonel) Totten was named in the act of Congress organizing the Smithsonian Institution in 1846 as one of the Regents to whom the business transactions of that celebrated establishment are intrusted. At an early meeting of the Board of Regents he was appointed one of the Executive Committee, and was continued in these offices by repeated election to the time of his death, a period of nearly eighteen years. He evinced a lively interest in the organization of the institution, and after a careful study of the will and character of Smithson, gave his preference to the programme prepared by Professor Henry, which was finally adopted. His advocacy of the plan was the more important since he was well acquainted with the scientific character of James Smithson, and had himself, as we shall see in a subsequent statement, been engaged in a line of research similar to one of those pursued by the founder of this institution.

In the reconstruction of the interior of the main part of the Smithsonian building which had partly been completed in wood, but which had given way, he strongly urged the employment of fire-proof material, to the adoption of which the preservation of the valuable collections of the Institution is indebted. In the discharge of his duty as one of the Executive Committee, he acted with the same conscientious regard to the sacredness of the trust which characterized all his official labors, and critically examined all the accounts, assured himself as to the proper expenditure of the funds, and advised as to the general policy to be pursued. In him the Secretary ever found a firm supporter, a sympathetic friend, and a judicious adviser. Unostentatious, unselfish, and only desiring to advance whatever cause he might be connected with, he gave the most valuable suggestions as if they were of little moment, and in such a way that they might appear to be deductions from what others had said or done, being more anxious that his suggestions should be properly carried out than they should be accredited to himself.

As a recreation from the more arduous studies of his profession, he devoted in the early part of his life his spare hours to Natural History, paying much attention to the Mollusca of the Northern coast of the United States; and he was perhaps, the first, or at least one of the first, to introduce into this country the use of the dredge for the search of these animals, thus not only obtaining many species which would otherwise have escaped attention and getting fresh and unmutilated specimens of species previously known only from dead imperfect shells, but enabling us to learn something of the habits and associations of the animals, — information of much greater scientific value than the discovery of a few new species. His observations and studies in conchology were embodied in an article entitled "Descriptions of some Shells belonging to the Coast of New England," published in the American Journal of Science and Arts for 1834 and 1835, and Dr. A. A. Gould was largely indebted to him for material employed in his "Invertebrata of Massachusetts," many of the species of shells contained in which were first found to inhabit our coast by General Totten; others were new species discovered by him, though described by Dr. Gould, while some nine or ten specimens were not only discovered but described by him. The descriptions of species and remarks evince his powers of observation and critical acumen, and almost all of the forms described have stood the test of subsequent examination, and the validity of their specific distinction been confirmed, although several of them are among the most common shells of the coast; on account of their small size, they had been previously overlooked or neglected, but their insignificance in size did not diminish their interest in the eyes of one who viewed nature in all her manifestations as worthy of contemplation. One of the most beautiful and almost the smallest of the bivalves of our coast, called by him *Venus gemma*, has since been dedicated to him under the name of *Gemma Tottenii* by Mr. William Stimpson.

General Totten collected principally on the shores of New England, and his explorations with the dredge were almost entirely made in the vicinity of Newport, R. I., and of Provincetown, Mass. A list of the shells of Massachusetts was contributed by him to one of the preliminary reports on the Natural History of that State. The principal species described by him are as follows: *Madiola glandula* (now known as *Mytilus decussatus*), *Venus gemma* (*Gemma Tottenii*), *Solemya borealis*, *Bulla oryza*, *Natica immaculata*, *Turbo minutus* (*Kissoa minuta*), *Turritella interrupta* (*Chemnitzia interrupta*), *Acteon trifidus* (*Chemnitzia trifida*,) and *Pasithea nigra*. This last-named species he described from young shells, and afterwards finding the adult shell, which is very different, called it *Cerithium reticulatum.* It has for many years been called *Cerythium Sayi,* but a late author has again credited it to him, under the name of *Brittium nigrum.*

A species of *Succinea* (*S. Totteniana*) was dedicated to General Totten by Mr. Isaac Lea of Philadelphia.

Conchologists are also indebted to General Totten for the discovery of means for the preservation of the epidermis or periostraca of shells, which is in many species so liable to crack, and this recipe has been received with much approbation by many collectors who have found it to supply a want much felt. The valuable collection of rare shells which he made at this period of his life he presented to the Smithsonian Institution, without the usual condition that it should be preserved separately, but to be used most advantageously for the advancement of science to complete the general collection of the Museum, or for distribution as duplicates to other establishments.

In the "Annals of the Lyceum of Natural History of New York" for 1824 (Vol. I. pp. 109–114) he published "Notes on some new Supports for Minerals, subjected to the Action of the Common Blowpipe." These researches on the use and power of the blowpipe appear to have been incited by an article of James Smithson, the subsequent founder of the Smithsonian Institution, and the memoir of Totten commences with a reference to and rehearsal of the experiments of that gentleman, as detailed in a letter to the editor of the Annals of Philosophy. Smithson, it was remarked, had communicated several ingenious modifications of Saussure's process with supports of splinters of sapphire, which process, he observes, "has been scarcely at all employed; owing partly to the excessive difficulty, in general, of making the particles adhere, and in consequence of the almost unpossessed degree of patience required, and of the time consumed by nearly interminable failures." Detailing the processes of Mr. Smithson, three in number, and the success of that gentleman, he adopted a modification of Smithson's third process, having recourse, as a support, to a portion of the mineral itself, which he designed to expose to the action of the flame. "Instead, however, of taking upon the point of platinum wire a very minute portion of the paste made of the powdered mineral," according to Mr. Smithson's method, he "formed a paste by mixing the powder with very thick gum-water and rubbing a little of it under the finger, formed a very acute cone, sometimes nearly an inch in length, and generally about a twentieth of an inch in diameter at the base." To the apex of such cones, the most minute particles would adhere under the strongest blast of the blowpipe, and being insulated by the destruction of continuity of the particles of the cone, the flame could be directed upon it with undiminished fervor. Experiments were made on a number of minerals, confirming those of Mr. Smithson, and greatly extending the power of the blowpipe, and he was thus led to add to the three classes divided in relation to this instrument a fourth, namely, "such as are fusible, *per se*, in microscopical particles."

The attention of the inhabitants near the shores of the great lakes of the North had often been arrested by the sudden disappearance in the spring of the ice on the surface. The lakes would be covered with a continuous sheet of solid ice in the evening, and in the next morning all would have vanished. Wild speculations had been entertained as to the explanation of this phenomenon previous to the investigation of the subject by General Totten, who presented an article on the subject to the American Association for the Advancement of Science at the Springfield meeting in 1859.

From this it appears that his attention had been directed to it forty years before at Plattsburg, N. Y. Ice is composed of a congeries of prismatic crystals, whose axes are at right angles to the surface of the mass. "Examinations then and afterwards made of floating fresh-water ice have shown that the natural effect of the advancing year is gradually to transform ice, solid and apparently homogeneous, into an aggregation of these irregular prismatic crystals, standing in vertical juxtaposition, having few surfaces of contact, but touching rather at points and on edges, and kept in place at last merely by want of room to fall asunder. Until this change has somewhat advanced, the cohesive strength of ice of considerable thickness is still adequate to sustain the weight and shock of the travel it had borne during the winter, but becoming less and less coherent by the growing isolation of the prisms, or more and more 'rotten' as the phrase is, though retaining all its thickness, the ice will at last scarcely support a small weight, though bearing upon a large surface; the foot of man easily breaking through, and very slight resistance being made to the point of a cone." The points of contact of the particles being destroyed, each will drop into the position in the water below required by the place of its own centre of gravity, — that is to say, it will be upon its side, exposing large surfaces to the action of the warm water. With the ice in such condition, a heavy wind will cause the disruption of the particles and the speedy disappearance would be the consequence. This remark of General Totten as to the crystallization of ice has since been extended to nearly all substances, which in becoming solid assume the crystallized form. The axes of the crsytals tend to assume a position at right angles to the surface of cooling.

As illustrative of the mind of General Totten, it may be stated, that he seldom failed to give valuable hints for the improvement of processes or inventions which were brought before him in the course of the discharge of his numerous official duties, — among these was an instrument for ascertaining the daily amount of evaporation from a given surface by means of the descent of water contained in an inverted graduated tube, the open end of which was immersed in the basin from which the evaporation took place. With a slight correction for variation in barometrical pressure, this instrument gives, with more precision than any other with which we are acquainted, the amount of evaporation.

I have, Gentlemen, thus faintly and inadequately sketched the life and services of our departed friend and associate; but, faint and inadequate as my sketch may be, I feel confident that every one will recognize in it the lineaments of a great and true man. Labors so protracted, results so important and varied, it is the destiny of but few to achieve, and for him who achieves them may justly be claimed a high niche in the temple of Fame, and the grateful homage of the patriot and of the seeker after Truth. One of the oldest of the corporators of this Academy, it was permitted him only to contribute his past labors and his shining example. But these are indeed a rich legacy. Proud, indeed, may this youthful institution be that it can enroll among its members the name of JOSEPH GILBERT TOTTEN, — proud, too, may each one whom I now address — each one of its members — be, if he shall achieve but a far less claim to recognition among men of science. To the aged among us, — to those who were young with him, and like him have crowned a life of toil by honorable achievements, — I need not speak. *They* require no example, and they may feel in contemplating his history an additional assurance that their own works too "shall praise them." To the more youthful or to the middle-aged, who have just commenced, or but partially accomplished, the steep ascent which leads to honorable fame, his life is precious in its teachings.

He was a patriot in the broadest and best sense of the term. To his country he had given himself, and every faculty of his being was devoted to her honor and welfare, — realizing almost literally the thought of Rousseau, "the child on entering life ought to see his country, and to the hour of his death to see but her."

Like all who have left lasting results for the benefit of their country or of mankind, he was a hard worker. But ill-regulated labor, however arduous, could never have accomplished what he accomplished. Beyond all men I ever knew, he was *systematic;* and few indeed are the examples of a life, in *all* things, so perfectly regulated. The beautiful *order* which pervaded all that he did is scarcely less worthy of study and admiration than the achievements to which it so materially contributed.

He was no trifler with the realities of life, who dallied with them for his pleasure or who wielded them as instruments of ambition or self-interest. To him as to all true men, the meaning of life was concentrated in one single word, DUTY. This "chief end of man," which is to glorify God by obedience to his laws in the use of the faculties he has bestowed, was his ruling principle, — the celestial cynosure to which his eye was ever directed, and from which no allurement of lower motives could divert it. Nor was his sense of duty of that frigid, repulsive nature which reduces the conduct of life to a formula, and, substituting rules for emotions, seems but a refined selfishness. He was warm and sympathetic, finding his chief happiness in the pleasures of domestic and social intercourse, but singularly susceptible to everything that ministers to innocent enjoyment.

Perhaps no more striking illustration than his history affords could be found of the truth that the path of duty is the path of happiness. His life was eminently a happy one, and his, indeed, was that "peace of mind which passeth understanding." Though devoted from his youth to the military service of his country, and doomed to the vicissitudes of a soldier's lot, he was permitted to a greater degree than most men to enjoy the blessings of the domestic circle. There, indeed, he sat enthroned, the idol of a family of whose supreme affection and immeasurable devotion he was the object. Nor dare we call those blows by which a Heavenly Father reminds us that this world is not our "abiding place," and teaches us to look beyond to "an house not made with hands, eternal in the heavens," as sources of unhappiness to him who receives them as from the hand of One "who chasteneth whom he loveth." One by one he lived to see all his three sons, two of his four daughters, and finally the companion of the joys and sorrows of so many years, precede him to the grave.

Beautiful beyond all else that earth presents is that conjugal companionship, so touchingly depicted by Burns, which, beginning in youth, is permitted to continue unbroken till the Psalmist's period of life is overpassed. During the later years of their lives, Mrs. Totten, no longer bound to the domestic hearth by the cares of a growing family, became truly an inseparable companion. Never, when it was at all practicable to have her with him, did he ride or walk, or make a journey, or perform one of his periodical tours of inspection, without her companionship; nor could one see them together without feeling that they presented a model of whatever is amiable and lovely in the conjugal state. If he was to her the embodiment of all that is most worthy of respect and love in man, not less marked was his deference to her. In her own sphere — as woman, wife, mother — she was supreme, and her judgment his law. When, but two years before his own death, she was somewhat suddenly called away, it seemed as if he regarded it as a message from on high, "set thy house in order, for thou shalt die and not live." No murmur escaped his lips, and no long-continued sadness clouded his brow, but there was an unwonted gentleness and quietude in his demeanor, — a softening as it were of his nature, — which revealed how deeply "the iron had entered his soul." His health and bodily strength seemed to continue little impaired, and his devotion to the duties of his office undiminished. But once, during a life protracted beyond the usual span, had that powerful frame submitted to the sway of sickness, and he seemed to have unusual promise of a still further protracted life. But such promises proved deceitful. Early in March, 1864, he was attacked with pneumonia. His illness was not at first deemed alarming, and, indeed, at one time he was supposed to be convalescent, but a relapse ensued, and on the 22d of April he expired, having borne the sufferings of his sickness with cheerfulness and resignation, and retained to the last the perfect use of all his mental faculties. He had long been a member and communicant of the Episcopal Church, and died in the Christian's hope of a joyful resurrection.

Gentle, kind, and good, mild, modest, and tolerant, wise, sagacious, shrewd, and learned, yet simple and unpretending as a child, he died as he had lived, surrounded by hearts gushing with affection, and the object of the respect and love of all with whom he had ever been associated.

The greatest of sculptors, the greatest of painters, a man unsurpassed in boldness and originality of thought, and whose name is among those of the few whose genius over-passes the limits of country and claims homage from all mankind, — MICHAEL ANGELO, — in a work stamped with the maturity of his powers, carved a figure known to the world as "Il Pensiero," or *Thought.* There exists in art no other personification of meditation, — no other type of self-collectedness and profound thought.

The sculptor arrayed it not as a philosopher, as a monk, as an artist, as a theologian, as a scholar, nor even as a pope. And yet these different types of thinkers were not wanting in the past or present of the age and country of a Raphael, of a Correggio, of a Leonardo da Vinci, of a Dante, of a Savonarola, of a Marco Polo, of a Columbus, of a Machiavelli, of a Galileo, of a St. Francis de Assis, of a St. Thomas Aquinas, of a Julius II., of a Leo X., and of a Clement VII.

How, then, has Michael Angelo arrayed his personified "Thought"? In the garb of a SOLDIER, upon the breast the cuirass, upon the brow, wrapt in meditation, the iron casque of the man of war. The great sculptor has divined the mysterious cause why, among all people, among all classes, and in all epochs, the soldier is honored. Instinct teaches the people, and genius taught Michael Angelo, that among so many glorious examples, among so many immortal victims, so many illustrious martyrs or devotees of thought, illustrating an age or a country, the soldier stands forth pre-eminently, in all ages and in all countries, the victim always ready, the defender always armed, the servant, the apostle, and the martyr.

It is the Christian version of the ancient allegory which made Minerva issue from the brain of Jupiter: Minerva, or *wisdom armed*, the helmet upon her brow, the sword in her hand.

Will the foregoing paragraphs, which I have translated somewhat freely from the "Soldat" of Joachim Ambert, a work devoted to the illustration of the Soldier's career, be deemed an immodest or extravagant glorification of the profession of arms? Far be it from me to exalt unduly that profession, but I would at least make a claim for it, the more necessary since popular apprehension tends to lose sight of the thinker in the man of force and of blood, that, more than any other, it embraces all sciences and all branches of human knowledge, and leads its followers into vast and diverse fields of thought. Let the illustrious dead be our witnesses; that idea which the genius of a Michael Angelo inspired and embodied in marble, that idea which the lives of a Cæsar, a Frederic, a Washington, a Napoleon, and a Wellington have justified; the union of FORCE and THOUGHT finds yet another and a varied illustration in the accomplished soldier and profound thinker whose life and works we now commemorate.

# APPENDIX.

## RESOLUTIONS OF THE LIGHTHOUSE BOARD.

*Resolved*, That the members of the Lighthouse Board feel most deeply the loss sustained by the branch of the public service under their charge in the death of Brevet Major-General Joseph Gilbert Totten, who has been one of the most useful and active members of the Board from its first appointment in pursuance of law in 1851, under the Secretary of the Treasury, as a temporary Board of Inquiry into the Lighthouse Establishment of the United States, through all the years of organization of the establishment and of its executive duties.

*Resolved*, That the high scientific attainments, the admirable administrative qualities, the perfect knowledge of general principles, and attention to every minute detail of the system, impressed the mental and moral qualities of General Totten upon his associates in a way to make his mind eminently a leading one of the Board, while his suavity, patience, perfect amiability, and retiring modesty rendered him one of the most charming of associates in executing work to which he was so much more than sufficient.

*Resolved*, That in the discharge of the duties of inquiry of the first Board, the resulting organization, the adoption of the present system of lighting by lenses, the subject of construction, theoretical and practical, and the use of materials, the experience and experimental knowledge of General Totten were of the highest value to the Board, and his careful application of the sciences were of the greatest importance to the Lighthouse System; and that in the large qualities of common sense in all the transactions of the Board, general as well as technical, and in his high sense of justice directing great mental power, the Board constantly felt the support of General Totten as one to be relied upon for guidance in all difficult questions of administration.

*Resolved*, That the affectionate qualities of General Totten's heart so endeared him to his colleagues, that in now expressing themselves in regard to his death, they are fully prepared to share to the utmost the deep grief of his family, to whom they offer their sincere condolence for the loss of one not to be replaced, but to be ever mourned as the true, devoted, and sincere friend.

*Resolved*, That a copy of these resolutions be transmitted to the family of General Totten, and to the Honorable Secretary of War, and to the Honorable Secretary of the Treasury.

*Resolved*, That these proceedings be published in the Washington newspapers.

# ANNUAL

OF THE

# NATIONAL ACADEMY OF SCIENCES

FOR 1866.

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CAMBRIDGE:
WELCH, BIGELOW, AND COMPANY,
PRINTERS TO THE UNIVERSITY.
1867.

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# CONTENTS.

## I.

# AN ACT

## TO INCORPORATE THE NATIONAL ACADEMY OF SCIENCES.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That Louis Agassiz, Massachusetts; J. H. Alexander, Maryland; S. Alexander, New Jersey; A. D. Bache, at large; F. A. P. Barnard, at large; J. G. Barnard, United States Army, Massachusetts; W. H. C. Bartlett, United States Military Academy, Missouri; U. A. Boyden, Massachusetts; Alexis Caswell, Rhode Island; William Chauvenet, Missouri; J. H. C. Coffin, United States Naval Academy, Maine; J. A. Dahlgren, United States Navy, Pennsylvania; J. D. Dana, Connecticut; Charles H. Davis, United States Navy, Massachusetts; George Engelmann, St. Louis, Missouri; J. F. Frazer, Pennsylvania; Wolcott Gibbs, New York; J. M. Gilliss, United States Navy, Kentucky; A. A. Gould, Massachusetts; B. A. Gould, Massachusetts; Asa Gray, Massachusetts; A. Guyot, New Jersey; James Hall, New York; Joseph Henry, at large; J. E. Hilgard, at large, Illinois; Edward Hitchcock, Massachusetts; J. S. Hubbard, United States Naval Observatory, Connecticut; A. A. Humphreys, United States Army, Pennsylvania J. L. Le Conte, United States Army, Pennsylvania; J

Leidy, Pennsylvania; J. P. Lesley, Pennsylvania; M. F. Longstreth, Pennsylvania; D. H. Mahan, United States Military Academy, Virginia; J. S. Newberry, Ohio; H. A. Newton, Connecticut; Benjamin Peirce, Massachusetts; John Rodgers, United States Navy, Indiana; Fairman Rogers, Pennsylvania; R. E. Rogers, Pennsylvania; W. B. Rogers, Massachusetts; L. M. Rutherfurd, New York; Joseph Saxton, at large; Benjamin Silliman, Connecticut; Benjamin Silliman, Jr., Connecticut; Theodore Strong, New Jersey; John Torrey, New York; J. G. Totten, United States Army, Connecticut; Joseph Winlock, United States Nautical Almanac, Kentucky; Jeffries Wyman, Massachusetts; J. D. Whitney, California, their associates and successors duly chosen, are hereby incorporated, constituted, and declared to be a body corporate, by the name of the National Academy of Sciences.

SECT. 2. *And be it further enacted*, That the National Academy of Sciences shall consist of not more than fifty ordinary members, and the said corporation hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institutions, and to report the same to Congress.

SECT. 3. *And be it further enacted*, That the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated, and the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and re-

ports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

SOLOMON FOOT,
*President of the Senate pro tempore.*

GALUSHA A. GROW,
*Speaker of the House of Representatives.*

Approved March 3, 1863.

ABRAHAM LINCOLN, *President.*

## II.

# CONSTITUTION AND BY-LAWS

## OF THE ACADEMY.

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### PREAMBLE.

Empowered by the Act of Incorporation adopted by Congress, and approved by the President of the United States, on the 3d day of March, A. D. 1863, the National Academy of Sciences do enact the following Constitution and By-Laws.

### ARTICLE I.

*Of Members.*

Section 1. The members of the Academy shall be designated as Members, Honorary Members, and Foreign Associates.

Sect. 2. The Academy shall consist of the fifty members named in the Act of Incorporation, and of such others, citizens of the United States, as shall from time to time be elected to fill vacancies, in the manner hereinafter provided.

Sect. 3. Every member shall, upon his admission, take the oath of allegiance prescribed by the Senate of the United States for its own members; and, in addition thereto, an oath faithfully to discharge the duties of a member of

the National Academy of Sciences to the best of his ability. He shall also subscribe the laws of the Academy.

SECT. 4. The members of the Academy shall be arranged in two Classes, according to their special studies, viz.: A, the Class of Mathematics and Physics, and B, the Class of Natural History. The corporate members may select the Class in which they desire to be arranged.

SECT. 5.* The members of the Classes shall arrange themselves in Sections, by inscribing their names under one of the following heads: — CLASS A. *Mathematics and Physics.* Sections: 1. Mathematics; 2. Physics; 3. Astronomy, Geography, and Geodesy; 4. Mechanics; 5. Chemistry and Mineralogy. CLASS B. *Natural History.* Sections: 1. Geology and Palæontology; 2. Zoölogy; 3. Botany; 4. Anatomy and Physiology; 5. Ethnology and Philology.

But the Academy retains the power of transferring a member from one Section to another by a unanimous vote.

SECT. 6.† A member of any Section may be elected a member of any one other Section by a vote of a majority of the members thereof present, subject to the approval of the Academy, but shall thereby acquire no new right of voting as a member of a Class.

The Academy may also, by a vote of three fourths of the members present, appoint a member of any Section a member of any one other Section which is unable to elect for itself. Such member shall acquire no new right of voting as a member of a Class.

SECT. 7. The Academy may elect fifty Foreign Associates, who shall have the privilege of attending the meetings of the Academy, and of reading and communicating

* Amended January 4, 1865; January 24, 1866, and January 24, 1867.

† Amended August 25, 1865.

papers to it, but shall take no part in its business, and shall not be subject to its assessments.

They shall be entitled to a copy of the publications of the Academy.

## ARTICLE II.

### *Of the Officers.*

SECT. 1.* The officers of the Academy shall be a President, a Vice-President, a Foreign Secretary, a Home Secretary, and a Treasurer, all of whom shall be elected, for a term of six years, by a majority of votes present at the first stated session after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for six years shall be held in the same manner at the session when such vacancy occurs, or at the next stated session thereafter, as the Academy may direct.

SECT. 2. The officers of the Classes shall be a Chairman and a Secretary, who shall be elected at each January session. The nominations shall be open, and a majority of votes shall be necessary to elect.

SECT. 3. The officers of the Academy and the Chairmen of the Classes, together with four members, two from each Class, to be annually elected by the Academy, at the January session, by a plurality of the votes, shall constitute a Council for the transaction of such business as may be assigned to them by the Constitution or the Academy.

SECT. 4. The President of the Academy, or, in case of his absence or inability to act, the Vice-President, shall preside at the meetings of the Academy and of the Council; shall name all committees, except such as are otherwise

* Amended January 24, 1866.

especially provided for; refer investigations required by the Government of the United States to members specially conversant with the subject, and report thereon to the Academy at its next January session; and, with the Council, shall direct the general business of the Academy.

It shall be competent for the President, in special cases, to call in the aid, upon committees, of experts, or men of remarkable attainments, not members of the Academy.

SECT. 5. The Foreign and Home Secretaries shall conduct the correspondence proper to their respective departments, advising with the President and Council in cases of doubt, and reporting their action to the Academy at its January session. It shall be the duty of the Home Secretary to give notice to the members of the place and time of all meetings, and to make known to the Council all vacancies in the list of members.

The minutes of each session shall be duly engrossed before the next stated session, under the direction of the Home Secretary.

SECT. 6. The Treasurer shall attend to all receipts and disbursements of the Academy, giving such bond, and furnishing such vouchers, as the Council may require. He shall collect all dues from members, and keep a set of books, showing a full account of receipts and disbursements. He shall present at each stated session a list of the members entitled to vote, and a general report at the January session. He shall be the custodian of the corporate seal of the Academy.

