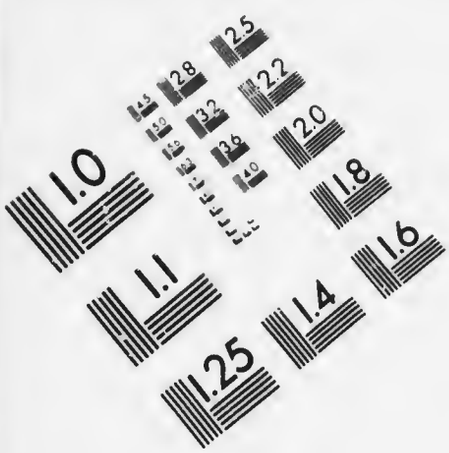
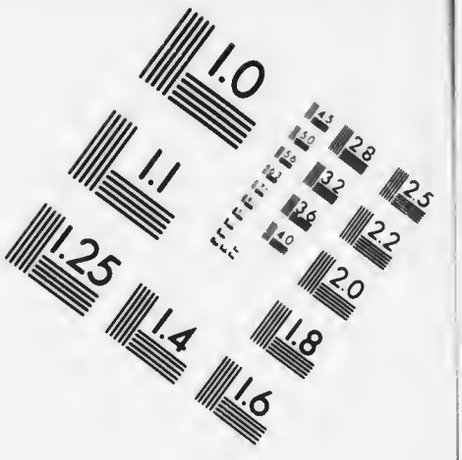
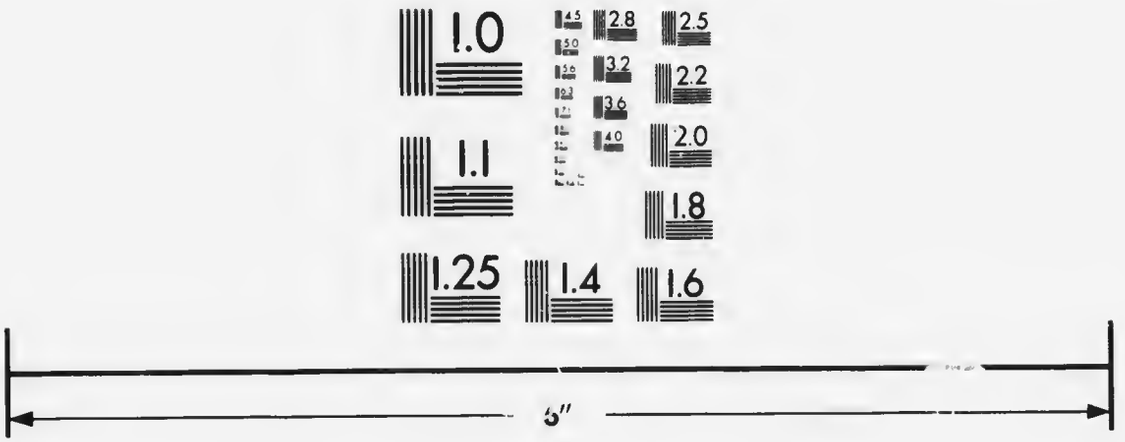
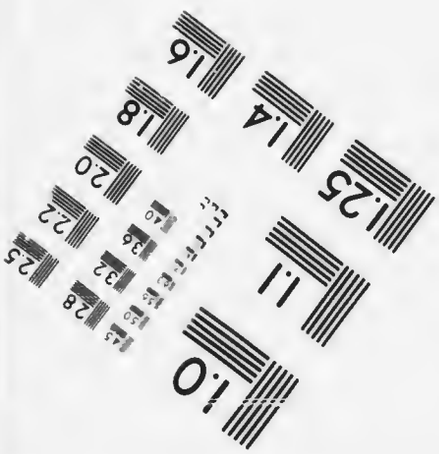
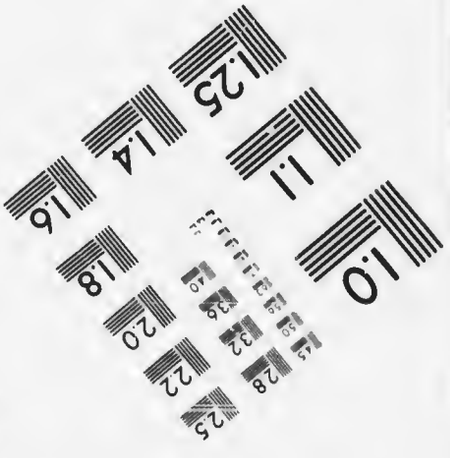