## ARTICLE III.

### *Of the Meetings.*

SECT. 1.* The Academy shall hold two stated sessions in each year, — one in the city of Washington, on the Wednesday next succeeding the third Sunday of January, and one in August, at such time and place as the Academy shall have determined upon, in private meeting, on the last day of the preceding January session.

SECT. 2. The names of the members present at each daily meeting shall be recorded in the minutes; and the members present at any meeting shall constitute a quorum for the transaction of business.

SECT. 3. Scientific meetings of the Academy, unless otherwise ordered by a majority of the members present, shall be open to the public; those for the transaction of business closed.

SECT. 4. The Academy may divide into classes for scientific or other business. In like manner the Classes may divide into Sections.

SECT. 5. The Classes shall meet during such periods of the stated sessions of the Academy as may be fixed by the Academy. Special meetings of a Class may be called by the Council at the request of five members of the Class.

SECT. 6. The stated meetings of the Council shall be held at the times of the stated or special meetings of the Academy. Special meetings shall be convened at the call of the President and two members of the Council, or of four members of the Council.

SECT. 7. No member who has not paid his dues shall take part in the business of the Academy.

* Amended August 25, 1865.

## ARTICLE IV.

*Of Elections, Resignations, and Expulsions.*

SECT. 1. All elections shall be by ballot, unless otherwise ordered by this Constitution; and each election shall be held separately.

SECT. 2. Whenever any election is to be held, the presiding officer shall name a Committee to conduct it, to collect the votes, count them, and report the result to the Academy. The same law shall apply in the Classes.

SECT. 3. Nominations for officers shall be made at the close of the first daily meeting of a stated session; and no candidate shall be voted for unless thus nominated.

SECT. 4.* For election of members, the Council shall first decide the Class in which the vacancy shall be filled. Each Section of that Class may then select one or more candidates, after a discussion of their qualifications, and present their claims to the Class, who shall select three to be presented, in the order of their preference, to the Academy; from these three the Academy shall elect by a majority of the members present. But no election shall take place at the same session at which the presentation to the Academy is made. The member elect shall be assigned to the Section in which he has been proposed. The Academy may nominate candidates in any Section which fails to propose them for itself, provided that it shall first be decided by a vote of two thirds that such nomination is proper and advisable.

SECT. 5. Every member elect shall accept his membership, personally or in writing, before the close of the next stated session after the date of his election. Otherwise, on proof that the Secretary has formally notified him of his

* Amended August 25, 1865, and January 23, 1867.

election, his name shall not be entered on the roll of members.

SECT. 6. Elections of Foreign Associates shall be conducted as follows: —

Each Section shall report to its class, nominating a candidate whose special researches need not belong within the province of the Section, but must be comprised within the range of the Class.

From these candidates each Class shall select one name to be presented to the Academy, and from these two names the Academy, after full discussion, shall make the election, at such time as it may have previously appointed for the purpose.

SECT. 7. A diploma, with the corporate seal of the Academy and the signatures of the officers, shall be sent by the appropriate Secretary to each member on his acceptance of his membership.

SECT. 8. Resignations shall be addressed to the President and acted on by the Academy. No resignation of membership shall be accepted unless all dues have been paid.

SECT. 9. Members resigning in good standing will retain an honorary membership; being admitted to the meetings of the Academy, but without taking part in the business. Honorary members will not be liable to assessment.

SECT. 10.* If any member be absent from four consecutive stated sessions of the Academy, without communicating to the Academy a valid reason for his absence, his name shall be removed from the roll of members, but may at any time, upon a written request by the member, be inserted by a vote of two thirds of the Academy in the list of honorary members.

* Amended January 23, 1867.

SECT. 11. Members and officers habitually neglecting their duties shall be impeached by the Council, and at once notified thereof in writing by the Home Secretary.

SECT. 12. Impeachments of members or officers shall first be tried before the Council; which may be convened specially for such purpose. If it decides that the impeachment is proper, such impeachment shall be tried in private session before the Academy at its next stated meeting.

SECT. 13. The expulsion of a member shall be formally and publicly announced by the President at the stated session during which such expulsion shall take place.

## ARTICLE V.

*Of Scientific Communications, Publications, and Reports.*

SECT. 1. Papers on scientific subjects may be read at the meeting of the Academy or of the Classes or Sections to which the subject belongs.

SECT. 2. Any member of the Academy may read a paper from a person who is not a member; and shall not be considered responsible for the facts or opinions expressed by the author, but shall be held responsible for the propriety of the paper.

SECT. 3. The Academy shall provide for the publication, under the direction of the Council, of Proceedings, Memoirs, and Reports.

SECT. 4. Propositions for investigations or reports shall originate with the Classes to which the subjects belong, and be by them submitted to the Academy for approval; except requests from the Government of the United States, which shall be acted on by the President, who will in such cases report, if necessary, at once to the Government, and to the Academy at its next stated session.

SECT. 5. The judgment of the Academy shall be at all times at the disposition of the Government, upon any matter of Science or Art within the limits of the subjects embraced by it.

SECT. 6. An annual Report to be presented to Congress shall be prepared by the President, and before its presentation submitted by him, first to the Council, and afterwards to the Academy at its January meeting.

SECT. 7. Medals and Prizes may be established, and the means of bestowing them accepted, by the Academy, upon the recommendation of the Council; by whom all the necessary arrangements for their establishment and award shall be made.

## ARTICLE VI.

*Of the Property of the Academy.*

SECT. 1. All investments shall be made by the Treasurer, in the corporate name of the Academy, in stocks of the United States.

SECT. 2. No contract shall be binding upon the Academy which has not been first approved by the Council.

SECT. 3. The assessments required for the support of the Academy shall be fixed by the Academy on the recommendation of the Council.

## ARTICLE VII.

*Of Additions and Amendments.*

Additions and Amendments to the Constitution shall be made only at a stated session of the Academy. Notice of a proposition for such a change may be given at any stated session, and shall be referred to the Council, which may amend the proposition, and shall report thereon to the Academy at its next stated session, with a recommendation that it be accepted or rejected. Its report shall be considered by the Academy in Committee of the Whole, and immediately thereafter acted on. If the addition or amendment receive two thirds of the votes present, it shall be declared adopted, and shall have the same force as the original law.

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## EXPLANATORY CLAUSE.

In consequence of differences of opinion in relation to the interpretation of Section 4 of Article IV. of the Constitution of the Academy, the following resolution was passed August 5, 1864: —

"*Resolved*, That the Academy is of opinion that Section 4 of Article IV. of the Constitution is to be interpreted to mean, that any Section of either Class making a nomination shall be restricted in the choice to persons eminent in the branch or branches of science understood to be included in the title of the Section."

# BY-LAWS.

### OF THE OFFICERS.

I. In the absence of the Chairman or Secretary of a Class, a member shall be chosen to perform his duties temporarily, by a plurality of the *viva voce* votes, upon open nomination.

II. The accounts of the Treasurer shall be referred to an Auditing Committee of three members, to be appointed by the Academy at the meeting at which the accounts are presented; which committee shall report before the close of that session, and shall then be discharged.

### OF THE MEETINGS.

III. A Committee of Arrangements for each stated session of the Academy, of five members, shall be appointed by the President, the Class Secretaries to be *ex officio* two of the members of the Committee. This Committee shall meet not less than two weeks previous to each session. It shall be in session during the meetings to make arrangements for the reception of the members; to arrange the business of each day; to receive the titles of papers, reports, etc.; and to arrange the order of reading, and in general to attend to all business and scientific arrangements.

IV. At the meetings the order of business shall be as follows: —

1. Chair taken by the President, or, in his absence, the Vice-President.
2. Roll of members called by Home Secretary.
3. Report by Treasurer of members entitled to vote.
4. Minutes of the preceding meeting read and approved.
5. Stated business.
6. Reports of President, Secretaries, Treasurer, Classes, and Committees.
7. Business from Council.
8. Other business.
9. Communications from members.
10. Communications from persons not members.
11. Announcements of the death of members. Biographical notices read.
12. Rough minutes read for correction.

V. The rules of order of the Academy shall be those of the Senate of the United States, unless otherwise directed.

VI. It shall be in order for twelve members to require that any matter of business be discussed in Committee of the Whole, for amendment; the vote upon amendments to be taken in the whole Academy; and the amended proposition or propositions to be similarly voted on.

VII. The scientific meetings shall be convened at twelve o'clock M. in winter, and ten A. M. in summer, in order to allow time for the business meetings of the Academy, and for the meetings of Classes, Sections, and Committees.

## OF ELECTIONS AND OBITUARIES.

VIII. No more than ten Foreign Associates shall be elected at any one stated session.

IX. The death of members shall be announced by the President on the last day of each stated session, when a

member shall be selected by the Academy to furnish a biographical notice of the deceased at the next stated session. If such notice be not then furnished, another member shall be selected by the Academy in place of the first, and so on until the duty is performed.

X. The deaths of such eminent scientific men of the country as have taken place since the last session of the Academy shall be announced by the President. The names shall be selected by the Council.

XI. All discussions as to the claims and qualifications of candidates, whether at meetings of the Sections, the Classes, or the Academy, will be held strictly confidential, and remarks and criticisms then made may be communicated to no person who was not a member of the Academy at the time of the discussion.

## ON SCIENTIFIC COMMUNICATIONS, PUBLICATIONS, AND REPORTS.

XII. An analysis of the memoirs and reports read in the meetings of the Classes shall be given by the Secretaries of the Classes to the Home Secretary for publication in the proceedings of the Academy. For any failure in this duty, the delinquent officer shall be impeached by the Home Secretary.

XIII. The Secretaries shall receive memoirs at any time, and report the date of their reception at the next session. But no memoir shall be published unless it has been read before the Academy, Class, or Section, and ordered to be published by the Academy. Papers shall be published in the order in which they were registered, but papers which have not been sent to the Secretary within a month from the time of their reading shall not be published without a special vote of the Academy.

XIV. Memoirs shall date in the records of the Academy from the date of their presentation to the Academy, and the order of their presentation shall be that on which they were registered, unless changed by consent of the author.

XV. The publication of any communication to which objection is made by the Section to which the subject belongs shall be suspended until a second time authorized by a vote of the Academy.

XVI. Papers from persons not members, read before the Academy, Classes, or Sections, and intended for publication, shall be referred, at the meeting at which they are read, to a Committee of members competent to judge whether the paper is worthy of publication. Such Committee shall report to the Academy as early as practicable, and not later than the next stated session. If they do not then report, they shall be discharged, and the paper referred to another Committee.

XVII. Abstracts of papers published in the transactions of other societies or in journals may be communicated orally to the Academy; and if, on submitting any such communication to a Committee, its publication be approved, it may be ordered for publication on a vote of the Academy.

XVIII. Short communications or abstracts of memoirs may be sent by any member to the Home Secretary, who shall, if requested by the author, without delay circulate them among the members.

XIX. An Annual of the Academy shall be prepared by the Secretaries, and published on the first day of each year.

XX. The printing of the Academy shall be under the charge of the Secretaries and the Treasurer, as a Committee of Publication, who shall report in relation thereto at each January meeting of the Academy.

XXI. The Annual Report of the Academy may be accompanied by a memorial to Congress in regard to such investigations and other subjects as may be deemed advisable, recommending appropriations therefor when necessary.

XXII. The Home Secretary shall present to the Council estimates for books and stationery, binding, &c., required for the use of the Academy.

## OF THE PROPERTY OF THE ACADEMY.

XXIII. The proper Secretary shall acknowledge all donations made to the Academy, and shall report them at the next stated session: —

XXIV. The books, apparatus, archives, and other property of the Academy shall be deposited in some safe place in the city of Washington. A list of the articles deposited shall be kept by the Home Secretary, who is authorized to employ a clerk to take charge of them.

XXV. A stamp corresponding to the corporate seal of the Academy shall be kept by the Secretaries, who shall be responsible for the due marking of all books and other objects to which it is applicable.

Labels or other proper marks, of similar device, shall be placed upon objects not admitting of the stamp.

## CHANGES IN THE BY-LAWS.

XXVI. Any By-Law of the Academy may be amended or repealed on the written motion of any two members, signed by them, and presented at a stated session of the Academy; provided the same shall be approved by a majority of the members present at the next stated session.

# III.

## ORGANIZATION OF THE ACADEMY.

1866.

ALEXANDER DALLAS BACHE, *President.*
JOSEPH HENRY, *Vice-President.*
LOUIS AGASSIZ, *Foreign Secretary.*
WOLCOTT GIBBS, *Home Secretary.*
FAIRMAN ROGERS, *Treasurer.*

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### COUNCIL FOR 1866.

The Officers of the Academy and the Chairmen of the Classes *ex officio.*

BENJ. A. GOULD.
J. L. LE CONTE.
M. C. MEIGS.
W. D. WHITNEY.

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## OFFICERS OF THE CLASSES.

1866.

### CLASS OF MATHEMATICS AND PHYSICS.

BENJAMIN PEIRCE, *Chairman.*
J. E. HILGARD, *Secretary.*

### CLASS OF NATURAL HISTORY.

LOUIS AGASSIZ, *Chairman.*
SPENCER F. BAIRD, *Secretary.*

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## SECTIONS.*

### CLASS OF MATHEMATICS AND PHYSICS.

#### SECTION I. *Mathematics.*

J. G. BARNARD. WILLIAM CHAUVENET.
H. A. NEWTON. BENJAMIN PEIRCE.
THEODORE STRONG. JOSEPH WINLOCK.
And under Art. I., Sect. 6,
BENJ. A. GOULD. J. H. C. COFFIN.

#### SECTION II. *Physics.*

F. A. P. BARNARD. W. H. C. BARTLETT.
JOSEPH HENRY. A. A. HUMPHREYS.
OGDEN N. ROOD.
And under Art. I., Sect. 6,
WOLCOTT GIBBS.

#### SECTION III. *Astronomy, Geography, and Geodesy.*

STEPHEN ALEXANDER. ALEXIS CASWELL.
J. H. C. COFFIN. CHARLES H. DAVIS.
ARNOLD GUYOT. BENJ. A. GOULD.
JOHN RODGERS. LEWIS M. RUTHERFURD.
And under Art. I., Sect. 6,
WILLIAM CHAUVENET. JOSEPH WINLOCK.
HUBERT A. NEWTON.

* At date of publication of the Annual, April, 1867.

### Section IV. *Mechanics.*

J. E. Hilgard.
D. H. Mahan.
Fairman Rogers.
Joseph Saxton.
J. F. Frazer.
Montgomery C. Meigs.

And under Art. I., Sect. 6,

Benjamin Peirce.
J. G. Barnard.
Joseph Henry.
F. A. P. Barnard.

### Section V. *Chemistry and Mineralogy.*

Wolcott Gibbs.
Benjamin Silliman, Jr.
Samuel W. Johnson.

## CLASS OF NATURAL HISTORY.

### Section I. *Geology and Palæontology.*

J. P. Lesley.
Leo Lesquereux.
James Hall.
J. S. Newberry.
J. D. Whitney.

And under Art. I., Sect. 6,

Arnold Guyot.

### Section II. *Zoölogy.*

Louis Agassiz.
James D. Dana.
Spencer F. Baird.
Alexander E. R. Agassiz.
Jared P. Kirtland.
John L. Le Conte.

### Section III. *Botany.*

George Engelmann.
John Torrey.

And under Art. I., Sect. 6,

Leo Lesquereux.

SECTION IV. *Anatomy and Physiology.*

S. WEIR MITCHELL. JOHN C. DALTON.

SECTION V. *Ethnology and Philology.*

WM. D. WHITNEY. GEO. P. MARSH.

# IV.

## COMMITTEES OF THE ACADEMY.

### I.

*Committee on Weights, Measures, and Coinage.*

(Appointed May 4, 1863, at the request of the Hon. S. P. Chase, Secretary of the Treasury of the United States, dated April 24, 1863.)

JOSEPH HENRY, *Chairman.*

J. H. ALEXANDER. ARNOLD GUYOT.
FAIRMAN ROGERS. BENJAMIN SILLIMAN, JR.
WOLCOTT GIBBS. WM. CHAUVENET.

JOHN TORREY.

A. D. BACHE. (By resolution of the Academy.)
JOHN RODGERS. (Jan. 5, 1864.)
L. M. RUTHERFURD. (Jan 5, 1864.)

And by authority of Art. II., Sect. 4,
SAMUEL B. RUGGLES.

Mr. Henry, Chairman of the Committee on Weights, Measures, and Coinage, reported to the Academy on behalf of the Committee, January 9, 1864, and offered the following resolution, which was adopted: —

*Resolved,* That the Committee on Weights, Measures, and Coinage have leave to continue their labors and business now in progress, with power.

The Committee presented a final report January 27, 1866. The report was adopted, a copy ordered to be transmitted to the Secretary of the Treasury, and the Committee discharged.

## II.

### *A Committee on the Expansion of Steam.*

February 29, 1864. The Hon. Gideon Welles, Secretary of the Navy, invited the appointment of a committee of three members of the Academy, to act jointly with three members named by the Department and with three members of the Franklin Institute of Pennsylvania for the promotion of the Mechanic Arts, to conduct, witness, and report upon experiments which may be agreed upon by the Commission on the Expansion of Steam. The experiments are to be reported as early as practicable to the Department, and to be submitted also to the National Academy of Sciences for its judgment and suggestions.

March 10. The Committee of the Academy was appointed, to consist of

FAIRMAN ROGERS. F. A. P. BARNARD.
JOSEPH SAXTON.

[The Navy Department named as its members of the joint Commission,

HORATIO ALLEN, *Chairman.*
C. H. DAVIS, B. F. ISHERWOOD.

The Franklin Institute named as its members of the joint Commission,

J. H. TOWNE. J. V. MERRICK.
R. A. TILGHMAN.]

The joint Commission reported, January 26, 1866, that the experiments are still going on in New York, but that, owing to the great number of trials necessary to eliminate practical sources of error, the report of the Commission is not yet completed.

### III.

*A Committee on the Practicability and best Means of Improving the Navigation of the River and Reclaiming the Harbor of San Juan del Norte, Nicaragua.*

(Appointed August 10, 1866, at the request of the Minister of the Republic of Nicaragua through the State Department.)

A. A. HUMPHREYS, *Chairman.*
C. H. DAVIS. J. E. HILGARD.

And under Art. II., Sect. 4,
HENRY MITCHELL.

The Committee reported to the Academy January 26. The report was adopted, and a copy transmitted to the Secretary of State.

### IV.

*A Committee on the Galvanic Action from the Association of Zinc and Iron.*

(Appointed January 8, 1867, at the request of the Quartermaster-General.)

JOSEPH HENRY, *Chairman.*
J. H. C. COFFIN. JOSEPH SAXTON.

The Committee reported January 24, 1867. The report was adopted, and a copy transmitted to the Secretary of War. At the request of the Secretary the Committee was continued and requested to report upon the best material for constructing head-blocks for marking soldiers' graves.

## V.

*A Committee to investigate and report upon the Subject of Magnetic Deviations in Iron Ships.*

(Appointed May 20, 1863, at the request of the Navy Department.)

CHARLES HENRY DAVIS, *Chairman.*

JOSEPH HENRY. BENJ. PEIRCE.
WOLCOTT GIBBS. FAIRMAN ROGERS.
J. E. HILGARD. JOHN RODGERS.

And by authority of Art. II., Sect. 8,
WM. P. TROWBRIDGE.

The Committee reported January 7, 1864. The report was adopted and the Committee continued. January 26, 1866, the Committee reported further, that a number of compasses upon national vessels had been corrected and investigations made. On motion, the Committee was continued.

## VI.

*A Committee on Testing and Estimating the Strength of Distilled Spirits.*

(Appointed, at the request of the Secretary of the Treasury, February 7, 1866.)

JOSEPH HENRY, *Chairman.*
J. E. HILGARD.
M. C. MEIGS.
JOSEPH SAXTON.
F. A. P. BARNARD.
JOHN TORREY.

F. A. P. Barnard and John Torrey were appointed a subcommittee to make a series of special investigations. The Committee reported January 26, 1867. The report was adopted, and a copy transmitted to the Secretary of the Treasury.

## V.

## MEMBERS OF THE ACADEMY.

| | |
|---|---|
| Agassiz, Louis, | Cambridge, Mass. |
| Agassiz, Alexander E. R., | Cambridge, Mass. |
| Alexander, Stephen, | Princeton, N. J. |
| Barnard, Frederick A. P., | New York, N. Y. |
| Barnard, John G., | U. S. A., Washington, D. C. |
| Bartlett, Wm. H. C., | U. S. A., West Point, N. Y. |
| Baird, Spencer F., | Washington, D. C. |
| Caswell, Alexis, | Providence, R. I. |
| Chauvenet, William, | St. Louis, Mo. |
| Coffin, John H. C., | U. S. N., Washington, D. C. |
| Dalton, John Call, | New York, N. Y. |
| Dana, James Dwight, | New Haven, Conn. |
| Davis, Charles Henry, | U. S. N., Washington, D. C. |
| Engelmann, George, | St. Louis, Mo. |
| Frazer, John Fries, | Philadelphia, Penn. |
| Gibbs, Wolcott, | Cambridge, Mass. |
| Gould, Benjamin Apthorp, | Cambridge, Mass. |
| Guyot, Arnold, | Princeton, N. J. |
| Hall, James, | Albany, N. Y. |
| Henry, Joseph, | Washington, D. C. |
| Hilgard, Julius E., | Washington, D. C. |
| Humphreys, Andrew A., | U. S. A., Washington, D. C. |
| Johnson, Samuel W., | New Haven, Conn. |
| Kirtland, Jared P., | Cleveland, Ohio. |
| Le Conte, John L., | Philadelphia, Penn. |
| Lesley, J. Peter, | Philadelphia, Penn. |

| | |
|---|---|
| Lesquereux, Leo, | Columbus, Ohio. |
| Mahan, Dennis H., | U. S. A., West Point, N. Y. |
| Marsh, George P., | Burlington, Vt. |
| Meigs, Montgomery C., | Washington, D. C. |
| Mitchell, S. Weir, | Philadelphia, Penn. |
| Newberry, John Strong, | New York, N. Y. |
| Newton, Hubert A., | New Haven, Conn. |
| Peirce, Benjamin, | Cambridge, Mass. |
| Rodgers, John, | U. S. N., Charlestown, Mass. |
| Rogers, Fairman, | Philadelphia, Penn. |
| Rood, Ogden N., | New York, N. Y. |
| Rutherfurd, Lewis Morris, | New York, N. Y. |
| Saxton, Joseph, | Washington, D. C. |
| Silliman, Benjamin, | New Haven, Conn. |
| Strong, Theodore, | New Brunswick, N. J. |
| Torrey, John, | New York, N. Y. |
| Whitney, Josiah Dwight, | San Francisco, Cal. |
| Whitney, Wm. Dwight, | New Haven, Conn. |
| Winlock, Joseph, | Cambridge, Mass. |

HONORARY MEMBERS (Sect. 9, Art. 4).

| | |
|---|---|
| Wyman, Jeffries, | Cambridge, Mass. |
| Leidy, Joseph, | Philadelphia, Penn. |
| Longstreth, Fisher Miers, | Darby, Penn. |
| Gray, Asa, | Cambridge, Mass. |

Of the fifty members originally appointed by Act of Congress, eight have died since the first Session of the Academy, namely, Joseph S. Hubbard, Joseph G. Totten, Edward Hitchcock, Benjamin Silliman, Sr., James M. Gilliss, Augustus A. Gould, Alexander Dallas Bache, and John Henry Alexander.

## VI.

## FOREIGN ASSOCIATES.

Sir Wm. Rowan Hamilton.*
Karl Ernst von Baer.
Michael Faraday.
L. Elie de Beaumont.
Sir David Brewster.
G. A. A. Plana.*
Robert Bunsen.
F. W. A. Argelander.
Michel Chasles.
Henri Milne-Edwards.
Alexander Braun.
George B. Airy.
Richard Owen.
Friedrich Wöhler.
Sir Roderick I. Murchison.
Victor Regnault.
Joachim Barrande.
Heinrich Wilhelm Dove.
C. H. C. Burmeister.
C. A. F. Peters.
Justus von Liebig.

* Since deceased.

VII.

# ANNUAL REPORT OF THE PRESIDENT

FOR 1866.

# ANNUAL REPORT.

WASHINGTON, D. C., March 19, 1866.

SIR: In conformity with the requirements of the act of incorporation, approved March 4, 1863, I have the honor to submit herewith a report of the operations of the National Academy of Sciences during the past year.

Very respectfully,

JOSEPH HENRY,
*Vice-President National Academy of Sciences.*

HON. SCHUYLER COLFAX, *Speaker of the House of Representatives.*

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NATIONAL ACADEMY OF SCIENCES,
Washington, D. C., March 19, 1866.

SIR: In accordance with the requirements of the Constitution of the National Academy of Sciences, (Article V., Section 6,) the following report of the proceedings and labors of the Academy during the year 1865 is respectfully submitted to Congress.

Since the presentation of the last Annual Report, (February 13, 1865,) no new subjects of investigation have been presented to the Academy by the departments of the government of the United States, and consequently no new Committees have been appointed.

The Committee on Weights, Measures, and Coinage, appointed May 4, 1863, at the request of the Hon. S. P. Chase, Secretary of the Treasury of the United States, were instructed by the Academy, at its session in August last, to present a report at the January session of 1866. The report, although belonging to the business of the year 1866, is hereto appended. (See Appendix A.)

On the 29th of February, 1864, a communication was received from the Hon. Gideon Welles, Secretary of the Navy, inviting the appointment of a committee of three members of the Academy, to act jointly with three members named by the Department, and with three members of the Franklin Institute of Pennsylvania for the Promotion of the Mechanic Arts, to conduct, witness, and report upon experiments which may be agreed upon by the Committee on the Expansion of Steam. The experiments are to be reported as early as practicable to the Navy Department, and to be submitted also to the National Academy of Sciences for its judgment and suggestions.

The President of the Academy appointed a Committee consisting of the following members: —

Fairman Rogers, F. A. P. Barnard,
Joseph Saxton.

The Navy Department named as members of the joint Commission, —

Horatio Allen, *Chairman.*

Charles H. Davis, *Rear-Admiral United States Navy.*

B. F. Isherwood, *Chief of Bureau of Steam Engineering.*

The Franklin Institute named as members of the joint Commission, —

J. H. Towne, I. V. Merrick,
R. A. Tilghman.

On the 5th of January, 1865, the Committee of the Academy, through Mr. Saxton, reported progress. The Committee has not yet presented a report, but the experiments have been conducted during the past year at great expense of time and labor, and it cannot be doubted that the results will be of much practical value. It is particularly desirable that the subject should be investigated with the greatest care and thoroughness, and that the conclusions drawn should be based upon a large and extensive range of experiments.

On the 8th of May, 1863, at the request of the Navy Department, a Committee was appointed to investigate and report upon the subject of Magnetic Deviation in Iron Ships. This Committee consisted of the following members: —

A. D. Bache, *Chairman*,
Joseph Henry,
Wolcott Gibbs,
Benjamin Peirce,
Charles H. Davis,
Fairman Rogers,

And by authority of Art. I., Sect. 8,

W. P. Trowbridge.

This Committee presented a report to the Academy January 7, 1864, when, on motion, the report, with the accompanying documents, was accepted, and the Committee continued. (See Annual Report of President, 1863, pages 23–96.)

A copy of the report was forwarded to the Navy Department February 11, 1864.

At the last session of the Academy, held January 24, 1866, Mr. F. Rogers reported, from the Committee on Magnetic Deviations, that its labors are still continued, and that the compasses of a number of national vessels have been corrected and investigations made. Also, that, at the request of the members, Admiral Davis had been appointed Chairman in place of Mr. Bache, who has been unable to serve on account of illness, and Com. John Rodgers and Mr. J. E. Hilgard had been added to the Committee. On motion, the Committee was continued, and requested to report, if possible, at the next session of the Academy.

Since the presentation of the last report, the Annual of the National Academy for the year 1865 has been prepared and published; copies of this, in accordance with a formal vote of the Academy, have been distributed to the members of both houses of Congress, and also to the heads of the departments and bureaus under the government of the United States.

At the two sessions of the Academy held during the year 1865 thirty-three original communications were read. The following are the titles of these communications: —

1. On a Chronograph for Measuring the Velocity of Projectiles, by J. E. Hilgard.

2. On the Homologies and Classification of the Cephalopods, by L. Agassiz.

3. On the Geographical Distribution of North American Birds, by S. F. Baird.

4. Note on the Changes that have taken place in the Bar of Charleston Harbor since the Sinking of Obstructions in the Main Channel, as developed by the United States Coast Survey, by J. E. Hilgard.

5. On the Tables of the Moon, by Benjamin Peirce.

6. On the Metamorphoses of some Malacopterygians, by L. Agassiz.

7. On Chemical Classification, by Wolcott Gibbs.

8. On the Dimensions and Proportions of American Soldiers, by B. A. Gould.

9. On a Method of Exhibiting certain Statistics of Hospitals, by J. L. Le Conte.

10. On the Glacial Phenomena and Present Configuration of the State of Maine, by L. Agassiz.

11. On a Regulator for Maintaining Uniform Motion, and an Apparatus for Recording Time Observations in Type, by J. E. Hilgard.

12. On the Progress of the Geological Survey of California, by J. D. Whitney.

13. On the Mineral Lands of the United States, and the Relations of the Government to their Management, by J. D. Whitney.

14. On the Origin and Formation of Sedimentary Rocks, by J. S. Newberry.

15. On the Origin and Distribution of Petroleum in the United States, by J. S. Newberry.

16. The Theory of the Sling, by Benjamin Peirce.

17. The Fucoids of the Coal Measures, by Leo Lesquereux.

18. Letter from Mr. Agassiz.

19. Observations of the Right Ascensions of Stars within one Degree of the North Pole, by B. A. Gould.

20. On Observations of Tides at the Island of Tahiti, made by Captain John Rodgers, of the United States Navy, for the United States Coast Survey, by J. E. Hilgard.

21. Discussion of Magnetic Observations made at Eastport, Maine, during the Years 1861–1864, by the United States Coast Survey, by J. E. Hilgard.

22. On Rifled Guns, by W. H. C. Bartlett.

23. A New Theory of the First Principles of the Differential Calculus, by Theodore Strong.

24. On the Ages of the United States Volunteer Soldiery, as deduced from the Statistical Bureau of the Sanitary Commission, by B. A. Gould.

25. On a Photometer, by O. N. Rood.

26. On the Structure of the Moon, by S. Alexander.

27. On the Systems of Mountain Upheaval to which the Continent of North America owes its Present Configuration, by J. D. Whitney.

28. Abstract of Geological Investigations made in China and Mongolia, by Raphael Pumpelly. (Communicated by J. D. Whitney.)

29. Examination of Shells obtained by the Sounding-Lead in the Coast Survey of New York and New Jersey, with some Nautical Hints, by Augustus A. Gould.

30. On the probable immediate Cause of the Glacial Epoch of the Post-Tertiary, by A. Guyot.

31. On the Lower Silurian Oils of Kentucky and Tennessee, by J. S. Newberry.

32. Suggestions relative to the Annular Eclipse of the Sun, of October next, by S. Alexander.

33. On Certain Converging Series expressing the Ratio of the Diameter to the Circumference of the Circle, by William Ferrel. (Communicated by Benjamin Peirce.)

34. On a Tide Meter, by J. M. Batchelder. (Communicated by Benjamin Peirce.)

Of the communications heretofore presented, five are included in the first volume of the Memoirs of the National Academy of Sciences, now being printed by order of the Senate of the United States. The minor papers will be collected and published in a smaller volume, under the title of Proceedings.

The current expenses of the Academy, and the cost of publishing the Annual, have been, as before, defrayed from the contributions of members.

The vacancies in the Academy have been filled by the election of William D. Whitney and S. Weir Mitchell.

The Council for the year 1866 consists of M. C. Meigs,

B. A. Gould, J. L. Le Conte, and W. D. Whitney, together with the officers of the Academy, members *ex officio.*

The next session of the Academy will be held at Northampton, Mass., on the first Tuesday in August, 1866.

Respectfully submitted.

JOSEPH HENRY,

*Vice-President National Academy of Sciences.*

HON. SCHUYLER COLFAX, *Speaker of the House of Representatives.*

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## APPENDIX A.

*Report of the Committee on Weights, Measures, and Coinage to the National Academy of Sciences, January,* 1866.

The Committee are in favor of adopting, ultimately, a decimal system; and, in their opinion, the metrical system of weights and measures, though not without defects, is, all things considered, the best in use. The Committee therefore suggest that the Academy recommend to Congress to authorize and encourage by law the introduction and use of the metrical system of weights and measures; and that, with a view to familiarize the people with the system, the Academy recommend that provision be made by law for the immediate manufacture and distribution to the custom-houses and States of metrical standards of weights and measures; to introduce the system into the post-offices by making a single letter weigh fifteen grammes instead of fourteen and seventeen hundredths, or half an ounce; and to cause the new cent and two-cent pieces to be so coined that they shall weigh, respectively, five and ten grammes, and that their diameters shall be made to bear a determinate and simple ratio to the metrical unit of length.

# VIII.

## LIST OF PAPERS PRESENTED TO THE ACADEMY,

### TO JANUARY 26, 1867.

1. On the Individuality among Animals, with Reference to the Questions of Varieties and Species, by Louis Agassiz.
2. On the Elements of the Mathematical Theory of Quantity, by Benjamin Peirce.
3. On the Discussion of Magnetic Observations made at Girard College Observatory, in the Years 1840–1845, Parts IV., V., and VI.; Horizontal Force; Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon, by A. D. Bache.
4. On the Force of Fired Gunpowder, and the Pressure to which Heavy Guns are actually subjected in Firing, by F. A. P. Barnard.
5. Reduction of the Observations of the Fixed Stars made by J. Lepaute d'Agelet at Paris, during the Years 1783–1785, with a Catalogue of the corresponding Mean Places referred to the Equinox of 1800, by B. A. Gould.
6. On the Metamorphoses of Fishes, by Louis Agassiz.
7. On the Saturnian System, by Benjamin Peirce.
8. Notes on the Parallelogram of Forces and on Virtual Velocities, by Theodore Strong.

9. On the Geographical Distribution of Fishes, as bearing upon their Affinities and Systematic Classification, by Louis Agassiz.
10. On the Discussion of Magnetic Observations made at Girard College Observatory in the Years 1840–1845, Parts VII., VIII., and IX.; Vertical Force; Investigation of the Eleven-year Period of the Solar Diurnal Variation and Annual Inequality, and of the Influence of the Moon.
11. Description of an Anemograph designed for the University of Mississippi, by F. A. P. Barnard.
12. On Materials of Combustion for Lamps in Light-houses, by Joseph Henry.
13. On Photographs of the Solar Spectrum, by Lewis M. Rutherfurd.
14. On Tangencies of Circles and Spheres, by J. G. Barnard.
15. On Observations of the Planet Venus near the Times of her Inferior Conjunction, September 28, 1863, and subsequently, by Stephen Alexander.
16. Brief Note on the Forms of Icebergs, by Stephen Alexander.
17. Memoir of the late Henry Fitz, by Lewis M. Rutherfurd.
18. On the Distribution of certain important Diseases in the United States, by Augustus A. Gould.
19. On the Integration of Differential Equations of the first Order and higher Degrees, by Theodore Strong.
20. Criticism on the Forms of Ships, by Captain J. Cole. (Presented by Theodore Strong.)
21. On the Light visible on the Moon's Surface, and that seen adjacent to her Edge, when the Sun is either partially or totally eclipsed, by Stephen Alexander.

22. On the Influence of the Hour of the Day on the Results of Barometric Measurements of Altitudes, (not read,) by Arnold Guyot.
23. On Shooting Stars, by H. A. Newton.
24. A Method of determining the Errors of a Vertical Divided Circle, by Simon Newcomb. (Presented by Benjamin Peirce.)
25. Considerations relative to various Phenomena presented by certain Comets, by Stephen Alexander.
26. Memoir of Lieut. E. B. Hunt, by F. A. P. Barnard.
27. On a Chronograph for Measuring the Velocity of Projectiles, by J. E. Hilgard.
28. On the Homologies and Classification of the Cephalopods, by L. Agassiz.
29. On the Geographical Distribution of North American Birds, by S. F. Baird.
30. Note on the Changes that have taken place in the Bar of Charleston Harbor since the Sinking of Obstructions in the Main Channel, as developed by the United States Coast Survey, by J. E. Hilgard.
31. On the Tables of the Moon, by Benjamin Peirce.
32. On the Metamorphoses of some Malacopterygians, by L. Agassiz.
33. On Chemical Classification, by Wolcott Gibbs.
34. On the Dimensions and Proportions of American Soldiers, by B. A. Gould.
35. On a Method of Exhibiting certain Statistics of Hospitals, by J. L. Le Conte.
36. On the Glacial Phenomena and Present Configuration of the State of Maine, by L. Agassiz.
37. On a Regulator for Maintaining Uniform Motion, and an Apparatus for Recording Time Observations in Type, by J. E. Hilgard.

38. On the Progress of the Geological Survey of California, by J. D. Whitney.
39. On the Mineral Lands of the United States, and the Relations of the Government to their Management, by J. D. Whitney.
40. On the Origin and Formation of Sedimentary Rocks, by J. S. Newberry.
41. On the Origin and Distribution of Petroleum in the United States, by J. S. Newberry.
42. The Theory of the Sling, by Benjamin Peirce.
43. The Fucoids of the Coal Measures, by Leo Lesquereux.
44. Letter from Mr. Agassiz.
45. Observations of the Right Ascensions of Stars within one Degree of the North Pole, by B. A. Gould.
46. On Observations of Tides at the Island of Tahiti, made for the United States Coast Survey, by J. E. Hilgard.
47. Discussion of Magnetic Observations made at Eastport, Maine, during the Years 1861–1864, by the United States Coast Survey, by J. E. Hilgard.
48. On Rifled Guns, by W. H. C. Bartlett.
49. A New Theory of the First Principles of the Differential Calculus, by Theodore Strong.
50. On the Ages of United States Volunteer Soldiery as deduced from the Statistical Bureau of the Sanitary Commission, by B. A. Gould.
51. On a Photometer, by O. N. Rood.
52. On the Structure of the Moon, by S. Alexander.
53. On the Systems of Mountain Upheaval to which the Continent of North America owes its present Configuration, by J. D. Whitney.
54. Abstract of Geological Investigations made in China and Mongolia, by Raphael Pumpelly. (Communicated by J. D. Whitney.)

55. Examination of Shells obtained by the Sounding-Lead in the Coast Survey of New York and New Jersey, with some Nautical Hints, by Augustus A. Gould.

56. On the probable immediate Cause of the Glacial Epoch of the Post-Tertiary, by A. Guyot.

57. On the Lower Silurian Oils of Kentucky and Tennessee, by J. S. Newberry.

58. Suggestions relative to the Annular Eclipse of the Sun, of October next, by S. Alexander.

59. On Certain Converging Series expressing the Ratio of the Diameter to the Circumference of the Circle, by William Ferrel. (Communicated by Benjamin Peirce.)

60. On a Tide Meter, by J. M. Batchelder. (Communicated by Benjamin Peirce.)

61. On the Silver Reduction Process of Nevada, with Statistical Tables, and Metallurgical Data, by B. Silliman.

62. On a New General Method of Volumetric Analysis, by Wolcott Gibbs.

63. On Sodium Amalgam, and its Application in Saving Precious Metals, by B. Silliman.

64. On the Limits and Character of the Vision of American Soldiers, as deduced by the Statistical Department of the U. S. Sanitary Commission, by B. A. Gould.

65. On the Primary Triangulation of the Coast of New England, in connection with the U. S. Coast Survey, by A. D. Bache.

66. On the Relation of Language to Ethnology, by W. D. Whitney.

67. On Certain Mineral Districts of Arizona, by B. Silliman.

68. On California Petroleum, and the Products of its Distillation, by B. Silliman.

69. Observations on the Annular Eclipse of October, 1865, made at Lebanon, Ill., by Stephen Alexander.
70. On a Photometric Method, by Ogden N. Rood.
71. On a Normal Map of the Solar Spectrum, by Wolcott Gibbs.
72. On Traces of Glaciers under the Tropics, by L. Agassiz.
73. On the Secular Acceleration of the Moon's Mean Motion, by John N. Stockwell.
74. On the Origin of Solar Heat, by Benjamin Peirce.
75. On the Morphological Value and Relations of the Human Hand, by B. G. Wilder.
76. On the Correlation of Gravity and Temperature, by P. E. Chase.
77. Grounds of Analogy between Linguistic Science and the Physical Sciences, by W. D. Whitney.
78. On the Limitation of Homologies, by L. Agassiz.
79. On a New Method of Optical Analysis, by Wolcott Gibbs.
80. On Recent Soundings in the Gulf Stream, by Henry Mitchell.
81. On Repeated Linear Substitutions, by J. E. Oliver.
82. On some Points in the Geological Structure of Southern Minnesota, by James Hall.
83. A New Theory of Planetary Motion, by Theodore Strong.
84. On the Linear Evaluation of Surd Forms, by William Watson.
85. On the Study of Young Animals, and its Bearing upon the Progress of Palæontology and Zoölogy, by Alexander E. R. Agassiz.
86. On the Mass of the Satellites of Saturn, by Benjamin Peirce.
87. On a Remarkable Rainbow, by Benjamin Peirce.

88. Investigation in Regard to Sound, in its Economical Applications, by Joseph Henry.
89. On the Geographical Distribution of Fishes in the Waters of the Amazon, by Louis Agassiz.
90. On the Stature of American Soldiers, by B. A. Gould.
91. On the Influence of the Hour of the Day on the Heights obtained by Barometric Measurements, by Arnold Guyot.
92. On Astronomical Photography, by Lewis M. Rutherfurd.
93. On the Reduction of Photographic Observations, with a Determination of the Position of the Pleiades from Photographs by Mr. Rutherfurd, by B. A. Gould.
94. On a Table for Facilitating the Conversion of Longitude and Latitude into Right Ascension and Declination, by Wm. Ferrel.
95. On the Nephila Plumipes, or Silk Spider of South Carolina, by B. G. Wilder.
96. On the Systematic Value of Rhynchophorous Coleoptera, by J. L. Le Conte.
97. On the November Meteors, by Hubert A. Newton.
98. On the Total Eclipse of the Sun of August 7th, 1860, in Connection with some Remarks of the Annular Eclipse of October, 1865, by Stephen Alexander.
99. On some of the Phenomena presented by the Planet Venus when near her Inferior Conjunction, by Stephen Alexander.
100. On the Relative Longitude of Europe and America, and the Velocity of Galvanic Signals in the Atlantic Cable, by B. A. Gould.
101. On the Principles of the Classification of Fishes, by Louis Agassiz.
102. Recent Observations on the Glacial Phenomena of the Basin of the Great Lakes, by J. S. Newberry.

IX.

# BIOGRAPHICAL NOTICE

OF

# JAMES MELVILLE GILLISS,

By BENJAMIN APTHORP GOULD.

[Presented Jan. 26, 1866.]

# BIOGRAPHICAL NOTICE

OF

# JAMES MELVILLE GILLISS.

MR. PRESIDENT AND GENTLEMEN OF THE ACADEMY: —

THE year which has just elapsed has been more sparing of our number than its predecessors; yet death has taken one from the ranks of the Academy who could ill be spared, and on the 9th of February last the tidings went forth from this capital to all parts of the land, that a great bereavement had come upon the science of America. A month before we had met Gilliss here in the vigor of his manhood, the fullness of his energy, and the manly dignity so characteristic of his bearing.

> " O, had it been but told you then
> To mark whose lamp was dim,
> From out these ranks of active men
> Would you have singled him?"

His life has been in some respects its own sufficient record, for its impress has been given and will long remain; yet in other respects the time is not yet come for the full portrayal of his many services to science and to his country, — for these are still too recent for complete recital, and their enumeration and description might tend to impair their best influence. Loyalty to his country, his government, his science, his friends, — stern integrity, unflinching resolve, and earnest piety were the predominant traits of his moral nature. A keen sense of duty, which never permitted to himself those indulgences which his charity readily conceded to others, was blended with exquisite sympathy and kindliness. In his remarkable character the two extremes met of austerity and geniality; but the sternness was for himself, the tenderness was for his fellow-men.

James Melville Gilliss was born in Georgetown, D. C., on the 6th of September, 1811, the oldest son of George and Mary (Melville) Gilliss. His father was in the service of the United States government, and had been so since its transference to this city. The family was originally of Scottish origin, but had been in this country for several generations.* At the age of fifteen years Gilliss entered the navy as midshipman, and made his first cruise in the "Delaware," under Captain Downes. Returning after an absence of three years, during which he served also in the "Concord" and the "Java," he passed his examinations with honor, and received in 1831 the grade of passed midshipman.

Even at this early age the aspirations which guided his whole career began to manifest their influence. In a letter written long years afterwards to his friend Dr. Gerling of Marburg, he says:—

* For most of my information regarding Captain Gilliss's ancestry, I am indebted to the Rev. Isaac W. K. Handy, D. D., of Orange Co., Va., who has kindly supplied it to me from the MS. of "The Annals and Memorials of the Handys and their Kindred," soon to be published. The line of descent was as follows:—

*A.* Thomas Gilliss, an early settler of the Eastern Shore of Maryland and native of Scotland.

*B.* Capt. Thomas Gilliss, born at Monokin (now Princess Anne), 1668, July 12, married as his third wife Anna, widow of Capt. John Handy, and daughter of Thomas Dashiell.

Children by 3d wife:—

7. Joseph.
8. Sarah (m. Major Thomas Irving).
9. Nelly (m. Capt. George Handy).
10. Anne (m. John Irving).

"Very shortly after I came to Washington for duty as a Passed Midshipman, members of Congress were told in my presence, 'There is not an officer of the navy capable to conduct a scientific enterprise.' The charge was intended prejudicially to the service to which I belonged, and was the more humiliating because the speakers were unknown, and defence was not possible. But from that hour no effort has been spared by which the standard of intelligence in the service might be increased and its reputation enhanced."

How much the scientific reputation of the navy may have been directly or indirectly advanced by the exertions of our lost colleague, I will not undertake to estimate; but thirty years have wrought a wondrous change, and the response which the logic of history would furnish to any disparaging remark to-day needs no added encomium of mine.

So keenly was the young officer touched by the assertion, whether true or not, that on the instant he resolved to disprove it in his own person. Such is his account, and from that moment he was wont to date his scientific impulses; yet

*C.* Joseph Gilliss, of Somerset Co., Maryland, (7th child of Thomas,) married: —

1. Anne, daughter of Col. Isaac Handy.
2. Betty Irving.

Children: —

1. Thomas Handy, b. 1768, d. 1851.
2. Esther (m. Dr. W. Cheney).

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3. Joseph.
4. George.
5. Anna.
6. Sarah (m. —— Polk).
7. Nelly.
8. Eliza.

*D.* George Gilliss, of Georgetown, D. C., (4th child of Joseph,) married Mary Melville, their third child being,

*E.* James Melville Gilliss, born September 6, 1811.

those who knew him best can hardly believe that to so slight an incident we owe the rousing of his strong powers, and the commencement of that useful scientific career by which he accomplished so much for our country, and which terminated only with his life.

Desiring to perfect his own culture, he applied for leave of absence to prosecute his studies, and in 1833 entered the University of Virginia, resolved, so far as lay in his own power, to bring to his country's service the highest scientific culture attainable. His residence at the University, however, was of less than a year's duration. Excessive study impaired his health, and a severe inflammation of the eyes confined him for many weeks to a dark room. Upon his partial recovery he made a fourth cruise, ending in October, 1835, after which he resumed his studies in Paris, and pursued them there for about six months, before returning to his professional duties.

In the following year, Mr. Gilliss was ordered from Philadelphia, where he had been on duty, to Washington, as assistant to Lieut. (now Commodore) Hitchcock, who was then in charge of the Depot of Charts and Instruments. This institution had been established by the Navy Department six years previous, through the influence of Lieut. (now Admiral) Goldsborough, for the care and distribution of the charts and instruments required by national vessels. Among the duties of the officers was the rating of chronometers. The determination of time was at first made by sextant and circle observations ; in 1831 a small transit-instrument was mounted for this purpose ; and when in 1833, Lieut. (now Commodore) Wilkes was assigned to its charge, he removed the office to the vicinity of his own residence, about 1,200 feet north of the Capitol, erected a small wooden observatory fourteen feet by thirteen, in which he mounted a 4-inch transit-instrument of larger dimensions, lent the office by the Coast Survey. This instrument was made by Troughton, and had a clear aperture of 3¾, with a focal length of 63 inches.

In a very short time after the arrival of Gilliss in Washington, he was placed in full charge of this establishment, and here he made his first astronomical observations, these his being at first solely for determining time, like all those of predecessors. A year later, during the winter of 1837–38, he observed an extensive series of transits of the moon and moon-culminating stars for the determination of longitudes in connection with a survey of Savannah River; but these observations appear never to have been reduced.

At this time he was married to Miss Rebecca Roberts, the daughter of John Roberts, Esq., of Alexandria, D. C., with whom he passed a life of uninterrupted domestic happiness.

For more than twenty-seven years, his interests and cares and aims were hers; and he owed much to her encouragement and sympathy in his intellectual as well as his domestic life.