# IMAGE EVALUATION TEST TARGET (MT-3)




Photographic Sciences Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

CIHM/ICMH
Microfiche
Series.

CIHM/ICMH
Collection de
microfiches.

Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- ☐ Coloured covers/ Couverture de couleur
- ☐ Covers damaged/ Couverture endommagée
- ☐ Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- ☐ Cover title missing/ Le titre de couverture manque
- ☐ Coloured maps/ Cartes géographiques en couleur
- ☐ Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- ☐ Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- ☐ Bound with other material/ Relié avec d'autres documents
- ☐ Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- ☐ Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- ☐ Additional comments:/ Commentaires supplémentaires:

- ☐ Coloured pages/ Pages de couleur
- ☐ Pages damaged/ Pages endommagées
- ☐ Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- ☑ Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- ☐ Pages detached/ Pages détachées
- ☑ Showthrough/ Transparence
- ☐ Quality of print varies/ Qualité inégale de l'impression
- ☐ Includes supplementary material/ Comprend du matériel supplémentaire
- ☐ Only edition available/ Seule édition disponible
- ☐ Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

| 10X | 12X | 14X | 16X | 18X | 20X | 22X | 24X | 26X | 28X | 30X | 32X |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ✓ | | | | | | |



*(From Canadian Naturalist. Vol. X, No. 5.)*

# THE RELATIONS

OF

# THE NATURAL SCIENCES.

By T. Sterry Hunt, LL.D., (Cantab.) F.R.S.

(The President's address before the Mathematical, Physical and Chemical Section of the Royal Society of Canada, at the first meeting of the Society, Ottawa, May 27, 1882.)

The occasion which brings us together is one which should mark a new departure in the intellectual history of Canada. Science and letters find but few votaries in a country like this, where the best energies of its thinkers are necessarily directed to devising the best means of subduing the wilderness, opening the ways of communication, improving agriculture, building up industries, and establishing upon a proper basis schools in which the youth of the country may be instructed in those arts and professions which are among the first needs of civilized society. The teachers under such conditions can do little more than interpret to their pupils so much of the wisdom of the past, and of contemporary science, as may suffice for the immediate wants of the country, and will have but scanty leisure for original investigation in the field of knowledge. There are however never wanting earnest and curious minds who feel an almost irresistible impulse to labor in this field, to enlarge the bounds of thought, and to grapple with the great problems of man and nature. To foster this spirit, to encourage its beginnings, and to extend the influence of its example, should be the aim of wise statemen and legislators who seek to elevate their kind and ennoble their nation: knowing that the brightest glories and the most enduring honors of a country are those which come from its thinkers and its scholars.

The world's intellectual workers are, from the very nature of their lives of thought and study, separated in some degree from the mass of mankind. They feel however not less than others the need of human sympathy and co-operation, and out of this need have grown academies and learned societies devoted to the cultivation of letters and of science. The records of these bodies in Florence, in Rome, in Paris, in London, and elsewhere, are the records of scientific progress for the last three centuries. Such bodies do not create thinkers and workers, but they give to them a scientific home, a centre of influence, and the means of making known to the world the results of their labors.