In 1838 the exploring expedition sailed under the command of Capt. Wilkes, and for the purpose of determining differences of longitude by means of moon-culminations, occultations, and eclipses. Special instructions were drawn up by him for the observations of these phenomena, and application was specially made by him to the department that Lieut. Gilliss "should not be permitted" to leave the depot during the absence of the expedition. The late Mr. W. C. Bond, who had a transit-instrument mounted at his house in Dorchester, was also engaged for the same purpose, the instructions to him and to Gilliss being duplicate. These instructions also contemplated extended magnetic and meteorological observations, and he availed himself of this opportunity to procure a portable 3¼-inch achromatic, equatorially mounted, a variation-transit for use in measuring the magnetic declinations, a balance magnetometer, a dip circle, two clocks, and a chronometer for sidereal time. The instructions from the Secretary of the Navy (Mr. J. K. Paulding) were dated 1838, August 13, and Gilliss's observations began in the very next month. Here commences his astronomical career. Young as he was, he must be considered the first representative of practical astronomy in America. Astronomical observations had been made for a century, it is true. Men, his seniors, now living, and others still not long deceased, had made them before him, and were able to aid him with counsel and even experience. Among these I may mention Hassler, the founder of the Coast Survey, Bache, our own beloved and revered President, whose absence we are mourning, Prof. Bartlett, our honored colleague, Messrs. W. C. Bond, R. T. Paine, Patterson, Olmsted, and Loomis. But it was Gilliss who first in all the land conducted a working observatory, he who first gave his whole time to practical astronomical work, he who first published a volume of observations, first prepared a catalogue of stars, and planned and carried into effect the construction of a working observatory as contrasted with one intended chiefly for purposes of instruction.

"From that time," (September, 1838,) says Gilliss,* "till the return of the expedition in June, 1842, I observed every culmination of the moon, and every occultation visible at Washington, which occurred between two hours before sunset and two hours after sunrise. The transit was extremely deficient in optical power, and would not define stars smaller than the second magnitude when the sun was two hours above the horizon. The number of transits recorded exceeds 10,000, embracing the moon, planets, and about 1,100 stars. The average annual number of culminations of the moon observed was 110, and of lunar occultations about 20."

* Senate Report No. 114, 28th Congress, 2d Session, p. 65.

The difficulties under which he labored, and the zeal with which he pursued his aim, may be inferred from the modest Preface to the volume containing his observations at this little observatory, which were not reduced and published until four years after their completion. It will be borne in mind that these observations of moon-culminating stars constituted but a part of his duties during all this period, — that the instruments and charts of the office were to be cared for, the magnetical and meteorological observations assiduously prosecuted, and many official details to be attended to. Moreover the amount of his astronomical work was understated by him in his report as above cited, inasmuch as his printed volume of observations gives the places of 1,248 fixed stars. Of these stars 6,823 transits are published, as also 365 transits of the moon, 37 of planets, and 84 occultations.

As this volume* is now rare, it may not be amiss for me to quote the greater portion of the Preface.

"With but little experience in the manipulation of fixed instruments; without a book relating to the subject in any manner, except 'Pearson's Introduction' and 'Vince's Astronomy,' or an acquaintance in the astronomical world from whom suitable advice could be obtained, literal compliance with the directions of the Department was the only course to be pursued at the commencement of the observations. Indeed, as I had never seen a volume of the annals of European observatories, there could be no reason to suppose they did not embody every requisite to be complied with in recording observations; and it was not until the latter part of 1840 I became aware that the exact state of astronomical

* Astronomical Observations made at the Naval Observatory, Washington, under orders of the Hon. Secretary of the Navy, dated August 13, 1838, by Lt. J. M. Gilliss, U. S. N. Printed by order of the Senate of the U. S., Washington, 1846.

science demanded more than a simple record of the transits, after the errors of the instrument had been rectified. For information and counsel on this, as well as other important points, I most respectfully tender my thanks to Rev. Richard Sheepshanks, and to S. C. Walker, Esq., gentlemen whose devotion to and labors in the cause of astronomy have established for them most enviable fame.

" Limited to the Nautical Almanac and the catalogues contained in the volumes mentioned, for observable objects, my attention was early arrested by discrepancies between the clock errors resulting from standard stars and some of those comprised in the list of moon-culminations; discrepancies amounting in several cases to more than two seconds of time, which, being confirmed by the observations of consecutive nights, were consequently altogether beyond the limits of probable errors. Receiving about this time, through the kindness of Mr. William Simms, a copy of that *vade mecum* of astronomers, 'The Catalogue of the Royal Astronomical Society,' it occurred to me, that, whilst carrying out the objects of the exploring expedition, the mites which I could add to the data for more correctly locating 'the landmarks of the universe' would not be entirely unworthy of collection; and, with this object in view, I determined henceforward to increase the number of stars to be nightly observed, so as to embrace one in each three and a half to four minutes between the times of transit of the first and last moon-culminating star,— the interval fixed on being the time ordinarily occupied by the transit of one star over all the wires, and setting the finder for its successor. This was all I could hope to accomplish with the means in my power, unless careful estimations of the apparent magnitudes of each star observed should enable me to detect, at the termination of the series, variations in their brightness, or to confirm the degree of lustre already assigned to them.

"All the observations of the volume, excluding a part of those on three dates, (as stated in the foot-notes,) were made by myself. Absence on two of these days was caused by illness; and it is proper to state, that, with the above exceptions, there was not a visible culmination of the moon which occurred when the sun was less than an hour above the horizon, during the entire period embraced by the observations, or an occultation after the 15th June, 1839, except one which I did not personally observe, although my residence, till the middle of May, 1839, was two miles distant from the observatory. Earlier in the afternoon or later in the morning than just specified, the transit-instrument would not show stars of the 2 – 3 magnitude.

"Occupation during the day in attention to the duties originally allotted to the office, and the want of sufficient assistance, prevented any attempt at reduction of the constantly accumulating materials prior to the summer of 1843.

"It remains but for me to express my gratitude that the prosecution of these observations should have resulted in the foundation of a permanent naval observatory, and have obtained for me, though for a brief period, the privilege of association with many of the most distinguished astronomers of the present century."

In describing the results attained, the mention of a serious obstacle ought not to be omitted, — the very inadequate construction of the little building in which the observations were made. The observing slits of the roof of the ten-foot structure which served as his observatory extended only to within three feet of the ridge-pole on each side, thus precluding all observations between 26° and 53° North declination, a region which actually includes a portion of the moon's path. This was partially remedied by extending the aperture for about $5\frac{1}{2}°$ on the Southern side, which was found to be the utmost that the strength of the edifice permitted, and it was found necessary to compensate even this gain by introducing transverse bars of iron, and nearly one seventh part, 12 out of 88, of the standard stars of the Nautical Almanac still remained hidden from view.

The magnetic and meteorological observations carried on at the same time by Capt. Gilliss were probably as laborious, and were certainly as conscientiously prosecuted as the astronomical ones. They were subsequently reduced and published, the last volume appearing in the same year with that containing the astronomical results.

I have said that Gilliss's volume of observations was the first one published on our side of the Atlantic, and have shown how, in spite of many and serious obstacles, his conscientious assiduity and unwavering zeal accomplished not only all that his instructions required, but much more than this. It remains to speak in this connection of the character of the observations and their results.

I need not remind you, gentlemen, how many an accomplished practical astronomer lacks that delicacy of the senses, and those other physical powers, by which alone the most refined observations may be attained. Even the best observers have not always the highest qualification in these respects; for a quick ear, a sharp vision, and a delicate touch are by no means all that constitute the highest skill in an observer. The refined methods of observing, the adroit precautions against incidental errors not dependent upon the senses, the ingenious devices for detecting, measuring, and allowing for errors unavoidably incurred, as distinguished from the simple endeavor to avoid them,—an endeavor of which the success must necessarily be more restricted by the limits of our senses, however acute, than the attempt at measuring and eliminating these errors is found to be, — these are unquestionably the highest characteristics of the practical astronomer; and experience has shown that these will more than compensate for the dimmed eye, the unsteady hand, and the impaired susceptibilities of advancing years. The whole spirit of modern practical astronomy tends in this direction. Never otherwise could that great dictum of the immortal Struve have passed into an astronomical theorem: "Whatever may be seen may be measured." It is by this principle that the modern forms and appliances of the choicest astronomical instruments are regulated, and the modern methods of observation prescribed. No longer are azimuthal errors supposed to be eliminated by adjustment upon a meridian mark, or collimation-errors removed by analogous processes, or clock-rates assumed as constant through protracted intervals of time, nor the graduations of any instruments implicitly relied on for delicate determinations, nor positions based upon the most massive structures assumed to remain constant. The chief effort of the skilful observer of to-day is directed rather to the elimination and the measurement than to the avoidance of error; for human sense is but fallible, while human intellect and art are at least a reflex, if not a spark, from the divine altar.

Yet despite all this, it would be folly to attempt to portray the indescribable advantage to an observer which is afforded by delicacy of the senses. Training will do much· but the culture of delicate perceptions must accomplish more than the training of average ones. And it was Gilliss's peculiar privilege to be endowed with a wondrous acuteness of the perceptive powers of eye and ear, as manifested in his astronomical observations. No one at all conversant with observations can examine the printed record, however casually, without a vivid perception of this marked peculiarity. Before it was my privilege to know him and to appreciate his manly truthfulness and scrupulous honor, I once heard another astronomer impugn his observations in this respect. I asked whether the recently published volume of observations were good and creditable to Astronomy in America. "Yes," was the reply, "they are very good, too good for Gilliss's reputation. No man could have made such good ones." In fact it is rarely that the record of a transit over the middle thread of his reticule does not accord, to the nearest tenth, with the mean of observations over the five threads.

It is true that *few* men could have made such observations; but happily there are tests, unsuspected then, so searching that cavil is impossible. Not only do the original records exist, in such a form as to preclude any idea that they could have been tampered with, — not only have subsequent observations confirmed those of Gilliss and made manifest their high precision, — not only was our colleague spared to enrich the annals of astronomy with yet more results of just such quality, in the other hemisphere, but a touchstone exists, potent as Ithuriel's spear. I refer to the so-called personal scale, by which the counting and assortment of the last figures, in a very large number of observations, enables the inquirer to determine the degree of precision of these last figures by the law of probabilities. This searching test was applied to this volume of observations by Prof. Peirce, and with results signally confirming the faith of Gilliss's warmest admirers. In the long list of observers, living and dead, whose results were thus critically and searchingly tested, Gilliss held the second place (and scarcely second indeed) for the close precision with which his tenths of seconds had been noted, — a degree of accuracy only attainable by extreme concentration of energy, and assiduous training superposed upon physical perceptions much more delicate than those of most men. Indeed, a moderate amount of scrutiny will detect the growth and development of his powers in this respect from year to year.

Walker tested the same work in a different and more laborious way. He reduced more than a thousand observations over the lateral threads in order to compare their results with those given by the central one, and with similar results. At a meeting of the American Association for the Advancement of Science, he publicly stated, that, after an extensive series of analogous examinations, made for the purpose of deciding the relative weight to be assigned to the results of different observers, he had found transit-observations of only one astronomer, Argelander, which manifested equal precision with those of Gilliss.

Such were the observations made by Gilliss in the years 1838–42, beginning at the age of twenty-seven, without previous training other than he had given himself, without astronomical acquaintances, and, what was more than all, without scientific sympathy until the observations had been prosecuted for more than two years.

The printed volume contains nearly 700 octavo pages, comprising the detailed observations of each year, with the details of their reduction, the work of each year being specially referred to the mean equinox of its commencement; and at the close, a General Catalogue of the mean right-ascensions of 1,248 stars, formed from these annual tables,— together with their precessions, proper motions, and polar distances, derived from the British Association Catalogue, and added for convenience in making one of his own results.

We come now to one of the noblest achievements of Gilliss's life,— the construction and equipment of the Naval Observatory. To understand the exact bearing and amount of his services in this connection, it will be well to revert to previous efforts in the same direction, and I will take the liberty of making use, without apology, of a summary of this history, which I prepared a few years since for another purpose.

The claims which science — and especially those departments of scientific inquiry which cannot be prosecuted without the aid of implements inaccessible to most private men — may legitimately make upon a civilized community, if not, indeed, upon its government, are too patent to most thoughtful men, for the want of any proper observatory in the United States thirty years ago not to have been a source of regret, and an occasion for effort to those interested in the intellectual development of our nation. When we consider that not only had England and France led the way, and, for centuries, practically acknowledged the title of the eldest of sciences to national encouragement and support, but that scarcely a principality or petty duchy existed on all the continent of Europe so insignificant, or so poor, that it did not support an astronomical observatory, we cannot but feel astonishment at the unwillingness manifested by the then dominant school of legislators to promote astronomical research by providing some means at the national expense. It was, to be sure, not as a system of wise economy and large policy like that to which this Academy probably owes its origin, and on which its claims to national support might be entitled to acknowledgement; nor even to that still larger and more comprehensive statesmanship, which recognizes in the promotion of scientific research a sure and efficient mode of developing the national resources, both intellectual and material, — that the foundation and support of an observatory at government expense was urged. But it was insisted on by its advocates on the ground that the importance of astronomical observations to the world at large, especially their manifest bearing upon commerce, rendered it the bounden duty of the United States, as a mercantile nation, to contribute their part toward those observations and computations for which all other civilized countries strove to do their share, and that a decent national pride should render us unwilling to rely exclusively upon Europe for data indispensable to navigators, even did it not lead us to desire that our republic should emulate her monarchies in the advancement of the highest civilization. Curiously enough, the so-called constitutional arguments brought forward in opposition to such plans did not possess sufficient force to prevent the equipment of that expedition for general geographical exploration to which, through a singular change of circumstances, the establishment of a government observatory was ultimately due. The essential importance of a central observatory for the exploration and survey of our own territory, for the determination of the geographical position of our own ports and inland towns, was also made prominent; yet it seems almost incredible that only thirty years ago, not merely did such arguments as these fail of all effect, but even those men who entertained larger and more elevated views seem not to have thought it worth their while to develop them. But such was the case, and the few instances in which any exertions were made in this direction afford us admirable examples of seed sown upon stony ground, — not to allude to another scriptural comparison perhaps yet more appropriate.

The first of these efforts will probably be found in the first message sent to Congress by John Q. Adams, after his inauguration as President of the United States, in March, 1825. In this message "he earnestly recommended the establishment of a National Observatory, as, also, of a Uniform Standard of Weights and Measures, of a Naval Academy, a Nautical Almanac, and a National University. But all these recommendations were treated with neglect by Congress; although time has written a sufficient commentary on their wisdom and foresight. An excellent report on the subject, advocating the views of the President, was made by Mr. C. F. Mercer, chairman of the Committee of the House, to whom, in the ordinary routine, the subject was referred; but the recommendations of the President, and of the Committee, were suffered to lie unnoticed on the tables of both Houses; and it was reserved for the Emperor Nicholas of Russia to follow those counsels which party rancor precluded the Congress of the United States from adopting on the recommendation of their President, and by the establishment of the noblest Observatory of the world to render the capital of his empire a capital of astronomical science."

The first structure in the United States which might claim the name of a fixed Astronomical Observatory was the ill-constructed little edifice of which I have already spoken, 14 feet long, 13 feet broad, and 10 feet high, in which Gilliss industriously labored for nearly four years, making the excellent observations of right-ascension already described, and furnishing the first volume of astronomical observations published in this hemisphere, and probably a more precise record of transits than has ever been made in America by any other person.

In 1838, the year in which Lieutenant Gilliss commenced his observations, a small astronomical structure had been built at the Western Reserve College, in Hudson, Ohio, through the exertions of Professor Elias Loomis, and equipped with a 4-inch equatorial telescope and a 3-inch transit-circle, both of English manufacture. With these Professor Loomis made a number of astronomical observations; but the duties of his office, as teacher, left him little opportunity for continued research.

It was in this same year, 1838, that the money bequeathed by Smithson to found that noble institution which will render his name immortal was received by our minister in London. Mr. Adams, then a member of the House of Representatives, again exerted his most strenuous efforts to secure the establishment of an astronomical observatory as a part of the institution. He immediately waited on President Van Buren, and, in a long interview, urged his views of the subject. A few months later, at the call of the Secretary of State, he reduced his views to writing, advocating the application of part of the fund to the establishment of a great observatory, and of a Nautical Almanac. Mr. Van Buren expressed his concurrence with the views, but never acted in the premises.

Indeed, so bitter was the rancor of political partisanship at this time, and so intense the hatred entertained by the then dominant section of the country against Mr. Adams, that, to use the language of his biographer, opposition to the design became identified with party spirit, and to defeat it no language of contempt or of ridicule was omitted by the partisans of General Jackson. In every appropriation which it was apprehended might be converted to its accomplishment, the restriction "and to no other" was carefully inserted. In the second section of an act passed on the 10th July, 1832, providing for the survey of the coasts of the United States, the following limitation was inserted by the Naval Committee: "*Provided, that nothing in this act, or in the act hereby revived, shall be construed to authorize the construction or maintenance of a permanent Astronomical Observatory.*" Yet, at the time of passing this act, it was well understood that a part of the appropriation it contained must necessarily be applied to astronomical observations. And, indeed, I may anticipate the order of this narrative by adding here that when, at last, Congress did appropriate the means for erecting an Astronomical Observatory, and subsequently for its support, it was under a fictitious name; the authors of the laws intending an Astronomical Observatory, and being well aware that the funds would be so applied, but causing the insertion of the proviso in the one case, and of the feigned name in the other, for the purpose of preventing the institution from being attributed to the influence of Mr. Adams.*

In 1840, precisely fifteen years after that first message to Congress in which he had advocated the establishment of a National Observatory by government, Mr. Adams, being Chairman of the Committee on the Smithsonian Fund, made a second report, in which, after recounting all the principal facts connected with the bequest and its acceptance, he again advocated the views which he had so often urged. But while the question was pending, a resolution was passed by the Senate appointing a Joint Committee on the subject of the Smithsonian bequest. The House, in courtesy, concurred, and appointed on its own part the members of the Select Committee of which Mr. Adams was Chairman to be members of the Joint Committee. It may readily be imagined that the two portions of the Committee were unable to agree; and it was finally decided that each of the two component parts should present its own report; and while Mr. Adams reported † a series of resolutions prescribing the investment and management of the fund, and directing that the first appropriation of interest-money should be "applied for the erection of an Astronomical Observatory,

* Quincy. Memoir of the Life of J. Q. Adams.

† Twenty-sixth Congress, 1st Session, Rep. No. 277.

and for the various objects incident to such an establishment," Mr. Preston, of South Carolina, the Chairman of the Senate Committee, presented counter-resolutions, containing the provision that no part of the funds should be applied to the erection of an Astronomical Observatory. This report of Mr. Adams is well worthy the perusal of every lover of the exalted science of astronomy, both for the richness of its information and the beauty of its eloquence. In 1840 and 1841, two observatories were established,—the first at Philadelphia, by the High School of that city, and the second at West Point, by the United States Military Academy. The former was placed under the direction of the late Sears C. Walker, the other pioneer of practical astronomy in the United States, and of Professor E. O. Kendall; the latter under that of Professor Bartlett. To these astronomers we owe the first introduction into the country of those German instruments which the combined genius of Bessel, Struve, and Argelander, that wondrous triad, together with Fraunhofer, and his gifted co-laborers in the highest fields of optical and mechanical art, had devised and perfected. To these observatories at West Point and Philadelphia, or rather to the ability and assiduity of their directors, working in the hours of relaxation from professional duties, we owe the first important series of astronomical observations made in the United States. It is to the stimulus given by their observations,—especially the admirable ones of Mr. Walker, rendered peculiarly valuable by his computations, for which they supplied the material; and to their publications, particularly the able report on European Observatories, presented by Professor Bartlett to the Engineer Department on returning from a journey to Europe for the purpose of ordering instruments,—that we are doubtless indebted for much of that public sentiment which, combined with other influences, at last brought about the establishment of the Naval Observatory.

In 1841, after three years of zealous observations, Gilliss obtained authority to import a meridian-circle. This could not be erected in the little hut where he was then observing, and he availed himself of the opportunity to urge both upon the Navy Department and upon members of Congress the establishment of a permanent Observatory for the Navy, to be attached to the Depot of Charts and Instruments. Let me quote his own words from his official report after the successful accomplishment of this design.

"As the observations progressed, the unsuitableness of the building, the defects of the transit-instrument, the want of space to erect a permanent circle, and the absolute necessity of rebuilding the observatory in use, became each day more urgent, and, at my earnest solicitation, the Commissioners of the Navy recommended an appropriation for a permanent establishment in December, 1841. Even this, however, was not accomplished without difficulty. But the efforts of the honorable Secretary to advance science, and more especially those branches of it in which the Navy is interested, are well known to the country; and immediately appreciating its importance, he brought this subject before Congress in his report to the President of December, 1841.

"Much delay occurred with the Naval Committees in Congress. The Hon. Francis Mallory, to whom it was referred by the House Committee, espoused the cause warmly, but the majority kept aloof from the depot (although so near) until the entire winter passed away. Finally, on the 15th March, 1842, I succeeded in persuading the only member of the committee who was skeptical to visit the observatory, and on that very day a unanimous report and bill were presented to the House of Representatives. Believing the chances of success would be greater if a bill could be passed by the Senate, by the advice of Mr. Mallory, I waited on the Naval Committee of the Senate, but my entreaties for a personal inspection of our wants were put off from time to time. The question was probably decided by an astronomical event.

"At a meeting of the National Institute, at which the Hon. William C. Preston was present, I gave notice of having found Encke's comet with the $3\frac{1}{2}$ feet achromatic, the comet being then near its perihelion. A few days subsequently, I made what was intended to be a last visit to the chairman of the Senate Committee, and found Mr. Preston with him. As soon as I began the conversation about the little observatory, Mr. Preston inquired whether I had not given the notice of the comet at the Institute, and immediately volunteered, 'I will do all I can to help you.' Within a week, a bill was passed by the Senate.

"It is hardly necessary to trace its progress in the House. A majority was known to be favorable, but its number on the calendar, and the opposition of one or two members, were likely to prevent action upon it; and that it did receive the sanction of the House of Representatives at the last hour of the session of 1841–42, the Navy is indebted to the untiring exertions of Dr. Mallory."

Meanwhile Mr. Adams, on the 15th April, 1842, had presented yet a third report from the committee on the Smithsonian fund in the form of a bill, providing for its administration on the same principles which he had advocated in former years, and directing that the income already accrued should be invested as a capital, and its interest applied to the construction and maintenance of an Astronomical Observatory. The bill failed; for as Mr. Adams's biographer remarks, "there was no purpose on which the predominating party were more fixed than to prevent the gratification of Mr. Adams in this well-known cherished wish of his heart." Yet an Observatory, under a feigned name, and restricted to the Navy Department instead of being made a national institution, was established by act of that very Congress at that very session, without a division, or indeed any opposition in either House; and four years later the Smithsonian Institution was organized essentially on the basis so often urged by him, although omitting the Observatory element, which was then no longer desirable, inasmuch as the end had been obtained by other means.*

The bill introduced by the Naval Committee of the House of Representatives was read twice and disposed of by reference to the Committee of the whole on the State of the Union. But on the 23d of June, a bill identical in its language with the one thus laid to rest was introduced in the Senate, as related by Lieutenant Gilliss in the extract which I have presented from his report. This passed through the several stages of legislation in due order, without hindrance or objection; went to the House on the 30th July; was referred to the same committee as before; but as a Senate bill was treated with courtesy. It was reported back without discussion, passed by the House without debate, and on the 31st August, 1842, became a law.

Thus was established the present Naval Observatory, owing, like all progressive steps in our country, at least, to the combination of many influences, and the gradual education of the community by a few leading intellects,—yet how large a share in the work was due to Gilliss, this history will show. His useful observations, together with his excellent administration of the affairs of the Depot of Charts and Instruments,

* Gilliss's Report, p. 65.

had won the confidence of his official superiors, and impressed all whom he could induce to see what he was doing. To his immediate influence must be attributed the official recommendations of the Naval Commission in December, 1841; that of the Secretary of the Navy in the same month; the unanimous presentation of a bill in its favor by the Naval Committee of the House, after much reluctance, and in spite of strong political prejudice against this very measure under another name; the winning to his views of the identical Senator who had presented resolutions concerning the Smithsonian fund, "providing that no part of the funds should be applied to the erection of an Astronomical Observatory," and that persistent advocacy which culminated in the final passage of the bill on the last day of August, 1842, without discussion and without a division.

Nine days later the Secretary of the Navy, "taking the Report of the Naval Committee, which accompanied the [House] bill, as the exponent of the will of Congress," assigned to Lieutenant Gilliss the duty of preparing the plans for a building and arranging for the instruments. How well he did his work I need not tell you.

After consulting those Americans most conversant with astronomical subjects, he visited Europe to obtain the counsel of foreign astronomers, and to make himself acquainted by personal inspection with the latest improvements in the construction of astronomical and magnetic implements. In March, 1843, he returned home, having ordered the instruments under authority from the Secretary of the Navy, and began the erection of the Observatory. The building was completed, the instruments mounted and essentially adjusted, and a library procured within eighteen months.

On the 7th February, 1845, Gilliss presented a detailed final report of his labors, which is published as Senate Document No. 114, 28th Congress, 2d Session. It contains full descriptions, with minute drawings, of the instruments, and suggestions as to the ends to which they might be most usefully devoted, and it is a curious fact that these instruments are essentially the same that, after the lapse of 21 years, are still in active and successful employment. The only important change is the disuse and removal (by himself) of the Ertel Circle,—obtained by him while still at the little box on Capitol Hill, and subsequently mounted at the new Observatory,—in order to make room for the magnificent meridian-circle also ordered by him, but which it was never his privilege to look upon. This noble instrument, purchased by the Navy Department under authority of the present Superintendent, then Chief of the appropriate Bureau, is now in working condition, and offers rich promise of contributions alike useful and honorable to science.

The great work was thus accomplished. The first working American Observatory had been built,—stimulating to quick emulation in the Observatory at Cambridge, and so on in the numerous other similar institutions which now ornament our land. Who should direct its activity? Lieutenant Gilliss had brought about its existence, had planned it, selected and ordered the instruments, superintended the construction of the building, mounted and adjusted the instruments, and at the close of September, 1844, reported the work done and the Observatory ready for occupation. No breath of scandal had ever sullied his fame. He was the sole working astronomer in the nation. His work had met the commendation of astronomers everywhere, so far as they had had opportunity to become acquainted with it.

It was not Gilliss who was assigned to its superintendence. But, on the 1st October, orders to assume the charge of this noble institution were issued by Hon. John Y. Mason, then Secretary of the Navy, to Lieutenant Matthew F. Maury, a young officer without scientific education or experience, and with small scientific pretensions. A corps of three lieutenants, six midshipmen, and a machinist was assigned him, and within the year four more lieutenants and three naval professors were added to this corps, in addition to the all-important, but unhappily very temporary services of the gifted and enthusiastic Walker. Surely with such an organization we might have looked for more than we received; especially when we remember that Walker, Hubbard, Coffin, Ferguson, Keith, Yarnall were among its members. Honor to their names for what they did accomplish.

The influences which prompted this appointment and the intensely mortifying treatment of Gilliss seem to have been no very recondite ones, and can be readily imagined by any of you, — for it needs but a five years' memory to recall those ancient days; yet never in the course of fifteen years of friendship, an unrestricted intercourse, and a close intimacy, did I hear one word of even pardonable bitterness, either concerning this severe disappointment, or the neglect of astronomy by the officers to whom the Observatory had been assigned. "It was hard," he would say, "but an officer must obey orders and not find fault with them." On the other subject he ever preserved a dignified reticence, and it is my firm belief that in his freest utterances he never spoke one word expressive of the sentiments which we may naturally suppose him to have entertained.

From February, 1845, to July, 1846, Gilliss was occupied with the preparation of his observations for the press, as has been already mentioned, and at the close of this work he was assigned to duty upon the Coast Survey under Professor Bache. While on this service he reduced for the use of the

Survey the entire series of moon-culminations previously observed and published by him. Fifteen manuscript folio volumes in the archives of the Survey contain this valuable work, the subsequent discussion of which by Walker, and still later by Peirce, led to the investigations by these geometers into the relative accuracy of Gilliss's observations, concerning which I have already spoken.

In May, 1847, Dr. Gerling, the eminent mathematician of Marburg, published a memoir, calling the attention of astronomers to the fact that the universally adopted value of the solar parallax depended solely upon observations of the transits of Venus in 1761 and 1769; and that, although the materials afforded by the observations then made had doubtless been exhausted by the labor and skill with which Encke had deduced the value since adopted by astronomers, yet a constant so important as this, which affords directly or indirectly the sole unit for the determination of all celestial distances, should not be subject to the possible uncertainties of any one method. Especially was it unfortunate that the only method employed depended upon a phenomenon which recurred, doubly to be sure, yet only at intervals of more than a century; and which would not again take place until after the lapse of more than a quarter of that period.

The combination of observations of Mars at opposition, made from terrestrial stations widely differing in latitude, had been frequently suggested; but Dr. Gerling advocated especially the similar employment of observations of Venus at inferior conjunction, and especially when at, or near, the stationary points, and of oppositions of Mars. His conviction in favor of this method rested principally on the consideration that, whereas, in transits of Venus, the quantity to be determined is the difference between the parallax of the planet and that of the sun, — the other methods yield the planet's parallax at once,—the element directly deducible bearing to the solar parallax the following ratios:

| | |
|---|---|
| At transits of Venus, | 2.57 |
| At oppositions of Mars, | 1.92 on the average. |
| " " " " | 2.74 in extremely favorable cases. |
| Inf. conjunctions of Venus, | 3.57 |
| Stationary positions of Venus, | 2.94 |

Thus the observations of Venus promised to yield a better determination of the solar parallax than any oppositions of Mars; and those at the stationary or turning points of her apparent path, a result surpassing in accuracy that from the average of these oppositions by about $\frac{6}{7}$ of its whole amount. The natural objection that the conjunctions of Venus must be observed by day, thus dispensing with the advantage of micrometer comparisons, and requiring meridian observations at midday, was recognized by Dr. Gerling, but the excellence and power of the newer meridian instruments were cited as compensating for this serious disadvantage. The observations during the stationary period were, however, chiefly urged.

Before the publication of this memoir, in which the subject was discussed at very considerable length, Dr. Gerling had, in April of the same year, (1847,) written to Gilliss, in acknowledgement of his volume of observations, and, in his letter of thanks, gave some account of his proposition.

"I am of opinion," said he, "that astronomers act unwisely in considering the solar parallax deduced from the transits of Venus in 1761 and 1769 sufficiently correct, and do not avail themselves of more modern methods of observation, for the purpose of gradually acquiring more accurate knowledge of it. It is true, indeed, that the oppositions of Mars were long ago proposed for this purpose; but I am not aware that any effective use has been made of them since

1751, although the Nautical Almanac has regularly furnished an ephemeris. There is, however, a *third* method, which presented itself to me some time ago, and I cannot comprehend why it should have been so entirely neglected. I mean, by observations of Venus during the period of its retrograde motion, and, more especially, when the planet is stationary.

"The delicate and faint crescent form of Venus, at the conjunctions, offers excellent opportunities for observation; and from what I have been able to accomplish with my small instrument, I have every reason to believe that most excellent results are obtainable with meridian instruments, at observatories in opposite hemispheres, but lying nearly under the same meridian. Furthermore, at that time, Venus is almost twice as near to the earth as is Mars when in opposition, and observations upon it have the very important advantage that it is not absolutely essential they should be simultaneous, or nearly simultaneous. Again, when the planet is stationary, the observations of one meridian may be readily referred to another by interpolation, without risk of error, and, at this time, it is much nearer to the earth than Mars can be in the most favorable case. Finally,—the distance of the planet from the sun being about 29°,—micrometrical may be combined with meridional observations. In my opinion, then, it should be our object to multiply meridian observations of Venus about the periods when it is stationary, and endeavor to obtain micrometrical measurements from all parts of the earth; more especially from voyagers."

After a summary of his views, Dr. Gerling continued: "The preceding synopsis of my paper will, I hope, reach you in print after a while. Meantime, I beg you will examine the subject, and, should you coincide in my views, I trust you will interest American astronomers as far as you can, for I flatter myself that observations will be instituted this year at European observatories; and, indeed, I am sure that a greater number of accurate meridian observations are likely to be made during the months of September, October, and November than is common. For the results and success of 1847, it is much to be desired that the few delicate meridian instruments in the southern hemisphere should be brought to co-operate with us; and this, perhaps, it is in your power to facilitate. Of equal consequence will be micrometer observations from the same section of the globe; but as the latter require no permanent observatory, and only a chronometer, a telescope fitted with a micrometer, and a knowledge of the neighboring stars, such observations may well be made by travellers. Whether there will remain time prior to the eastern period for the necessary instruction of voyagers to the southern hemisphere, I am not able to determine."

"This letter," says Gilliss, in the history of his expeditions, "bears date 17th of April, but was not received until the early part of July, and the next eastern stationary term was to occur in September. On conference with the late able astronomer, Professor S. C. Walker, he suggested the immediate publication of the letter, as the mode most expeditious of making it generally known, and, in accordance with his advice, printed copies of a translation were forwarded to all the astronomers and observatories of the United States, with as little delay as possible. There was too little time in which to perfect arrangements for more extended co-operation at that conjunction, and Dr. Gerling was shortly notified that the distribution of his letter was probably all that I should be able to do in the work for 1847. But, to prove my interest in the prosecution of the problem to its solution, I then proposed an expedition to Chile, to observe the planet near its stationary terms and opposition, in 1849, should my views receive encouragement from astronomers to justify such an undertaking. Nearly on the same meridian as Washington is the island of Chilóe,—a place of considerable trade with the nearer ports, and occasionally visited by American whale-ships. At all events, it was accessible without much difficulty, and I hoped to be able to induce the government to send me there, proposing to leave the United States in time to reach the island by the middle of March of that year, at latest. To avoid expense, which it was supposed would prove the first and main obstacle, I contemplated only one assistant, who, like myself, would be an officer of the Navy, and in the receipt of pay, whether abroad or at home, and would take instruments already belonging to, or under control of, the government. I proposed Chilóe, because it was the point farthest south on this continent at which a lengthened winter residence could be endured, in exposure, without incurring an outlay that might prove a serious impediment, and because I thought that a passage to it could be obtained in a whale-ship from one of our northern ports. It being inhabited by a civilized and most hospitable people, would tend to render a residence of five or six months, in the latter part of the autumn and winter, not altogether uncomfortable. Its distance is about 5,000 miles, due south from Washington; and a comparison of the observations I proposed to make there, with those to be obtained at the Washington Observatory, would give us a determination of the parallax from data wholly American. This last reason I hoped would benefit me, should it be necessary to seek the interposition of Congress."

Then commenced a series of efforts, prosecuted with the well-known energy of our lamented colleague, to prepare judicious plans and to interest both astronomers and lawgivers in the proposed enterprise. "Remembering," said he, in a letter to Gerling, in November following, "the vast outlays Europe has encountered in efforts for the faithful solution of this very problem, as well as in other hundreds of scientific enterprises, and the fact that America, which participates so largely in the benefits derived from the labors of astronomers, has hitherto contributed so trifling an amount to the common stock, I am the more keenly sensible of the noble opportunity now within our grasp to present the world, from our own continent as a base, the dimensions of our common system. . . . . There is but one perceptible obstacle, — pecuniary outlay, — yet when its very inconsiderable amount is contrasted with the grandeur and importance of the object to be attained, I cannot bring myself to believe that this objection will be suffered to weigh, and I therefore repeat the remark made in my former letter, — give the proposition the encouragement of scientific men, and I stand pledged for its successful equipment. At all events, regarding it as a possible attainment only, two questions present themselves for consideration, and it is time they were discussed: first, Is the locality proposed (Chilóe) the best which can be selected for the contemplated object? And second, Will the instruments which have been specified to you permit the accomplishment of that object in the most satisfactory or desirable manner?"

To the careful examination of these all-important questions Gilliss addressed himself with zeal, entering into correspondence on the subject with American and foreign astronomers, and gathering information and counsel from every possible quarter. He soon found that the climate of Chilóe was ill-adapted to his purposes, and that the better climate of Valparaiso would in all probability more than compensate for the diminished length of base which it would entail. Some disadvantage arose from the eastwardly trend of the coast farther north, which would carry the observer to the eastward of Washington; but this he overruled as a minor objection, "more especially as we have other observatories at Philadelphia, West Point, and Cambridge, whose equipments justify the expectation that they will take part in the observations; and there is but one to the westward of us at all likely to co-operate, viz. at Hudson, Ohio."

Encouragements soon began to arrive from the other side of the Atlantic. Gauss and Encke contributed the influence of their great names, and Bache, Peirce, and Walker added their endorsements to the plan. Resolutions of approval and recommendation were passed by the American Philosophical Society, of Philadelphia, and the American Academy of Arts and Sciences, of Boston; and each of these bodies, then the leading scientific tribunals of the land, appointed a committee to co-operate in furtherance of the undertaking. The Secretary of the Navy referred the matter to the action of Congress, and within a fortnight a report was made by the Hon. F. P. Stanton, of Tennessee, chairman of the Naval Committee, cordially approving of the plan. Gilliss had pledged himself that if the Navy Department would furnish the apparatus already within its control, and assistance from the officers under its direction, the total expenses of every kind for the expedition, exclusive of instruments, should not exceed $5,000. The Naval Committee reported an amendment to their bill, appropriating this sum, and giving the requisite authority to the Secretary of the Navy. The clause was sanctioned by both Houses of Congress, and the bill containing it was approved by the President on the 3d of August, 1848. Preparatory orders were at once issued by the Secretary, containing all needful authority for making the preliminary arrangements.

Before a year had elapsed, the programme had been matured, the formal concurrence of the committees of the two learned societies obtained, an equatorial telescope and a meridian-circle ordered and constructed, and Gilliss had reported to the Navy Department that the instruments and other portions of the equipment essential to the proposed observations were on their way to Chile, in charge of the officers assigned by the Department as assistants. Not a fortnight more than the year had passed when Gilliss himself was on his way to Valparaiso, where he arrived by the way of Panama, in advance of the ship containing the instruments and his assistants.

The detailed account of the organization of the expedition is very interesting, and may be found presented at length by Gilliss himself, in the third volume of the Results of the Expedition. The limits of this notice preclude any more minute description; but the whole constitutes a most interesting chapter in the history of science in America, and one no less important in its indirect influence than in its direct results. It was one of the earliest instances, if not the first, of deference by the legislative and executive authorities of the nation, to the views of the organized representatives of science within its borders. Rarely before had they been consulted when the weightiest scientific interests were at stake, and almost as rarely had any formal expression of their convictions, however unanimous, availed to guide the scientific policy of the nation. It was moreover the occasion of the first order to an American artist for a telescope of any considerable dimensions, and to the truly patriotic spirit shown by Gilliss on that occasion, at the instance of our colleague, Mr. Rutherfurd, whose efforts in that direction are so familiar to us all, may unquestionably be attributed much of that subsequent development of instrumental art of which we are now so proud, and which has already given such distinction to the names of Fitz, Spencer, Würdemann, Clark, Tolles, and others, all happily yet remaining to us except the first-named, — the pioneer of all. Although well aware of the danger of too much detail, I cannot refrain from giving the history of this first large American Equatorial. The five-foot telescope purchased for the exploring expedition, and upon which Gilliss has depended for his observations, was found, to his dismay and embarrassment, to have been stored in a position exposed to the extremes of temperature and moisture, which had seriously, if not fatally injured the object glass. Already the Fox's deflector had been found to be hopelessly injured, and the declinometer to have been given to a mixed commission for surveys in California. But in these difficulties the Smithsonian Institution, although scarcely more than organized, came to his relief. Professor Henry offered a seismometer and a complete meteorological outfit, and subsequently authorized the purchase, at the expense of the Institution, of a complete set of portable instruments for magnetic determinations. But where in this unforseen emergency to look for the telescope, the indispensable implement for the proposed observations, became a question of the most serious moment. Nearly one half of the appropriation was already pledged for the meridian-circle ordered from Berlin, and $1,000 at the least would be needed for the piers, buildings, &c.

To the honor of the Smithsonian Institution, this admirable organization came again to Gilliss's succor. Although all its available funds were in demand for current expenses, and for the erection of the expensive building, then slowly going on, so that any immediate appropriation of the requisite amount was out of the question, the Regents, at the instance of Professor Henry, manifested a deep interest in the undertaking, and at last offered the credit of the Institution by authorizing the purchase of an equatorial telescope of $6\frac{1}{2}$ inches aperture, provided it could be obtained at a stated price, with interest, on a credit of three years.

Let me continue in Gilliss's own words, — "No importer to whom application was made was willing to order one from Germany on such terms. Messrs. Merz, the successors to Fraunhofer, at first declined selling without the cash; indeed their ordinary custom is to demand one half the price in advance; and the only maker in the United States likely to execute properly the mechanical portions of so large an instrument refused to accept the offer. Just as I had made arrangements to borrow on my own account the sum charged by Messrs. Merz, and import an equatorial from them, Professor Henry authorized me to increase the offer to Mr. Young, of Philadelphia, and eventually a contract was concluded with him, on behalf of the Smithsonian Institution, the right being reserved to me to procure the object-glass and micrometer from such artists as might be preferred.

"About this time notice was published by Mr. Rutherfurd, in Silliman's Journal, of the performance of an object-glass made from imported materials by Mr. Henry Fitz, an optician at New York. Learning that several other lenses had been perfected by the same artist, I determined to examine them all, and then confer with Messrs. Bache, Peirce, and Walker. To be brief, the examination and conference resulted in an order to Fitz to grind a lens from Guinand's glass, to be of the same diameter (six French inches) as that of the telescope at the High School Observatory in Philadelphia, and to forward it to Professor Kendall. If he and other competent judges should pronounce it as good, *in every respect*, as the High School lens, it would be purchased at the

Munich price, $500. If inferior, we should have the right to retain and use it, free of cost, until another could be imported from Bavaria.

"Between the date of the order, November 27th, and the time that the tube was ready, April 15, 1849, Mr. Fitz prepared three lenses of that size. Veins developed themselves in one, only after it had been polished; and a second proved scarcely less objectionable in its crystallization. Of the third submitted for trial, Professor Kendall wrote to me, May 1: 'I had the pleasure of making trial of the Fitz object-glass last evening, and was highly gratified with the result. I compared it with ours upon the moon, Jupiter, several double stars, and the bright star Vega, with its companion, using a variety of powers, and it is my opinion that Mr. Fitz has fully accomplished all that he undertook to perform. From this trial I am unable to pronounce which is the better glass. The Fraunhofer did nothing which was not as well done by the Fitz glass. . . . Indeed, we are all delighted with his success, and I am fully persuaded that between this and one you might order from Merz the chances would be decidedly in favor of the former.'

"Gratification is a feeble word to express my pleasure at the success of the American optician, for I could not but think this first *Yankee* telescope of considerable size marked an era in the progress of mechanical science in our country, for which I hoped future astronomers would render due credit to the expedition. That Mr. Fitz was thoroughly competent to figure and polish, I was fully convinced, on examining the object-glasses previously made, and my only regret was that he could not forthwith undertake the whole task, and begin by manufacturing his own glass. But he had genius, and nothing would be more likely to stimulate him to undertake it than the success just met with.

"Thus, through the assistance of others, the Expedition would be most efficiently equipped; and the support of the Smithsonian Institution, at a very trying period, will always be remembered with the sincerest gratitude."

Two passed-midshipmen, Messrs. Archibald MacRae, and Henry C. Hunter were detailed as assistants, and a young civilian appointed as "Captain's clerk," and thus the expedition was equipped. Before their departure they were stationed for a short time at the Observatory, for instruction by the officers in charge of the instruments, and employed in selecting stars to be designated in advance as objects of comparison. Lithographed charts exhibiting the apparent paths of both Venus and Mars during the period of the proposed observations in the years 1849–52, were sent to all the northern observatories, since the observations for parallax would be available only when combined with corresponding observations in the Northern Hemisphere. And inasmuch as the co-operation of all other institutions would be matters of favor or of scientific zeal, special instructions were issued by the Secretary of the Navy to Lieutenant Maury to cause the requisite observations to be made at the Naval Observatory.

A circular was also prepared by Lieutenant Maury, and distributed to the various observatories of the world, describing the expedition, asking for their co-operation, and requesting that the results be sent annually to him at the Washington Observatory.

The precise place of observation was left to be decided upon Gilliss's arrival in Chile, the only limits determined in advance being the parallel of Valparaiso and Concepcion. It was not till after his arrival in Chile that the city of Santiago was fixed upon, as combining the greatest number of advantages; and there, upon Santa Lucia, a small porphyritic knoll in the eastern quarter of the city, the observatory was erected, which had previously been constructed in Washington.

The Chilian government received the expedition with a cordial hospitality, placing at his disposal any unoccupied public ground, admitting free of duty all the effects of the officers as well as the equipments of the expedition, and from first to last facilitating the enterprise by every means in their power. On the 6th December, 1849, the equatorial was in position, on the 10th the series of observations of Mars was commenced, and it was continued for the fifty-two remaining nights which had been designated in the programme, with the loss of only four, on which the weather was unfavorable. Early in February the circle was ready for use, and a series of zone observations was commenced with it at 15° from the pole, — working toward the zenith on successive nights in belts 24′ wide, until compelled to return below again in order to connect in right ascension. "We were always occupied," says Gilliss, "from five to six, and sometimes more, hours. Lieutenant MacRae and myself devoted alternate nights to these observations, very rarely having relief by clouds until after April 21. Indeed, between Feb. 4th and that date, seventy-six nights, there were only four of them obscure. The rains of latter autumn and winter came none too soon for us."

Meantime, at the application of the Minister of Public Instruction, three young Chilians were instructed in astronomy and the use of instruments; and magnetic and meteorological observations were systematically carried on. Mr. Hunter having been injured early in January by being thrown from a horse, was obliged to return to the United States, and his place was supplied by Passed-midshipman S. L. Phelps, the same who has since, as Lieutenant-Commander, rendered such essential service to the country in naval operations upon the Mississippi, and other Western rivers.

An accident to one of the micrometer-screws of the circle, rendering the simultaneous labor of both assistants necessary at the zones, their duties were fixed for each alternate night, while Gilliss himself employed the intermediate ones in examining such of LaCaille's stars between the zenith and the pole, as had never been twice observed. The pages of the astronomical periodicals of that time bear witness to the effectiveness of his scrutiny, by the record of many hundred errors detected in the Catalogue of LaCaille. On the reception in June of new micrometer-screws from the makers in Berlin, the original system of observations was resumed. During the series of observations of Venus, Gilliss records several occasions when the cusps of Venus could be distinguished by the unassisted eye.

I will not dwell further upon the details of the observations, for they are fully described in the magnificent volumes containing the results of the expedition. Let me simply sum up the work accomplished. Between the 6th December, 1849, and the 13th September, 1852, series of micromatic comparisons of Mars were made in forty-six days during the first, and ninety-three days during the second opposition, and micrometric comparisons of Venus on fifty-one days during the first, and twenty-seven days during the second inferior conjunctions; the observations on each day being continued through several hours, whenever the sky permitted, and the work being executed with the same delicacy and care which had characterized those earlier transit-observations on Capitol Hill in this city. In addition to this, very much else had been done; but these grand series of observations, executed in precise conformity to the programme laid down, warranted the confidence that his devotion had not been in vain, and that the problem of the parallax would be solved. His two hundred and seventeen series of observations extended over nearly three years; — if northern observations had accomplished half as much in correspondent observations, the question must be decided, and the celestial unit of measure determined with new precision.

What shall I say, Gentlemen of the Academy, of Gilliss's emotions, when, after returning from his long absence to combine and discuss the result of his five years' labor, he found the following correspondent observations awaiting him?

From the Washington Observatory, — eleven of Mars, of which six were recorded as wholly, and three others as partially unsatisfactory, and eight of Venus, two of which were noted as bad. From the Cambridge Observatory, — five of Mars, of which four were of one limb only. From the Greenwich Observatory, — four of Mars, three of them being designated as not good. From all other Northern observatories, none. His expedition was fruitless, so far as his primary object was concerned, but the consciousness was his, that he had done his duty.

He caused his results to be elaborated, thoroughly discussed, and all possible observations in the Northern and Southern Hemispheres to be collected and combined. No toil was spared in this work; and the recollection of the painful struggles to attain, through punctiliousness of computation, what had been hoped for from abundance and thoroughness of observations, is yet among the most vivid within the range of my memory. But it was in vain. The processes of reduction, the reference to approximate ephemerides, the determination of the comparison-stars, are all on record, and it will be for the future historian, when the true values are established beyond question, to decide whether a better determination can be elicited from the materials provided.

The final results attained were, — that from the second opposition of Mars, as also from either conjunction of Venus, no tolerably probable result could be deduced, by reason of the almost total lack of observations; and that whatever result was deducible must be from the first Mars-opposition alone. The materials here too were entirely inadequate, though in comparison with those for the three other series they seemed large; but on closer scrutiny a great portion of them proved not to have been made with the needful care. The only result to be deduced was altogether at variance with that which subsequent investigations have rendered probable.

Fortunately for science, and happily for Gilliss's own consciousness, his observations were not limited to those which it was his special duty to make. Even these on Mars and Venus, which failed of yielding their deserved fruit in affording those data which they were instituted to obtain, are yet of priceless value in the means which they afford, and which will doubtless soon be made useful for improving our knowledge of the orbits of our two neighboring planets.

Among other astronomical fruits of the expedition to Chile, I may mention the following: 7,000 meridian observations of 2,000 stars, chiefly the standard stars used for determining the errors of instrumental adjustment, and the LaCaille stars already mentioned. These, with their instrumental and tabular reductions, and a resultant catalogue of their mean places for the equinox of 1850.0, form a part of Vol. IV. of the series of the results of the expedition. The remainder consists of observations of Mars and Venus not included in the Parallax volume, and observations of the moon and moon-culminating stars. This volume was left ready for the press at Gilliss's death; and his distinguished successor, Admiral Davis, gives me the gratifying information that he proposes now to strike off and bind up the catalogue by itself, on account of its special utility to astronomers.

Equal, if indeed not superior in value to these are the Zones, comprising more than 33,000 observations of about 23,000 stars within $24\frac{1}{5}°$ of the South Pole. These comprise stars to the tenth magnitude inclusive, more than five sixths of which, or about 20,000 had not before been observed. These will constitute the Fifth Volume, which will contain about 1,200 quarto pages. The reduction of the declinations has already been essentially completed, and Admiral Davis, under whose charge the work is now placed, estimates that two years' more labor, with the present force, will prepare it for the press. I need not say with what satisfaction the publication will be welcomed by astronomers throughout the world.