It was with a wise forethought that more than a century since Franklin and his friends founded at Philadelphia the American Philosophical Society. Its planting then seemed premature, but its vigorous growth during a century has served to show that the seed was not too early sown. This, however, unlike many of the academies of the old world to which we have adverted, had no formal recognition from the state, and there came a period in the growth of the American Union when the need of an official scientific body was felt. Thus it was that nineteen years ago, in the midst of the great civil war, the American Congress authorized the erection of a National Academy of Sciences to which, as an American citizen, I have the honor to belong. The aim proposed in founding this Academy was to gather together what was best and highest in the scientific life of the nation, and moreover, to organize a body of councillors to which the executive authority could always look for advice and direction in scientific matters relating to the interests of the State. In that Academy—at first consisting of fifty, and now practically limited to one hundred members (a number which it has not yet attained)—the domain of letters is unrepresented; while the Royal Society of London is in like manner,—although scholars and statesmen seek the honors of its fellowship.—essentially an Academy of Sciences.

Our infant organization attempts a larger plan, and embraces with the mathematical and physical sciences, letters, philosophy, and history, imitating the Royal Irish Academy, which, like this, is divided into two classes; that of the Sciences, on the one hand, and that of Polite Literature and Antiquities on the other. The Institute of France, made up of five Academies, embraces the Fine Arts in its still wider scheme. The second class of our Society, with its two sections, aspires to cover the same

ground as the Academy of Sciences of the Institute of France, the Science division of the Royal Irish Academy, the Royal Society of London, and the National Academy of Sciences of the United States.

The two sections into which our second class is now divided, namely III. including Mathematic, Physic and Chemistry, and IV. embracing Biology and Geology, are, in their aims and their objects, closely related to each other, and widely separated from sections I. and II. which are devoted respectively to French and English Literature and History. Differences in language thus establish in the literary department of this society a natural division into two sections. In the department of the sciences, however, there is no natural basis for a similar division, and it will probably be found in the near future that subjects of common interest will draw more and more closely together our two sections until, as in the various societies which we have named, the distinction between mathematical, physical and chemical studies on the one hand, and geological and biological studies on the other, will be lost sight of. It seems to me therefore fitting that we should in this time and place consider the mutual relations of these two divisions, and inquire into the value of the distinctions upon which they have been based.

Apart from pure mathematic, which is based upon our intuitions of space, the sciences which now concern us have to do with material nature, and are properly called natural sciences. It is not their province to look behind or beyond the material world of nature, nor to grapple with the mystery of the Infinite with which, in the last analysis, the inquirer always finds himself face to face. Our various metaphysical systems are schemes which men have devised to solve this mighty problem, and to translate into intelligible language their efforts to comprehend it. What we call Nature is at once a mantle and a veil in which the spiritual both clothes and conceals itself. "I weave," Goethe makes the world-spirit say, "the living garment of the Deity." This phrase embodies a profound truth. All nature is living; it is, as the word *natura* itself, equally with its Greek equivalent, *physis*, implies, that which is growing, the perpetually-becoming or being born; and this sense, which underlies etymologically the words *natural* and *physical*, should never be lost sight of.

It is a common reproach in the mouths of certain cavillers at science that it does not explain the beginnings of life in matter.

That the plant and the animal are living, is evident to them, but they assume that the air, the water and the earth, the elements from which the plant grows and is fed, are dead; that life is a mysterious something which comes from without, and is extraneous to the organism. Perhaps we may trace the origin of this conception to the ancient legend, which appears in more than one form, of a human body fashioned out of dead matter and waiting for vivifying breath or fire. The student of inorganic nature, however, soon learns to recognize the fact that all matter is instinct with activities and finds that a great number of those processes which were formerly regarded as functions of organized bodies are really common to these and to inorganic matter. The phenomena of gravitation, of light and of electricity, the diffusion and transpiration of gases and liquids, the crystallogenic process, and the peculiar relations of colloids, are all, when rightly understood, manifestations of energies and activities which forbid us to speak of matter as dead. To all of these dynamical (or as they are generally called, physical) activities of matter, supervene those processes which we name chemical, and which give rise to new and specifically distinct inorganic forms. The attaining of individuality by matter, which has always seemed to me the greatest step in the progress of nature, is first seen in the crystal, but therein the forces of matter are in a static condition, except so far as certain dynamical relations are concerned. It is not until solid matter rises from the crystalline to the higher condition of the colloid, that it becomes capable of absorption, diffusion and even of assimilation; that, in a word, it assumes relations to the external world which show that it possesses an individuality higher than the crystal, and is, in fact, endowed with many of the activities belonging to those masses of colloidal matter which biologists have agreed to call living.