An unforseen and peculiar obstacle was encountered in the large azimuthal motion of the hill of Santa Lucia, which seemed to undergo a certain amount of rotation, alternating in direction as the scorching rays of the sun by day, or the frigid emanations of the near Andes by night, alternately exerted their maximum effect. This phenomenon seems to have been not only greater in degree, but entirely different in some respects from that other analogous phenomenon of diurnal azimuthal fluctuation, which there is now reason to believe very general, and of which I have spoken on other occasions. Add to this the earthquakes, of which he recorded one hundred and twenty-four observations during the three years of his sojourn in Santiago, and which inevitably destroyed or changed the adjustments of the instruments, the permanent or temporary loss of assistants on several occasions, and the exhausting nature of the observations, continued with such unfailing assiduity through seasons at once so cloudless and so enervating, and you may form some estimate of the effort and energy implied. Such are the astronomical results of this most honorable and useful expedition; yet these constitute by no means all the information it collected.

The observations on earthquakes are most valuable and extensive, comprising not merely those made under Gilliss's immediate direction, but others also, instigated or collected by him, of the same phenomena at other places than Santiago, during his stay in Chile. Among these is an admirable series, not less complete than his own, observed by Señor Troncoso at La Serena, the capital of the province of Coquimbo, about 250 miles to the north of Santiago. These, and a collection of the accounts of the chief Chilian earthquakes on record, are included in his first volume, and warranted in Gilliss's opinion sundry important deductions, the chief of which, apart from those of a purely local nature, are:—That there are no permanent centers of disturbance, the apparent direction of the vibrations varying at each occurrence. That a large proportion of the tremors are neither undulations nor vibrations, but rather rapid vertical displacements of the crust of the earth, almost, if not absolutely simultaneous over the disturbed district. And finally, the very curious one, that the season of the year seems to exert some influence,—the average monthly shocks at Santiago during thirty-five consecutive months being $13\frac{2}{3}$ for April, while it reached in no other month so large a number as $14\frac{1}{2}$, and similarly at La Serena, the average number during twenty-eight months being fifteen for November, eight for December, and for the mean of the other months less than four.

The barometer and thermometer were recorded seven times in the twenty-four hours for the whole thirty-five months, and hourly one day in each month. On three days in each month, one of these being the regular "term-day, extended systematic observations of direction and intensity of terrestrial magnetism were carried on; and on the first of each month, during preappointed hours, the fluctuations of the magnetic declination were watched, simultaneously with corresponding observations by the Coast Survey on the Atlantic and Pacific coasts of the United States, to discover whether these fluctuations showed indications of synchronism in the two hemispheres. The last of the six quarto volumes which record the results of the expedition is already published, and devoted to the meteorological and magnetic observations, and their tabular discussion.

The first volume of this series contains an elaborate treatise upon the physical and social characteristics of Chile, its commerce and its resources. The second volume begins with the narration of Lieutenant MacRae of a journey homeward and back across the Andes and Pampas. After the completion of the magnetic observations in Chile, they were placed in charge of Lieutenant MacRae, who was instructed to carry them across the Andes and the Argentine territory, returning home by the way of Buenos Ayres, making regular observations on his way for determining elevations, geographical positions, magnetic and meteorological data, for each 3,000 feet of ascent and descent, and for each hundred miles of longitude; and collecting at the same time, such other geographical and statistical data as he could. These instructions were well carried out by Lieutenant MacRae, but his mountain-barometer having been broken on the way, and his chronometers so much injured as to impair his reliance on them for longitudes, he offered on his return to retrace the journey at his own expense, and repeat the observations, provided a new set of instruments could be supplied. This was at once acceded to by the Secretary of the Navy, and the outlays for the transportation authorized. The description of the two journeys across the continent, with the accompanying tables of physical constants for a large number of stations, and meteorological records during each transit, form a valuable contribution to the results of the expedition. And together with these are published reports by the most competent authorities whose aid Gilliss could enlist on his return, giving descriptions and classifications of the various objects of natural history collected during the three years. There is also an interesting chapter by Mr. Ewbank, upon the curious antiquities brought home from Chile and Peru.

The third volume contains the observations for deducing the Parallax, together with their discussion as heretofore described. The fourth and fifth, as yet unpublished, are, as I have stated, to contain respectively the absolute determinations with the meridian-circle, and the invaluable circumpolar zones.

If I have devoted much time and space to the description of this interesting and valuable expedition, it is because few others on record have accomplished so much, in proportion to the means provided, and because the results have been especially honorable to all those who took part in it, — from the legislators, who introduced the measure in Congress, to the Chilian government, who purchased the instruments and equipments, when the contemplated work was done, and have established the first really National Observatory of the Western Continent. And moreover, in so far as the admirable Naval Observatory in this city may be regarded as a National Observatory, Gilliss's name is no less inseparably connected with the one than with the other.

Professor Moesta, a graduate of Marburg in Hesse, and a Chilian by residence, was appointed Director of the National Observatory of Chile, and has conducted it with honor to himself, and to the government which placed it in his charge.

On the 1st October, 1852, Gilliss left Santiago on his return homeward, and in the following month arrived in the United States, after an absence of three years and a quarter.

During the four years next ensuing, he was engaged under orders from the Navy Department in reducing the observations, and the preparation of his narrative, and of the work on Chile. In September, 1855, however, a great blow fell upon him. The Naval Retiring Board, under orders to report to the Secretary of the Navy the names of all officers who were in their judgment incapable of performing all their duties both ashore and afloat, in order that they be placed upon the "reserved list" with furlough pay, reported the names of 201 out of the 712 officers in the several grades prescribed by law. Of these 201 names, 49 were stricken from the rolls, and the remainder placed upon the reserved list. Strange as it may seem, Gilliss's name was among the number, the reason assigned—indeed the only one assignable — being, that twenty years had elapsed since his last sea service.

Gilliss felt this imputation keenly. His first volume only had appeared, and the Secretary promptly notified him that he would be retained on the same duty of preparing the remaining five for publication, and without diminution of his salary. Still a stigma was affixed, as he thought, and he fancied that disgrace, or at least humiliation, attached to his new position. He had fulfilled the first duty of an officer for all these years by implicitly obeying orders. No one of these orders had ever been solicited by him, excepting that for the charge of the expedition to Chile. Some of them had indeed been adverse to his known wishes, and in a published letter sent to those learned societies which had enrolled him among their members, he earnestly, yet with remarkable gentleness and courtesy of language, set forth the injustice with which he considered that he had been treated. He urged that a man of trained mind could no more forget the profession acquired in the vigor of his youth, than he could forget the art of swimming, mastered at the same period of life, and that the only ground on which his "retirement" could be advocated or defended, namely, a presumed inability by reason of disuse to perform the duties of an officer at sea, was utterly fallacious. Yet, waiving that point, how could an officer be justly set aside for alleged incompetency in his profession, when his life had been spent in active, energetic fulfilment of orders of his superiors, over which he had no control, — even had these orders not been given without solicitation on his own part.

I pass this subject by, for it can do no good to dwell upon it. It is not for me, nor indeed for any of us, to pass judgment upon acts purely professional and technical; and there can be no one more painfully aware how frequently great individual injustice seems inseparable from the execution of plans judicious in themselves, and conducive to the public welfare. It is not an infrequent observation that wise laws do not always seem to go hand in hand with equity.

It may be well to state here that when, after the flight of Maury, in 1861, Gilliss had been assigned to the post which the scientific world had expected for him sixteen years before, he soon received a commission as Commander, and a little more than a year later he received his commission as Captain, in the regular order of his seniority.

Early in the summer of 1858, while he was still engaged in the reduction of his observations, Gilliss, seeing the announcement that European observers were preparing to visit Brazil for the purpose of observing the total eclipse of the sun in September following, and perceiving that no arrangements were in progress for sending observers to the rainless region on the western coast of South America, volunteered his services. On the 8th of June he addressed a letter to Professor Henry, as Secretary of the Smithsonian Institution, offering to undertake the journey; and the proposition meeting a ready response, arrangements were speedily made and carried into execution. The Coast Survey furnished instruments for determining geographical position and time, as also a tent; the Naval Observatory contributed two pocket-chronometers, and Mr. Fitz hurried to its completion, and lent for the enterprise, a $4\frac{1}{2}$-inch equatorial, mounted on a stand adjustable for different latitudes. Accompanied by a young friend from New York, Gilliss left that city on the 5th of August, for Payta, in Peru, where they arrived on the 21st of the same month.

It is intensely gratifying to the lover of science, in reviewing the history of this expedition, to note the international courtesies, the liberality, and the appreciation of scientific research, which it elicited on every side. Doubtless the personal reputation of Gilliss, especially high in that direction where so much of his scientific efforts had been expended, contributed largely to these amenities; and to his dignified yet modest bearing, together with his unfailing courtesy, unquestionably much was due. Still, such aid and ready assistance as the expedition received on every side clearly manifested an earnest desire to aid the scientific enterprise in every possible way. The United States Mail Steamship Company, the Panama Railroad Company, and the Pacific Mail Steamship Company, gave the use of their ships and cars, offering, moreover, every other assistance in their power. The British Steam-Navigation Company granted free transport with great cordiality, and instructed their agents to aid the objects of the expedition in every possible way. "And so faithfully were these instructions carried out," says Gilliss, "that I cannot too earnestly express my appreciation of the considerate kindness shown me by the manager and agents of the line at Callao, Valparaiso, and Panama, or of the captains while making the voyages on board their ships." "During two weeks' detention on the isthmus," when returning, "we were guests of the Pacific Mail Steamship Company." On the day of his arrival at Payta, was received, through the captain of a war steamer lying in that port, a message from the Admiral commanding the French fleet in the Pacific, offering to carry him to any point on the coast, or to facilitate the observations by any means at his disposal. The Peruvian Minister at Washington had given official letters commending the expedition to the interest of the local authorities. The cases containing instruments and personal effects were passed unopened through the Custom-House; the captain of the port, the prefect of the province, the governors of the towns, and the inhabitants of the regions traversed, afforded all the official aid and all the personal hospitality in their power.

Finding that the atmosphere near the coast was very unfavorable about the hour of sunrise, at which time the eclipse would occur, it was decided to travel inland to some point near the Andes, and close upon the central line of totality. Leaving the zenith-telescope of the Coast Survey, and a chronometer, with the Captain of the French steamer, who proceeded with the steamer to a point about sixty miles south of Payta, where the central line of the shadow would first touch the continent, Gilliss himself, with Mr. Raymond, his companion, carrying the smaller instruments, and after despatching the Fitz telescope, the tent and provisions, half a day in advance of them, took their way inland on mule-back. "The country between the two places is a desert of sand, which is so drifted by the strong daily winds, that the mule paths are obliterated almost as soon as made, and the traveller finds his way by the tall stakes that have been planted, and the skeletons of animals that have died on the road from heat and thirst." Passing through the town of Piura, where they rested for a day and obtained important local information, they followed the dry beds of the so-called rivers, pitching their tent nightly. Water for the party, none of the best, was carried by the muleteers in calabashes. On the second day the guide lost his way, and it was not until noon of the fourth day from Piura, the fifth of their travel, that they reached the little town of Olmos, in just 6° South latitude, which had been chosen for the place of observation. But the journey had been too exhausting, and long before his arrival Gilliss was suffering from an intense fever. Here his energy and determination made themselves strikingly manifest. The fever assuming an intermittent type, he availed himself of its intervals to select a site for his tent, about one mile from the town, to obtain time for his chronometers and observations for latitude, and, while lying prostrate on the ground, he instructed his companion as to each part of the telescope, until it was properly mounted, for on the next morning the eclipse was to take place. Happily the fever had abated when morning came, and the eclipse was satisfactorily observed, with all the magnificent phenomena of a total obscuration, which lasted for more than a minute. Descending to the town early next day, they reached Payta on the sixth day thereafter. The results of the observations of Messrs. Gilliss, Raymond, and the French officers, are published in the Smithsonian Contributions to Knowledge.

The tedious, exhausting, and even hazardous journey across the Peruvian desert had been undertaken in spite of the fact that a point on the sea-coast called Lambayeque was but twenty-two Peruvian leagues from Olmos, the road passing along a valley which offers resources throughout the whole distance. But Gilliss had been informed by the commander of the steamer that the surf at Lambayeque was heavy, and that the risk of landing there with instruments might produce detention. He was not the man to hesitate under such circumstances, and chose the desert, with its privations and hardships, but its increased chances of success. The event confirmed the propriety of the choice; for when Dr. Moesta, who came up from Chile for the same purpose, and endeavored to land at Lambayeque, the surf precluded all possibility of landing until the fifth. In spite of his best efforts, he could only reach a village five leagues south of Olmos before the 7th, the morning of the eclipse, and the morning was cloudy there. In December, Gilliss again reached New York, having availed himself of an opportunity of accompanying Dr. Moesta on his return to Chile, and thus revisiting for a few days the friends whom he had left in Santiago six years before.

Meanwhile, as the various reductions and publications of the Parallax Expedition went on, Gilliss was not idle in other directions. As the time for the total eclipse of 1860 approached, he suggested the noted expedition for its observation which was despatched to Labrador under our colleagues, Messrs. Alexander and Barnard, by Mr. Bache for the Coast-Survey, and that sent by Mr. Winlock of the Nautical Almanac to the Hudson's Bay territory, under Professors Ferrel and Newcomb. He himself took charge of a third, to Washington Territory, also under the auspices of the Coast-Survey. He observed the eclipse with great success, assisted by his eldest son, now a captain in the army, but then in the Coast-Survey service, and Mr. A. T. Mosman, also of the Coast-Survey. The point originally selected had been upon the Cascade Mountains near Puget's Sound, since this eclipse also would occur nearly at sunrise, and it was feared that the mountain ranges might intercept the view. But on arriving at Fort Steilacoom the officers of the garrison relieved his apprehensions on this score by showing the inaccuracy of the topographical information previously obtained. A point was found only ten miles from the fort, upon a small open prairie, which commanded an excellent view of the sun at its rising, and, profiting by the experience gained at Olmos, and the greater force at his disposal, the observations made here were even more successful. A very singular phenomenon was here observed, which is most graphically described in Gilliss's report. All the prismatic colors flashed with wondrous brilliancy in circular bands and rapid revolution over the black disk of the moon, changing their relative places like the figures of a kaleidoscope. The suspicion naturally arises that this phenomenon was physiological, but the contemporaneous view of the same spectacle by an observer at Fort Steilacoom, ten miles distant, using an opera-glass, seems to throw some doubt upon this explanation.

On the memorable 15th of April, 1861, Commander Maury fled from his post at the Naval Observatory, leaving in his haste unquestionable proofs of treasonable correspondence with the public enemy. A day or two later, orders were issued to Gilliss to assume the charge of the Institution, and poetic justice, though long deferred, was at last fulfilled. The sudden transformation which took place was like the touch of an enchanter's wand. Order sprang from chaos, system from confusion, and the hearts of the faithful few who had struggled on for years, hoping against hope, were filled with sudden joy. Short time elapsed before their number was augmented by the advent of new astronomers, and in the first week of January following, the reduced observations of the year were ready for the printer,—an unwonted sight, for the last volume printed contained the observations of 1849 and 1850, while only one seventh part of the Southern Zones, planned by Coffin and Hubbard, and observed between the years 1846 and 1849, had been reduced, and but one thirteenth part published.

You need no reminder, gentlemen, of the suddenness with which the American Navy sprang into existence, almost like Minerva in full panoply from the brain of Jove at the stroke of Vulcan. Apart from scientific duty, it fell to Gilliss's share to provide for the equipment of all national vessels with charts and instruments; and this he did, until the passage of the next supply-bill, from the unexpended balance of Maury's annual appropriation made in times of peace. But this was the least of his deserts: he did it from home resources; he gave a new impulse to the industry and skill of mechanic artists and opticians in the United States, and for the first time laid down and carried out the principle that no instrument should be imported for the American navy which could be manufactured as well at home. The workshops of the scientific artisans of whom we are so justly proud sprang into new activity, and the devices and admirable workmanship then and thus evoked reflect upon Gilliss's memory an honor second only to that due to the men whose ingenuity and enterprise responded to his summons,—men who need no mention here, for we delight to honor them. Spy-glasses, sextants, compasses, chronometers, barometers, and all the many minor instrumental equipments of the navy, were so ordered that the navy, the artisans, and the public purse were alike gainers. The American Nautical Almanac, which had so long earned scientific reputation for us abroad, was brought into use on board our own national vessels, and for the first time officers held glasses of American make, to note the running of American log-lines.

The energies of the Observatory were not merely stimulated, but became directed by a definite policy in the prosecution of distinct aims. The reduction of the accumulated mass of the whole ten, and the greater part of fourteen years' crude observations, was provided for, and plans for their publication were matured. The various astronomical institutions of the land were invited to systematic co-operation for the prosecution of organized schemes of joint activity. The long-deferred hope of determining the Parallax by simultaneous observations in Chile and in the United States was revived, and by a strange coincidence of circumstances, the last morning of his life witnessed the publication of the result deduced, according to the original plan, by the joint activity of the two observatories founded through his own exertions five thousand miles apart. The results deduced by Messrs. Ferguson and Hall from meridian and from micrometric observations closely accord with each other, and with those deduced within the last few years by other methods, — and a further discussion of materials from two other observatories shows a close corroboration of these values by one of them.

While the first public announcement of these interesting deductions was issuing from the press, Gilliss breathed his last. The message for his departure could not have come more suddenly, yet it found him prepared, and with his lamp trimmed and burning. A month before, we had parted from him here in the full culmination of his meridian power, and most of us had felt the cordial pressure of his friendly grasp. It was but a day before that he had welcomed home his eldest son, freed from the horrors of a rebel dungeon. It was but a few minutes since he had welcomed the new day. We hoped from him yet much more for the welfare and the honor of our country. Yet we will not call his death untimely. He had lived to see the would-be destroyers of the republic melting away, like the night dew as the sun grows high, — to behold his country, amid struggles which his enemies had fondly deemed her death-throes, putting forth new tokens of life, and inaugurating a new era for her science as well as for her liberties. After years of discouragement and disappointment, he had seen his own services recognized. While the institution in the other hemisphere whose successful foundation was due to his own ability and endeavor had become permanent and active, he had enjoyed the yet greater satisfaction of seeing the cloud disperse which had so long overshadowed that other institution which had been one of the dearest objects of his life, and whose reputation his earliest and his latest labors have alike identified with his own. When charlatanism and disloyalty were no longer predominant there, we may imagine the just pride with which he had entered its doors and assumed command. When he departed, the new day-star which has risen upon our nation was high enough in heaven to show him the auguries of the morning, yet it had not sufficed to throw those dark shadows which we must yet encounter, or to display the unwelcome forms which yet remain for our eyes. No lingering disease wasted his manly powers, nor was his active mind fettered in the dungeon of an exhausted body. His brain was full of large ideas, his heart teeming with kindly affections, when "God's finger touched him, and he slept."

[illegible]

X.

# BIOGRAPHICAL NOTICE

OF

# BENJAMIN SILLIMAN, SR.,

BY ALEXIS CASWELL.

[Read Jan. 25, 1866.]

# BIOGRAPHICAL NOTICE

OF

# BENJAMIN SILLIMAN.

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In performing the duty assigned me by the Academy,—that of preparing a memoir of a venerable and lamented associate, Professor Silliman, I have found myself embarrassed on two accounts: First, for the want of that personal acquaintance without which it is difficult to apprehend correctly those habits of thought and traits of character which it is my purpose to develop; and secondly, from being called upon to appreciate scientific labors out of my own field of study, and where I am little familiar with the details of scientific progress, and therefore specially liable to err. I am quite aware how inadequate any sketch of his character from me must seem to those who knew him well. Under these circumstances the rectitude of my intention will perhaps shield me from the severity of criticism.

The facts and dates which I shall have occasion to use have been derived to a considerable extent from an article under the word "Silliman" in the "New American Cyclopædia," understood to be sanctioned by the intimate friends of our deceased associate, and from a commemorative discourse of President Woolsey, delivered in the Central Church in New Haven, November 28, 1864.

Benjamin Silliman was born on the 8th of August, 1779, in the town of Stratford (now Trumbull), in the State of Connecticut. He was the son of General Gold Selleck

Silliman. The Silliman family is supposed to be of Swiss origin. From the early settlement of the country they had been residents of the neighboring town of Fairfield. In July, 1779, the British forces, under Governor Tryon, invaded the maritime towns in the vicinity, carrying consternation to the inhabitants, and conflagration and pillage to several of the towns and villages. The family of General Silliman sought refuge in the town of Stratford, somewhat removed from the coast. And it was there, as before stated, that the subject of this memoir was born. It may be proper to add, that General Silliman graduated at Yale College in 1752, was a lawyer by profession, and an ardent patriot. During the Revolutionary struggle he rendered honorable service to his country, and evinced a devotion to the principles of liberty that might well become a descendant of the heroic and liberty-loving Swiss.

We have not at hand the means of tracing the childhood and early youth of young Silliman. At the age of eleven years he was bereft of his father, and was left to the fostering care and guidance of his mother. It is a sufficient indication of his diligence and aptitude in learning, that he was fitted to enter Yale College at the early age of thirteen years. His older and only brother, Gold Selleck Silliman, who still survives him, was a member of the same class. They both graduated in 1796.

We have now before us a young man of seventeen years of age, deeply imbued with religious sentiments, honorably distinguished as a student, and emulous of rivalling him who was foremost in the pursuit of good learning. To these advantages he united those of a fine physical constitution, and a kindly and pleasing address. With such "vantage-ground" to start from, we might confidently predict that, to whatever field of study he might turn his attention, his life would prove a success.

To talented and ambitious young men the profession of the law was then as now, and probably more then than now, the road to honor and fortune. Following in the footsteps of his father, young Silliman turned his attention to the study of the law. While prosecuting these studies, at an interval of three years from the time of his graduation, he received the appointment of Tutor in his Alma Mater. His last collegiate year was spent under the Presidency of Dr. Dwight, who no doubt saw in his youthful pupil those elements of character which fitted him for the duties of a college teacher. His name first appears on the catalogue as a tutor in 1799. He held the office for three years. In connection with his duties as tutor, he continued to prosecute the study of the law, and was admitted to the bar of New Haven in 1802. But another field of labor awaited him for which no doubt the study of legal principles, and especially the law of evidence, had given him a most valuable preparation.

Chemistry and Natural History had begun to attract the attention of educators. They had heretofore been regarded more as an adjunct to the medical profession than as a branch of general education. The science of Chemistry was then in its infancy. Its foundations had been laid, and it was destined to a rapid growth. Priestley had shown the existence and properties of Oxygen. The important doctrines of latent and specific heat had been discovered by Black. Cavendish had shown the existence of Hydrogen as a distinct fluid, and had succeeded in the decomposition of water. Lavoisier had demonstrated the chemical changes involved in combustion and evaporation. Dalton had explained the properties of vapors and gases, and especially had discovered the law of combination in definite proportions, and of chemical equivalents. Cuvier in the meridian of his glory was building up the great science of Comparative Anatomy, and connecting the animal structure of long ages past with that of the living present. Davy and Berzelius and Gay Lussac were just entering on their several careers of discovery, which have rendered their names illustrious in the history of science. The science of Geology, as now understood, had then no existence.

With these facts before him, President Dwight saw the importance of making Chemistry and the natural sciences a part of general education. He discerned in his young friend those endowments and aptitudes of mind which promised success in these departments of science. He accordingly, in 1802, urged upon Mr. Silliman the expediency of abandoning the profession of the law, and of devoting himself to science. The suggestion was adopted, and the corporation of Yale College in that year elected "Benjamin Silliman, Esq., as the Professor of Chemistry and Natural History." It is our impression that there were at that time only two of our collegiate institutions where instruction was given in Chemistry, — those of Harvard College and the University of Pennsylvania.

Professor Silliman did not immediately enter upon the duties of his new office. He took time for preparation. Portions of two winters were spent in Philadelphia, as a student of Dr. Woodhouse, prosecuting his professional studies under advantages which probably no other American city could then furnish. Dr. Hare had at that time just invented and brought into use the Oxyhydrogen or Compound Blowpipe, which generated an intensity of heat hitherto unknown to the Laboratory, and gave to science a new and efficient means of research. It was fortunate for both, perhaps, that Professor Silliman was engaged with him in many experiments with this instrument. His first course of lectures was given in the winter of 1804, and repeated in 1805. With a view more fully to prepare himself for the duties of his professorship, he determined to avail himself of the advantages of foreign schools of science, and accordingly sailed for Europe in the spring of 1805. He remained abroad somewhat more than a year, attending lectures in London and Edinburgh, and devoting a portion of his time to travelling. In 1810 he published an account of his travels, entitled "Journal of Travels in England, Holland, and Scotland in 1805–06, in 2 vols. 8vo," which, in a subsequent edition, was printed in 3 vols. 12mo. This work is replete with useful and interesting matter, reflecting in an easy, perspicuous style the impressions of a diligent observer of men and things. It was widely circulated, and gave to the author an agreeable introduction to the reading public.

During this residence abroad he had the opportunity of becoming acquainted with many of the foremost scientific men of that period. Among others he mentions Dugald Stewart, Professors Hope, Murray, Playfair, Jamieson, and Seymour. In the preface to his Treatise on Chemistry, he acknowledges special obligations to his former teachers, Professors Murray and Hope of Edinburgh. Nor did he fail,—as who would?—to embrace the opportunity of listening, in the House of Commons, to the eloquence of Pitt and Fox, Sheridan and Windham.

On his return from Europe, in 1806, Professor Silliman resumed the duties of his professorship, embracing chemistry, pharmaceutics, mineralogy, and geology, which he continued to discharge with ability and rare popularity for a full half-century. He did not during this entire period have under his charge all these subjects, but it was only in 1855 that he relinquished his post as a college teacher. Very few men in any department can show a scientific career so laborious and so long continued.

Of the results of the instructions given to his college classes, I shall speak further on. But I may here say, that it was not the habit of his mind to confine himself to any single inquiry, or to any narrow routine of study. Whatever of scientific interest presented itself in any direction was sure to attract his attention. Though not to be placed in the list of great discoverers, he was among the earliest, in the progress of chemical science, to verify the discoveries of others, and so to illustrate and incorporate them in the body of science as to make them accessible to his pupil. The discovery of new truths is restricted to the fortunate few ; the diffusion of them belongs to the practical, diligent many. A brilliant reputation crowns the former; comprehensive usefulness is the reward of the latter. Professor Silliman, pursuant to the practical bent of his mind, appears to have made the diffusion of knowledge his chosen field of labor. He never lost sight of the general interest and public utility of science, yet this characteristic of his mind did not prevent him from prosecuting at times laborious original researches. In 1811 he instituted an extended course of experiments with Hare's blowpipe, in which he succeeded, as he tells us, in melting lime, magnesia, rock-crystal, gun-flint, corundum gems, and a long list of the most refractory minerals, "the greater part of which," he adds, "had never been melted before."* A detailed account of these experiments was published in the Transactions of the Connecticut Academy of Arts and Sciences, in 1812.

On receiving intelligence of Sir Humphrey Davy's discovery of the metallic bases of the alkalies, he immediately repeated his experiments, and "obtained, probably for the first time in the United States, the metals potassium and

* Journal of Science, Vol. I. p. 99.

sodium."* While conducting some experiments with a powerful Hare's Galvanic Deflagrator, in 1811, he observed that the charcoal "point of the *positive pole*" instantly "shot out" toward the *negative pole.* And on further examination he found that there was a corresponding cavity on the point of the negative pole. He hence inferred that there was an *actual transfer* of the matter of the charcoal points from one to the other. He further found, on careful examination, that the charcoal *was fused.* An account of this interesting discovery is given in the fifth volume of the Journal of Science. It is claimed for Professor Silliman that he was the first to establish *this transfer* of the *particles of carbon*, and the first also to *fuse carbon* in the voltaic arch.

Professor Silliman early felt the necessity of having some medium of communication between the cultivators of Physical Science and Natural History in different parts of the country. He saw how much science abroad was indebted to such journals as "Thompson's Annals of Philosophy" in England, and the "Annales de Chimie et de Physique" in France. He resolved on establishing a similar journal in this country, which should present to the public at brief intervals the results of scientific research, and by that means accomplish the two objects of diffusing information and stimulating inquiry. He accordingly, with pledges of assistance from a respectable corps of contributors, commenced the publication of the "American Journal of Science," more popularly known as "Silliman's Journal." The first number bears the date of 1819. For twenty years he was the sole editor, and the senior editor for eight years longer. He continued it under many embarrassments, and with far less patronage than its merits deserved. For a long time his own labors, which were never small, may almost be said to have been gratuitous;

* Am. Cyc., § Silliman.

and not unfrequently the expense of bringing out the numbers became a charge upon his private funds, at least till generous friends came to his relief. Whatever this journal has done for American Science at home and abroad, and how much it has done every one knows, it was the creation of Professor Silliman. Under the management of a man of less energy, less confidence of hope, less devotion to the interests of science, less practical tact and administrative ability, the American Journal of Science would probably be remembered only as a premature and unsuccessful attempt to follow in the footsteps of older and more scientific nations.

Professor Silliman wielded a prolific pen. In 1820 he published, in a duodecimo volume, the incidents and observations of a journey from Hartford to Quebec. This journey was performed by slow and easy stages, and the volume abounds in pleasant descriptions of the different towns through which he travelled, with historical reminiscences and notices of geological formations.

In 1829 he edited an edition of Bakewell's Geology, and added, in an appendix, a copious compend of his own course of lectures to his college classes. In this compend the author presents a clear and simple statement of the facts and principles of the science as they were then understood, basing his arrangements, as he remarks, "upon the great outlines of the Wernerian plan." Without following any one as an authoritative guide, he evidently accords to Werner a degree of merit which later writers, as I apprehend, have not found reason to bestow. He says, in his Preface, "It has become fashionable to decry Werner; but, without being his blind admirer, I may be permitted to ask, Who has done more for Geology, and who has done it better?"

In the controversy so long and so fiercely maintained respecting the Mosaic account of the Creation, he gave his decided support to the defenders of Scripture. He saw no necessary discrepancy on that subject between the teachings of science and the teachings of revelation. "The writer," he remarks in his preface, "after studying the subject for many years, has formed the opinion that the geological facts are not only not inconsistent with sacred history, but that their tendency is to illustrate and confirm it." With respect to the Mosaic account of the *Deluge*, he expresses himself even more strongly. "Geology," he says, "fully confirms the Scripture history of that event."

In 1830 he published an elaborate treatise on General Chemistry, in two volumes, octavo, entitled "Elements of Chemistry in the order of the Lectures given in Yale College." It lays no claim to originality in the treatment of the subject. From the results of his own laboratory, and from his much reading, he gathered up all the known facts and laws of the science, and embodied them in a form which he deemed most convenient for instruction. His object, as expressed in his own language, was "to unite copiousness with condensation, perspicuity with brevity, and a lucid order and due connection of subordinate parts with a general unity of design." The work was, we believe, well received by the scientific public, and somewhat extensively used for the purpose of elementary instruction. In the judgment of a contemporary journal entitled to high consideration, "it was a work that was needed," and that was "eminently adapted to the objects for which it was prepared."

In 1851 Professor Silliman made a second visit to Europe. Forty-five years had wrought great changes in the scientific circles familiar to his first visit. Many whom he had once known were no more. He had the happiness, however, of personally meeting many others whom he had long known as scientific correspondents. The account of this visit was given to the public in three volumes, duodecimo, in 1853. It was a work well stored with careful observations and interesting narratives, thus recalling many agreeable reminiscences in the minds of those who have visited the same scenes, and communicating much useful information to those who have not. To show the public appreciation of this work, we may remark that, while new works of the same general description have been constantly teeming from the press, this has already passed through six editions.

I have thus briefly referred to the published works of Professor Silliman. But these do not, by any means, comprise the whole of his scientific labors. His special field was the diffusion of science; and his special gifts and acquirements made him one of the most popular scientific lecturers in the country. His commanding presence, his urbanity of address, his wealth of knowledge, his ready and graceful elocution, were all fitted to win the public favor, and secure for him a large and delighted audience wherever it was his pleasure to speak. Without being profound or original, he selected from the great storehouse of knowledge, all familiar to him, so judiciously, and threw such an enchantment around his theme, that all felt a kindling of enthusiasm as they listened. They drank in the doctrines of latent heat and chemical equivalents, saw through all the forms and laws of crystallization, and could plainly read in minerals, and fossils, and rocks of the fields, the geologic eras which stretch back into the immeasurable past, where no human eye ever saw. It was the power of personal inspiration that seemed to quicken their intellects.

Between the years 1834 and 1845, Professor Silliman delivered courses of scientific lectures in nearly all the large cities of the country, ranging from Boston to New Orleans.

He gave four courses before the Lowell Institute in Boston, "Treated everywhere," says President Woolsey, in speaking of these lectures, — "treated everywhere with the highest consideration, welcomed by the numerous sons of Yale dispersed through this broad land, he had almost a triumphal progress, and widely diffused, it is believed, a taste for physical science."

Such is a brief summary of the scientific labors of our deceased associate. I can recall but few men who have labored so long, and done so much. But my task would be incomplete without some additional remarks illustrative of his character and services.

In the general retrospect of his life, one cannot but be struck with the amount of labor which he performed. The superintendence of his journal, preparing its articles, carrying on its large domestic and foreign correspondence, and looking after its insufficient finances, was itself no easy task. But to this he added almost daily lectures to his classes, often requiring much preparation, and yet found time to prepare books of instruction, and lectures for the public.

It seems to me that the *utility* of *science*, in its broadest sense, was always uppermost in his mind. He is always tracing abstract principles to their practical applications. In his several books and papers, he aims at the accomplishment of useful ends. His style of writing looks to this. It is direct, simple, perspicuous. Its only object seems to be to expound clearly the subject under consideration. It is business-like. It reads as if the author had too many important matters on his hands to occupy himself in the mere refinements of style.

We have already referred to the distinction between the discoverer of new truths and him who diffuses them abroad and gives to them their practical applications. The former is testing the powers of nature by the crucible and the balance and all those reagents which bring into play the affinities of matter; the latter is acting upon the intellectual powers of the community, and putting in motion far and wide over the land those mental agencies which result in wider general knowledge, higher culture, sounder practical judgments, and more productive industry. It is sometimes difficult to say which of these two classes of laborers confers the largest benefits upon the world. Nor, indeed, need we attempt to decide upon their respective merits. It is sufficient that they are both necessary to the highest ends of science. It was the fortune of our friend to act, for the most part, as the diffuser of knowledge. And by what criterion shall we estimate the obligations which we owe to him in this respect.

It was said of Dr. Black, by a very competent judge* of his scientific merit, that "his influence on science was chiefly exerted through the medium of his pupils and of his intercourse with general society." With equal truth may this be said of Professor Silliman, and especially when we consider the vast extent of his field of instruction. Among the pupils of half a century how many have caught the enthusiasm of the master and given their energies to science, and placed their names high on the list of its honored cultivators! How many hundreds and thousands of those who, in different cities, have listened to his eloquent lectures, have learned to appreciate science, and gather refined pleasure from its culture, and give to it their hearty patronage! How regularly and how widely has his Journal carried to the reading public intelligence of the latest discoveries, and the best practical applications of science!

Considering all this, who shall say that his efficient influ-

* Prof. J. D. Forbes, Encyc. Brit., 6th Dissertation, p. 927.

ence has not been felt in every institution of learning, in every profession, nay, in every workshop, and every cultivated field in this broad land of ours.

It is undoubtedly true, as has been stated by one of his accomplished colleagues, that "his mind was of the rhetorical, not of the analytical cast." He seldom expended his energies in attempting to unravel the dark and tangled web of science. Profound, original thought was not the productive element of his mind. He followed in the footsteps of the explorer, and quickly gathered up whatever was valuable in the way, and sent it forth on its mission of utility. In view, then, of what he has done for Chemistry, for Mineralogy, for Geology, and for the general diffusion of knowledge, we may well say that the name of Silliman will ever be an honored name in the annals of American Science.

Thus much we think may be justly and pertinently said of the scientific career of Professor Silliman. But he was more than a scientist: he was a *citizen*, a *patriot*, and a *Christian*.

As a *citizen* we believe he was universally honored and beloved. He was in every good work. His kindly interest in those about him, his uniform urbanity, his readiness to oblige, made friends of all who had the opportunity of knowing him. It will not be too much to say that his fellow-citizens by common consent regarded him as their first citizen. He was their representative man. His presence added dignity to every assembly. His counsels were listened to as words of patriarchal wisdom and authority.

As a *patriot* it is well known how ardent he was in the defence of the Constitution and the laws, when they were imperilled by the machinations of disloyal men. When the conflict arose between slavery and freedom in Kansas, he threw the whole weight of his influence into the scale of freedom. He saw clearly that the ambitious designs of the slave power must be strenuously opposed and defeated at that point. He was satisfied, as many others were, that lukewarmness or indifference then might be fatal to the interests of freedom throughout the republic for generations to come. That was one of the turning-points in our national destiny. A profound regard for justice and the rights of humanity and the honor of the nation urged him to do everything in his power to prevent the further extension of slavery in the Territories.

When the purposes of the slave power culminated in armed secesssion, there was but one course before him. It was to sustain the government and put down the rebellion by every means in the power of a great and free people. In the disruption of the government, and the establishment upon our borders of a political power based on human slavery as its "chief corner-stone," he saw nothing but national humiliation, disaster, and ruin. His country, entire and undivided, its Constitution and equal laws securing freedom and protection alike to all, — these were the objects of his profound regard. And higher objects than these the loftiest patriotism has, perhaps, never achieved.

I have yet to speak of our associate as a *Christian.* Without this, all that I have said and all that could be said would leave his real character unfinished, — nay, almost distorted and deformed. Early in life he became convinced of the truth of revealed religion and of his personal duty in response to its mandates. He made a public profession of his faith in Christ while a tutor in college, and became a member of the College Church. For more than threescore years, in all the relations of life, he exemplified the virtue of the Christian character. At the time of his death he was, with one exception, the oldest member of the College Church. If I may judge from the testimony of others, the lustre of his Christian character grew brighter and brighter as he drew towards the end of his pilgrimage. The contemplation of nature, no less than the sublime teachings of Scripture, inspired him with true devotion. His death was but the beautiful termination of a conscientious religious life. With physical powers far less impaired than is usual to his age, and with mental powers still fresh and active, he died in the bosom of his family almost without warning, and without pain, on the morning of Thanksgiving day, November 24, 1864, in the eighty-sixth year of his age. He had just closed his accustomed service of prayer and praise, with a heart full of gratitude to God for the blessings bestowed upon him, he was uttering words of endearment and affection to members of his family when the summons came, and he was numbered with the dead. In contemplating a scene so touching, who can refrain from exclaiming, in the language of Scripture, "Let me die the death of the righteous, and let my last end be like his"?

Professor Silliman was twice married. He was most happy in his domestic life, and in the children and grandchildren who will delight to honor his memory, and bear onward the torch of science which he has laid down.

[illegible]

XI.

# BIOGRAPHICAL NOTICE

OF

# EDWARD HITCHCOCK,

BY J. P. LESLEY.

[Read Aug. 9, 1866.]

# BIOGRAPHICAL NOTICE

OF

# DR. EDWARD HITCHCOCK.

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We cherish the memory of the good and wise, not because they are rare, for the world is full of them; they exist in every society and grade of society, in every business and profession, even in the limited circle of acquaintanceship of every respectable person. But we cherish the memory of the wise and good, because it is dear to us, because we have been taught, encouraged, aided, cheered, blessed, and ennobled by them; and their memory is a continuation of their living words and deeds, and we can make it an heirloom for our children. A man to be remembered is a man to be spoken of. Even in the most barbarous aboriginal stages of the history of mankind, men here and there appeared, whose biographies, could they be written, the world could make good use of. In our own days of high civilization, almost every active life deserves a record. But the law of natural selection rules in literature also, and the struggle for posthumous fame, like the struggle for animal life, is crowned only in the persons of the best competitors. One of these favored few we celebrate this evening.

A man of religion, a man of science; in both, a docile student and an expert teacher; in both, enthusiastic and self-sacrificing; in both, gentle, persuasive, affectionate, sympathetic; in both, shackled by traditions which he both feared and hated to break, yet vigorously holding up his shackles and keeping abreast and in some respects ahead of the advancing age.

Such was Edward Hitchcock, one of the fathers of American Geology, and one who continued to the close of a long life to be an original investigator. A man of ardent fancy, impulsive, curious and credulous; docile and teachable beyond any adult man of science I ever knew; modest to a marvel; yet, with all this, a man of sufficient self-reliance and determination for the most important practices of life, patient of difficulties, persevering and industrious for final success in any undertaking, sound in judgment and disciplined in temper, a friend to all, and the friend of all, his whole career laid claims to eminence, which would have been pre-eminence in American Theology, had it not been for the interference of his science, or in American Science, had it not been for his devotion to the ecclesiastical and financial interests of the College, which he saved from premature decay, and refounded upon the deliberate sacrifice of his own ambition.

Edward Hitchcock was born in 1793. His father was a small farmer who had learned the trade of a hatter, had fought in the Revolutionary war, and was a deacon in a congregational church, a man of strong mind and steadfast piety, a genuine New England Puritan.

His mother was a high-bred New England woman, one of those perfect creations of divine skill by which the development of our race is guaranteed, — a woman of quick intelligence, pure heart, and exquisite sensibility. The son was therefore born both to religion and to science. The keys of the spiritual and of the physical worlds were hid beneath his pillow. He heard told every morning the tremendous dreams of the Church, and became a poet. The Unitarian controversy made him a thinker. The Comet of 1811 made him an observer. Step by step his imagination and his understanding were unfolded, alternately and together; and neither at the expense of the other. The times were propitious. The nineteenth century opened when he was but eight years old, the age when the brain is fully formed and fit to begin its work. The harvests of New England are neither corn nor wine nor oil, but self-reliance and independence, economy and energy, intelligence, high aspirations, the power to learn and the right to teach, insight into the worth of ideas, and a scorn of facts which do not submit to universal laws, a curiosity bounded only by the limits of the possible, and a veneration for man as man, — the master, not the slave, of circumstance. These were the influential forces which worked around our young philosopher and poet, educating him to become the intellectual teacher of his village (Deerfield) at the age of twenty-two, the religious teacher of the church at Conway at the age of twenty-seven, Professor of Chemistry and Natural History at Amherst at the age of thirty-two, chief of the Geological Survey of Massachusetts at the age of thirty-seven, Doctor of Laws from Harvard, and representative of American Science as first President of the American Association for the Advancement of Science at the age of forty-seven. At fifty-one he represented both science and religion as President of Amherst College, and continued to be thus one of the foremost men of his age for twenty years longer, until his death in 1864. A venerable life!

There is something not a little awful in exploring the domains of a life that is not ours. It is a labyrinth illuminated with the faintest twilight; a group of caverns to be surveyed with ropes and torches, haunted by romance, and stocked with images to which the excited imagination of each spectator gives some different shape. The principles, the motives, of another man's soul are to me underground rivers, flowing in undiscernible abysses; and his thoughts flash before my eyes like Protei in the waters of the cavern at Adelsberg. What can I know of their birth, or of their true shapes and natures? I can see that many of them are blind; but I must argue that they are all well fitted for their native home. The good and the bad, the wise and the foolish, all add alike to the beauty of the entire universe. The biographical critic therefore runs a thousand risks, either of impertinently maligning the creature, or of presumptuously arraigning the Creator. Neither is all gold that glitters; and the biographer must not expect to be believed when he returns to the daylight of crowded life and describes his Wier's Cave as filled with exquisite carved statues of Washington, or the glittering crystals in the roof of his Mammoth Cave as equalling, in their brilliancy, number, and effect upon the senses, the stars in a tropical sky. Too much sensational biography has been allowed. Individual souls are worth no more to the race than individual soldiers to an army. Even in camp the waste is ten per cent. But the moment the army moves, the waste becomes thirty per cent. and forty per cent. Such is the waste of souls in time of spiritual excitement, in revivals of literature or religion, and in the periodical advancements of national politics towards a perfect socialism. Yet the histories of nations lost, and the biographies of souls wasted, deserve better to be written, because fuller of adventure, and therefore of instruction, than those of Rome and Cæsar. But the muse of history can only write in presence of its monuments. What botanist could succeed, were he to study only the fallen trunks and macerated leaves of the forest? The monuments of a life are its only guaranty of immortality; dim, mystical and fragmentary though the hieroglyphics be from which they that come after are to make out the complexity and grandeur of the character of him who has gone before.

The man whose eulogy we read to-night has left us monuments enough. They stand in long lines above his resting-place, like the Menhirs of Carnac, vistas of monoliths. Some men are satisfied if they erect but one, like that which now lies broken into four fragments at Loc-Maria-Ker in Brittany, along the ground. The intellectual energy of other men survives in some Druid circle sacred to a single deity. But Edward Hitchcock lived a various life, and wrote of all that touched the deepest consciousness of his age. His monuments stand in parallel ranges. In Religion he wrote five volumes and thirty-seven essays, pamphlets, and tracts. In Science he published fourteen volumes, five pamphlets, and seventy scientific papers, on Botanical, Mineralogical and Geological and Physical subjects, in journals and reviews. His works on Temperance are in three volumes and three smaller tracts. In early life he wrote a tragedy, the year the great Napoleon fell. And there are twenty-six titles given us of various other productions of his pen, which went to swell the current published literature of the times in which he lived. Other men write as much, and publish nothing. But who counts the half-cut stone still lying in the quarry as among the obelisks of Egypt? This man lived for his times, not for himself. He was no *dilettante*. The perfume of the flowering of his soul was not wasted on the desert air. He was no anchorite, but a true missionary both in religion and in science. He was not fond of that *dolce far niente* which confined the delights of the Decameron to a select circle of ladies, while the surrounding world was wretchedly perishing with the plague. He did not sympathize with the proud reticence of men of science who claim that the doctrine is esoteric; that to popularize science, degrades it.

What he learned, he communicated, like an apostle. And if, like an apostle, his zeal led him to act or teach an error, he was ready afterwards, like an honest man, to make his recantation, and advance the general intelligence in that way also. But he was saved from making great or many errors by the patience and precision with which he worked.

The best illustration of his precision is afforded by the history of his controversy with Mr. Blunt, the republisher of the Nautical Almanac in New York. In 1811 young Hitchcock had used the telescope of Deerfield Academy for observing the comet. "The subsequent winter," he says, "was in good measure devoted to a reduction of his observations, and, as he had access to few books, he was obliged to calculate by spherical trigonometry many elements which, at this day, are found in the tables of practical astronomy. The mere effort to form an accurate idea of the numerous spherical triangles he had to construct was an admirable discipline, and their accurate solution not less so." In making these calculations he was obliged to use Blunt's Almanac, on the opening monthly page of which this challenge was ostentatiously printed: "Ten dollars will be paid on the discovery of an error in the figures." The young astronomer amused himself by collecting such errors, and mailed his collection to New York. In spite of the placard their value was unrecognized. He then published the list in the American Monthly Magazine. Blunt's ire was roused; he hastened to explain that, although "one Edward Hitchcock had made the discovery of some few errors in the astronomical portions of his Almanac, the portion devoted to the practical use of sailors would be found to be perfectly reliable, and was a thousand times more important." The young astronomer was soon ready with another list, taken this time from the tables of lunar distances, practical enough on shipboard.

The publication of these twenty errors, and of thirty-five more six months later, were his only reply to the scurrilous attack of Mr. Blunt. True science received its proper reward. The boastful and stupid editor of the Almanac was compelled by public opinion to employ a competent person to recalculate the Almanac for 1819, and advertised the enlargement of his own ideas by prefacing in the new edition these more modest words: "It will afford much satisfaction and promote commercial advantages, if, on discovery of an error in any nautical work, publicity should immediately be given." No allusion, however, to "one Edward Hitchcock," — merely a presentation copy, in which thirty-five new errors were immediately discovered, announced, and acknowledged humbly by the editor. There is no estimating the value of such a bit of scientific history. When the young mountain poet of Israel encountered the giant Goliath of Gath, a slip of that young foot upon the rock, a quiver of the eyelid, would have changed the stream of history through all ages, and postponed the coming of Christ to save the world. But to the young poet himself, the prosperous issue of the adventure was more than the salvation of a world; for it made him the right arm of Israel, and the tongue of Christendom. The same law of the mutual intersubordination of the whole to the part, and of the part to the whole, however denied by the school of Buckle, holds good under all the disguises of modern socialisms. The young Hitchcock, in a moment of idle fancy, with the daring of a fresh observer who had never yet been punished for making a mistake, attacked one of the established institutions of the world, and, by his courage, clear sight, patience and good nature, introduced a practical reform which was felt on every ocean round the world, and, at the same time, lifted himself to the platform occupied by recognized and experienced men of science, where he continued to observe with the same patient precision, and publish with the same courage all he knew.

He says in his autobiography, reviewing the list of his publications, that it seemed as if he had written and published too much,— that, had he spent more time in preparing his productions, their literary execution would have been more creditable, and the thoughts more mature and effective; but the peculiar circumstances of his early life compelled him to a course which, probably, he adds, "were I to live my life over again, I should pursue essentially the same." But the subjects on which he wrote were novel, requiring original research, and the descriptions of them scientific accuracy rather than literary elegance. This is his self-excuse, gratuitous and unnecessary; for the style, especially of his later works, is sufficiently scholarly, and the order, as well as the expression, of his thoughts, lucid and complete.

This, however, is no place for the reading of a critical review of his geological or of his religious works. I can only group them in such a way before your imagination as to paint the foreground, the background, and the middle distance of his soul's life. In the foreground, the terraces of the Connecticut and Deerfield valleys, the fossil footprints on the quarries of Hadley, and the flattened pebbles of the gneiss; the middle distance full of the local geology of Massachusetts and Vermont, Martha's Vineyard, Portland and its vicinity, Texas, Western Asia, and the world at large, with a thousand physical and social subjects, all interesting to his active, serious, and affectionate mind; and in the background, Alps on Alps of sacred dogma and religious aspiration, with glaciers interspersed of cosmic speculations, and deeper vales of self-consecration, self-sacrifice, and beneficence, bearing their harvests of good fruit.

In the foreground of every life, distinguished from the common life of the crowd, lies some object characteristic and nominative, the seal and signature of that man's dæmon, by which he shall be recognized and spoken of forever. The print of a bird's foot on a slab of red sandstone is the *totem* of Edward Hitchcock. He was not the first to see these wonderful remains, nor even the first to see them with an eye of trained judicial and executive science. But though others built and owned the city, he carried off its gates upon his shoulders. His patience in examining these remains; his economical skill in collecting them; the taste and largeness of mind which he displayed in their arrangement, and the energy with which he pursued this new branch of Palæontology, until the world recognized its claims and learned its merits, entitle him to rank, at least, as the coequal of its true discoverer. Dr. Dean early convinced himself, and Dr. Hitchcock afterwards, that the vestiges were those of living creatures, birds wading on the estuary flats; and both together convinced the world of it. But, besides this, there was much more to do. Specific differences were to be determined. He, Hitchcock, determined one hundred and twenty species. Comparison with foreign specimens was indispensable. He made the finest cabinet in the world, and placed it at the disposal of students. He published plates and descriptions of its contents, so that geologists in other countries might discuss opinions. He exerted such an influence over the public mind that the State of Massachusetts became the publisher of the new department. No controversies will ever avail to divorce the name of Edward Hitchcock from that of Ornithichnology. His name has become itself an imprint — not a bird-track, but a bard-track — upon the rock. Sedgwick and the Cambrians, Murchison and the Silurians, Hugh Miller and the Devonians, Rogers and the Appalachians, Lyell and the Tertiaries, are not more household terms in the history of our science, than is "Hitchcock and the New Red Sandstone" of the Connecticut River Valley, with its beautiful trap ranges, Mount Tom, Mount Holyoke, and the rest of them; and its Robinson Crusoe footsteps in the sand of an age so ancient that the silence of the dawn of an eternity seems brooding in it, — broken only by the weird cries of these birds, or the horrid croaking of batrachians huge as our pachyderms, among whom they fed. This ancient mystery reminds one of the horrid stories of the haunted house of Pottsville, where the inmates would be sitting at their work, the doors would fly open, sighings would pass along the air, footsteps would be seen pressed into the soft plush of the carpet, but not a form possessing the solidity and heaviness of life could be once observed. Although the majority of these vestiges seem to have belonged to quadrupeds, yet a few of them were probably the tracks of bipeds; and even if these bipeds shall turn out to be reptilian in their principal features, and to belong to some synthetic type, like that expressed by the Solenhofen archæopteryx, the term "bird-track" will continue to be used for all of a trifid form, and Hitchcock will remain the great expounder of the difference.

His first account of them dates back thirty years. In 1836 he published his first description of the footmarks of Birds (Ornithichnites) on the New Red Sandstone of Massachusetts, in the twenty-ninth volume of Silliman's Journal. He followed it up with a description of those found in Connecticut in the thirty-first volume; a general table of fossil footsteps in sandstone and graywacke in the thirty-second volume; five new species in the first volume of the Transactions of the American Association; still new species, with descriptions of coprolites, in the forty-seventh volume of the

Journal; and an analysis of the coprolites in the forty-eighth volume. He described two more species in the fourth volume of the new series of the Journal, still more in the twenty-first volume. His first quarto volume on the Fossil Footmarks of the United States, from the Transactions of the American Academy, appeared in 1848, and additional facts respecting the Otozoum Moodii in the Proceedings of the Association for 1855. His quarto report on the Ichnology of New England appeared in 1858, with further remarks, in the Proceedings of the Association for 1860, and new facts and conclusions in the Journal for 1863. These are his monuments. Most men would consider them sufficient for one life. In his they merely mark an episode; but there were others: an episode only of his scientific life. I leave the notice of it here, with the remark that he worked in it almost alone, and that he has left it standing unaltered by the labors of others. His publications on this theme are not only classical, but standard. His determinations are of accepted authority, which no controversial doubts as yet obscure. I pass now to others of which this cannot be said,—in which he has been a disciple rather than a master,—and which are rather characteristic of the genius of the geologist, than influential in the progress of geology.

I refer first to the study of the Drift. In Structural Geology this is the great question of the day. The subject has extraordinary difficulties. Could we determine the cause of the drift deposits, it would explain much that is puzzling in all the formations, down to the very base of the Laurentian. The wildest speculations meet at this point of Geology. It is the horse-latitudes of the voyage. Forty years ago the Swiss geologists shocked the world with the announcement that all the giant blocks of primary rock which travellers see lying stranded half-way up the Jura had been carried thither by a forward expansion of the glaciers of the Alps, invading, oversliding, and deeply burying the entire plains of Switzerland. Twenty years ago Mr. Agassiz, having previously shown the Scotch and Welsh geologists the traces of a similar universal glacier, which once descended from their highlands and covered all Great Britain, appeared upon this side of the Atlantic to establish among us the grand mythology of universal ice. From Halifax to the Fond-du-lac, and from the Ottawa to the Ohio, he found its vestiges. And now he covers with it the entire water-plains of the Amazons, the Orinoco, and the La Plata, from the shores of the Andes to the sea, six millions of square miles of the earth's surface, a part of it directly under the equator and close upon the level of the sea.

But we are concerned, not with the truth of these ideas, but only with their introduction into America, and their partial adoption by Edward Hitchcock, towards the close of his life. I say their *partial* adoption, for in the discussions which ensued he exhibited his usual mixture of conservatism and love of new ideas. He was, as a man, both timid and adventurous. Adventurous and progressive where he thought he could see his way; hesitating and submissive to authority when himself in the dark. And this composition of adverse habits, held in balance by circumstances, not by will nor by genius, made him a representative man, — a geologist in whose writings one can read the halting progress of American Geology, — its ignorance of its own past history, its premature intuitions, its ill-bred waywardness and levity, its abortive investigations, its double-minded instability, its feeble conservatism, its energetic radicalism, the fertility of its fancy, and the haziness of its judgment, its patience to wait, and its power to work, for what it is as ready to abandon in a moment for something new.

The subject of Surface Geology, involving, of course, the question of the Drift, early claimed his attention, for his Geology of the Connecticut was published in 1823, after it had appeared as an article in the very first volume of Silliman's Journal, one year previous to Eaton's first report on the Geology of the Erie Canal, and Olmsted's first report of the Geological State Survey of North Carolina. At that time the only recognized agency to which the drift phenomena could be ascribed, was that of moving waters. Deltas, terraces, drift boulders, and polished rock-surfaces were all explained in a vague and poetical way by diluvial floods. The grandeur of the phenomena was not appreciated, but their nature was. When, ten years afterwards, the brothers Rogers got the first true glimpse of Appalachian erosion in its immensity of breadth and height, the aqueous theory swelled to commensurate proportions, just as the ice theory has grown to suit the geographical development of the drift appearances.

Had Dr. Hitchcock been more of a poet, and less of a Yankee, he would have adopted an hypothesis similar to that of the Rogerses, and been hampered by it all his life. But he soon detected traces of another agency, and although the absence of Alpine summits from New England, and the distance at which the northern icebergs melted from its coasts, deprived him of opportunities for coming to a lively consciousness of his suspicions, they prepared him to accept the first instructions on the subject which were sent to him from abroad. He always maintained that he got his first clear views of the joint action of ice and water from the researches of Sir James Hall, although Murchison, in his anniversary address before the London Geological Society in 1842, accords the honor of inventing the glacio-aqueous theory, as Hitchcock named it, to Peter Dobson, of Vernon, in Connecticut, whose first public communication on the subject appeared in the tenth volume of Silliman's Journal, in 1826, and whose letter to Dr. Hitchcock, in 1837, the latter never answered, but kept for six years among his papers, and only sent it for publication in the Journal in 1843, the year following that of Murchison's public indorsement of Mr. Dobson's views, as "a short, clear, and modest statement of the best glacial theory, — the essence of the modified glacial theory at which geologists (says Murchison) have arrived after so much debate." Mr. Dobson described certain red sandstone boulders, too angular to have been rolled by floods, and scratched upon their inner sides, "as having been dragged over rocks and gravelly earth in one steady position"; adding, "I think we cannot account for these appearances unless we call in the aid of ice as well as water, supposing that they have been worn by being suspended, and carried in ice over rocks and earth under water."

These views of Mr. Dobson had been twenty years on record, but neglected, when they were thus quoted and complimented by the highest authority in Great Britain. It was at one of those epochs of excitement which occur periodically in the history of every science. Agassiz had appeared at Edinburgh; and for him to come was to see and conquer. Neither Murchison nor Lyell at that time accepted his glacial hypothesis in its broad applications to the circumpolar earth and the entire drift. But from that day onward the younger geologists, with Ramsay at their head, worked at it *con amore*, and strengthened its claims to acceptation by annual fresh discoveries; but they have finished by assigning to it such incredible omnipotence, and claiming for it such impossible activity, as its great master has never authorized. So that its reputation has been seriously compromised, and, as was inevitable, a reaction has set in. Our business hereafter will rather be to shield the glacial theory from undue disparagement than to complain of its extravagancies.

Dr. Hitchcock, with the enthusiasm of his nature, had at first expressed himself too favorably of this hypothesis. He retracted his expressions when called to account for them by Murchison. In an article which he sent to Silliman's Journal, July 5th, 1842, he insists that Murchison, in his Annual Address, ought not to have charged him with being an advocate of Agassiz's ideas in an unmodified form; for, "although the *Études sur les Glaciers* had, indeed, thrown a flood of light unexpectedly into his path, yet he had always thought, and still thought, that the moraines of America were produced by icebergs, and not by glaciers." "Whatever impression," he writes, "my language has conveyed, I now declare that I have never supposed it possible to apply the glacial theory of Agassiz to this country without modification. I stated [before the Association of Geologists at Boston, in April] my conviction that glacio-aqueous action has been the controlling power in producing the phenomena of drift, by which I mean the joint action of ice and water, without deciding which has exerted the greater influence."

These words give us a clear knowledge of the attitude of his mind in the presence of a discussion which filled the geological world with clamor at that time as it does to-day, and obliged every geologist to define his position. His slow and cautious disposition, disciplined by field work on the one hand, and by college lecturing on the other, restrained his imagination from adopting any large hypothesis, but confined him to a few familiar statements of mere fact. All he knew, or cared to know, or believed that any one would ever know, was, that a sheet of loose sand, gravel, and boulder rocks, bearing certain marks of moving force upon them, covered certain portions of the surface of the earth, and that this sheet had been spread out not wholly through the agency of water. "Whether the vast currents of water which must have been concerned were the result of the sudden melting of the thick belts of ice around the poles, as Agassiz supposes, or of the elevation of the regions around the poles, whereby an ocean was thrown over the land, agreeably to the views of De la Beche, or by the elevation of different parts of the continents from the ocean, while the greater part of those continents was beneath the waters, according to Lyell and Murchison, I do not feel competent to decide. I rest at present in the position that ice and water were both concerned, and am in doubt whether geologists will ever be able to go much further and remain upon the *terra firma* of logical induction. But to have reached this principle, in which I fancy nearly all geologists now agree, seems to me an immense advance on this subject, and for this progress in my own mind I feel greatly indebted to Agassiz." In another sentence he adds: "It will be seen that my mind was entirely unsettled as to the origin of the ice and water which have produced the drift, and that I was quite as favorably inclined towards the peculiar views of Mr. Murchison as of any other geologist."

These views, if they can be called so, were repeated by Dr. Hitchcock at the Albany meeting, in 1843, during a lively discussion on the Drift which was introduced by Dr. C. T. Jackson, with these words: "Many eminent men incautiously embraced the new theory, which, within two or three years from its promulgation, has been found utterly inadequate, and is now abandoned by many of its former supporters,"— a rash statement, as we all now see clearly enough. Dr. Hitchcock saw its rashness then.

At the Washington meeting in 1844 he read a paper on the Berkshire trains, discovered by Dr. Reid. All that he knew of the Drift he had published the year before in his annual State Geological Report. This was a special and remarkable case. It has never been elucidated. Dr. Hitchcock describes the phenomenon, but leaves it unexplained. His conclusions are all merely negative, and exhibit, in a striking manner, the cautiousness and fidelity of his scientific methods. 1st. The blocks of the trains must have been scattered during the latter part of the drift period, and by the drift agent, whatever that was. 2d. It is impossible to explain the case by any merely aqueous theory of drift. 3d. It is equally impossible to explain it by icebergs; or, 4th, by river pack ice; or, 5th, by the medial moraine of a glacier; or, 6th, by reference to the unexplained patches of angular fragments on the Falkland Islands, described by Darwin. "In short," he concludes, "I find so many difficulties on any supposition which I can make, that I prefer to leave the case unexplained until more analogous facts have been observed."

At the meeting of the British Association at Edinburgh, in 1850, he read a paper upon his favorite subject, the terraces of the drift period, after he had made a visit to Wales, where he at once recognized the marks of the former existence of glaciers up to a certain height, above which he recognized the marks of mere drift agency, and to Switzerland, where he confirmed his faith in the views which Agassiz had taught respecting the former extent of the grand glaciers of the Alps. But his Massachusetts experiences had so prepossessed him with notions of *modified drift*, that he thought he could see how the moraine matter of the plain of Switzerland had been subsequently thrown into terraces. He was therefore prepared, on his return to England, to accept Ramsay's conjecture that there were two glacial epochs, — one before, and the other after the drift.

The following year, 1851, he visited the White Mountains, and studied the effect of one of those tremendous stone-slides which have played so important a part in the reduction to its present level of the central *massif* of New Hampshire, upon the face of the rock *in situ* over which it passed. Seeing no glacial markings whatever, he concluded that any aqueous theory of diluvial scratches must be insufficient. He had evidently come to feel the difference between the weight of a stone-slide, whether in or out of water, and the weight of a glacier or iceberg.

Finally, in 1857, appeared his contribution to the quarto publications of the Smithsonian Institution, called Illustrations of Surface Geology, in which he sums up his knowledge of the Drift. In the first part he compares the terraces of the Connecticut Valley with those of other regions. In the second part he discusses the modes and consequences of river erosion; and in the third part he gives the results of his previous five years' field work, devoted to the study of glacial striæ and moraines in the valleys of Massachusetts and Vermont. These moraines, he says, seem to him, like the Swiss moraines, to have been modified and obscured subsequent to their creation by another agency, which he does not distinctly call that of the Drift, but, as he expresses it, "by the long-continued presence and the action of water, as the surface emerged from the deep." Even at this late date, he had no distinct hypothesis to offer. He declared that he agreed more nearly with Mr. Redfield's views than any others. He thought "that the phenomena of boulders and drift should be attributed to mixed causes, and that the theories which refer these phenomena to the several agencies of glaciers, icebergs, and packed ice, are, in truth, more nearly coincident than is commonly imagined"! He found it (as Desor expressed it) "difficult to conceive how glaciers could exist and move in a wide and level country like the north part of the United States." And he winds up with these fine words, worthy of the man and of pure science, unsatisfactory enough to the theorist, but full of instruction for the neophyte: "I am aware that I am in conflict with the views of eminent geologists on several points; as I am, indeed, with my own opinions as held several years ago. And yet, for a long time, I have stood chiefly aloof from the various hypotheses that have been broached respecting Surface Geology. But I could not refuse to follow where facts seemed to lead the way. It becomes me, however, to be very modest in urging my conclusions upon others. If they cannot adopt my explications, I hope they will, at least, find my facts to be of some little service in reaching better conclusions."

I must now say a few words about a third subject of investigation which may possibly in future time conduce more to his reputation as an original observer and bold thinker in geology than any other: I refer of course to his extraordinary statements respecting the distortion of quartz pebbles in conglomerate rocks. It is possible that I may be giving to the father credit for what is due to the son. But the two worthy geologists of Amherst represent to the world as yet but one Hitchcock, so amicably have they married their hammers and clinometers together.

It was at the last meeting held by the American Association for the Advancement of Science before the breaking out of the accursed rebellion in the States of this Union devoted to slavery,—the meeting of the summer of 1860, at Newport,—that a paper was read upon the conglomerate pebbles of the cliffs upon the southern shore of Rhode Island; attempting to show that they had been pressed out of their original globoid shape, flattened, elongated, curved into sickle-blades, and otherwise distorted, like fossil shells in semi-metamorphic rocks.

The opinion was expressed that this process might be found to have been carried on in all rocks, to an extent only limited by their degree of metamorphism. Of course the few geologists present at the meeting were not prepared to recognize the fact of such distortion in the evidently water-worn slaty pebbles laid before them as specimens. Nor will any geologist, I believe, who may have had a large experience solely among the conglomerate outcrops of No. IV., No. X., and No. XII. of the Palæozoic system, consent to this hypothesis of quartz distortion for an instant. I venture to assert that among millions of pebbles taken from the coal measure, or even from the middle silurian mountains, there cannot be discovered *one* bearing the marks of such distortion; although many of them offer plainly enough the evidences of wear and tear by fracture and the sliding of one stratum of the rock upon the other.

But if the geologist who has lived among unmetamorphosed conglomerates shall enlarge his experience by passing over into such a region as Vermont, where every magnesian rock has become either steatite, serpentine, talc-slate or dolomite, where every argillaceous clay has been changed into pholarite, or roofing-slate, and every sandstone into quartzite, he may come to listen more patiently to Hitchcock's theorem, — that gneiss is nothing more nor less than metamorphosed old conglomerates, wherein the pebbles have been pressed into laminæ composed of sections of the original matrix, themselves also pressed flat and thin. It is a bold assertion. It will demand abundant proof. The microscope will have something to say about it. Certainly it explains the folded veins of quartz in mica-slate, as no other hypothesis has done. It is consistent with the now accepted view of metamorphism by pressure, under the conditions of a moist, low heat. At all events, its ample discussion and copious illustration by Dr. Hitchcock and his son, in the pages of his report of the Geology of the State of Vermont, will remain a part of the classics of our science.

But the daring novelty of this excursion from the beaten track is heightened, when we see it as the short cut of an old man to regain the head of the procession. So far from leading him into isolation from his fellows, his path lay practically parallel with that of the best thinkers of the day. Most men of sixty-seven would tremble to adopt a new hypothesis. How few even at forty-five are able to be tolerant of newer principles! But Hitchcock could follow whereever Bischoff, Senarmont, Delesse, Daubrée, Sorby, and Sterry Hunt could climb. He could give up the igneous origin of granite, the extrusion of molten masses from a planetary nucleus of lava, the metamorphism of rocks by a high heat. He was no chamber geologist, and so kept his soul fresh in the open air that no new discovery could take him by surprise. "The opinion is now gaining ground," he writes, "that in many cases, perhaps in nearly all, they are merely stratified rocks, which by heat, or the joint action of heat and water, have lost their stratification and assumed new crystalline forms. They are, in fact, an extreme product of metamorphism." He no longer believed in those semi-theological central fires which no man has seen or can see; in those figments of the imagination, a thin floating pellicle or wrinkling epidermis to the earth; a universal granite floor, beneath the lowest sediments, azoic and aboriginal; a billowy deep of lava, generating earthquake cataclysms, and ejections of interminable branching dikes of trap and porphyry and syenite — which make the wall charts of Hall and D'Orbigny look now so old-fashioned, and which, in fact, the study of the Laurentian regions of the north, as well as the calculations of physicists, have proved to be mere myths and fables of an olden day. What is to replace them, we know not yet, nor how to do without them in our Structural Geology. The situation of the geological world, just now, is not unlike that of the theological, with its Schenkels and its Colensos, its Ecce Homos and its Leben Jesus. But this is certain, — the empire of truth is of perpetual divine right, and cannot be shaken, its motto being, *Fiat justitia, ruat cœlum.* What cannot be demonstrated, is fictitious; what has been disproved, is not useful. Better get our first conglomerates from aerolites which we can collect and exhibit in our cabinets than from an aboriginal granite floor which no eye has ever seen, no hammer struck, no foot-rule measured. Better redraw all the anticlinals and synclinals of our cross sections, than gabble about the plications of a crust which seems to be a demonstrated mathematical absurdity. But the fine life-history of him whose eulogy we read to-night tells us a better way. Facts take time. It is not hard for honest folks to wait. All harvests are not for this generation of sowers and reapers. It would be well for all of us, could our enthusiasm, like his, be tempered with conservatism, and our conservatism be fired by an equal expectation of better things to come.

Here, gentlemen of the Academy, I must most unwillingly stop. I cannot give you, as I should like to do, a description of the geological survey of Massachusetts which occupied Dr. Hitchcock from 1830, when he was appointed to it, to 1841, when he published his final report; and again from 1852 almost until his death; nor of the geological survey of Vermont, which he reorganized in 1856, and published in 1861. I cannot even tell you, in the few minutes that I feel are all I have to spare, how greatly we owe to his enlightened exertions that movement of the public mind which about forty years ago produced the early State surveys; nor how much to him should be ascribed the merit of originating, or rather pressing to concreteness, the abstract conception of the desirableness to science in America of some closer personal association of its votaries. To him, more than perhaps to any other man, is due the title of founder of the association of American geologists and naturalists which afterwards assumed the name of the American Association for the Advancement of Science, which will hold its next meeting next week at Buffalo.

Neither can I describe Dr. Hitchcock as a teacher. His Elementary Geology, first published in 1840, reached its thirty-first edition in 1860, and was then rewritten to express the progress which the teacher himself had made. His Geology of the Globe was published in 1853.

Shall I allude to his scientific monuments at Amherst? I need only say to such of you as have not yet beheld them, Go and see what one man can accomplish! All honor to his fellow-workmen there! But what Amherst is, Hitchcock has made it, — so says all the world, and what all the world says must be true. He was the master-mind at that centre. Let Amherst erect a statue to him in front of his Museum, — a statue of pure, white Vermont marble, for he was an American Christian, — a statue lifted high upon a cubical plinth of Quincy granite, for he was a simple-hearted son of Massachusetts, — a statue facing Holyoke, for the oblique denudation of its summit, he discovered, and the marvellous beauties of its panorama were his heart's delight. America has reached the time when it needs the idolatry of hero-worship to counteract its excessive tendency to individualization, and its intolerant democracy. And this man is one of America's heroes.

He was, I have said, in some respects even in advance of his age. His theology was gentle, tolerant, and liberal. He was one of the first to recognize the claims to the honest attention of good physical observers which those strange and apparently abnormal physical phenomena make which went at first by the name of mesmerism, and which have been, since then, followed up and obscured by the fanatical and hurtful dishonesties and shameless and tasteless profanities of the modern round table. The evils attendant upon this strange psychological epidemic he was as quick to see as any man, and to recognize also its capacity for warping and marring the youthful science of this land; but no amount of materialistic denunciation from the side of specific science could scare this fearless investigator from confessing his faith in what of fact there was, so far as he could discover it, nor from exercising the function of true science, — to wash his facts from the filth in which they were rolled, — to set them upon their appropriate shelves in the order of their worth.

He was by nature not a materialist and a scoffer, but a spiritualist and a believer. He believed in immediate creation by the fiat of God. He believed in the Hebrew poem of the creation as a substantial history. But even here he showed himself a man of genuine scientific spirit. He was obliged to interpret, and of course to criticise the Scriptures of his Church. But it is interesting to see how we always in this life return to our first loves. It was in his *later* years that he took up with zeal the defence of Genesis. He was forty-two and forty-four years old when he published, in 1835 and 1837, his pamphlet on the connection of Geology with Revelation, and his pamphlet on the historical and geological deluges. But it was not until 1851, when he was fifty-eight years old, that he gave to the world the first edition of his book, "Religion of Geology and its Connected Sciences," while his book of "Religious Truth Illustrated from Science" did not appear until six years later, when he was sixty-four years old. Of these and other works to effect an impossible harmonization of the developments of modern science with those of the ancient imagination others would speak to better purpose.

By his early personal devotion to field-work, — by his long and successful college instruction of successive classes of young men, — by the purity and simplicity of his personal nature, which roused no jealousy and excited no suspicion, — by his cheerful, modest, but enthusiastic publication at all times of every new fact which he observed, and every new idea which facts observed gave birth to, — and by his ready concurrence in every useful scientific enterprise, Edward Hitchcock shines a star of first magnitude in the heaven of American Science.

Do you expect me now to speak of his religion? I am not capable of the task. I hold it true that the Christian is a higher type of man than the Savant. His theology I reckon as of no account: it is his Christianity that crowns his brows with light, and arms his hands with power. He may be a Unitarian, as Edward Hitchcock was in early life, or he may return, as Edward Hitchcock did in after years, to the Orthodox notions of his fathers: it makes less difference than people judge of it. Science will settle all those discussions in good time. But no amount of natural science will stand a man instead of faith in a higher law and an invisible world. No zeal for science will compensate for the lack of temperance, charity, and truth towards our brother man. It was the hold he had upon the Christian heaven that made this man, working among us like a brother, walk among us like a father, trusted and beloved by all. I do not believe in his theology: it savors too much of the central nucleus of fire; it makes our earth-crust too insecure; it is too full of old wives' fables. But we must all believe in his religion, and feel how grandly it ennobled his science, and glorifies his happy memory.

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