In these phenomena we have the first developments of individuality and of organization, and I think that the careful student who endeavours with a strong mental grasp to seize the true relations of things will see that we have here to do, not with a new activity from without, but with a new and higher development of a force which is inherent in matter, and thus manifests itself at a certain stage in chemical development. He will then, in the words of a philosophic poet,

> "See through this air, this ocean and this earth,
> All matter quick, and bursting into birth."

The adjective, quick, is here to be understood in its primitive sense of living, as opposed to dead, and aptly defines the notion which I have endeavored to convey. All the energies seen in nature, are in this view, but manifestations of the essential life or quickness of matter, whether displayed in the domain of what are called dynamical or physical activities, in chemical processes, or in the phenomena of irritability, assimilation, growth and reproduction which we may comprehensively designate as biotical.

When we have attained to this conception of hylozoism, of a living material universe, the mystery of nature is solved. The Cosmos is not, as some would have it, a vast machine wound up and set in motion with the certainty that it will run down like a clock, and arrive at a period of stagnation and death. The modern theory of thermodynamic, though perhaps true within its limitations, has not yet grasped the problem of the universe. The force that originated and impelled, sustains, and is the Divine Spirit, which

> "Lives through all life, extends through all extent,
> Spreads undivided, operates unspent."

The law of birth, growth and decay, of endless change and perpetual renewal, is everywhere seen working throughout the Cosmos, in nebula, in world and in sun, as in rock, in herb and in man, all of which are but passing phases in the endless circulation of the universe, in that perpetual new birth which we call Nature. This, it will be said, is the poet's view of the external world, but it is at the same time the one which seems to me to be forced upon us as the highest generalization of modern science.

The study of Nature in its details presents itself to the mind in a two-fold aspect,—as historical and as philosophical. The first of these gives rise to a General Physiography or description of nature, which we commonly call Natural History as applied to each of the three great divisions designated as the mineral, vegetable and animal kingdoms. This physiographic method of study in the latter two gives us systematic and descriptive botany and zoology, with their classification and their terminology; while the physiography of the mineral kingdom includes not only systematic and descriptive mineralogy, as generally understood, but those branches of geology which we designate as petrography and geognosy, or the study of the constituents of the earth's crust, their aggregation and their distribution.

The second aspect of the study of nature, which we have designated as philosophical, regards the logic of nature, or what the older writers spoke of as General Physiology. This, is sometimes appropriately termed Natural Philosophy, a designation which is the correlative of Natural History. With this method of study in the organic kingdoms we are familiar under the names of physiological botany and physiological zoology, which concern themselves with anatomy, organography, and morphology, and with the processes of growth, nutrition and decay in organized existences. The natural philosophy of the inorganic world investigates the motions and the energies of the heavenly bodies, and then, coming down to our planet, considers all the phenomena which come under the head of dynamic or physic, as well as those of chemistry. These various activities together "constitute the secular life of our planet. They are the geogenic agencies which in the course of ages have moulded the mineral mass of the earth, and from primeval chaos have evolved its present order, formed its various rocks, filled the veins in its crust with metals, ores, gems and spars, and determined the composition of its waters and its atmosphere. They still regulate alike the terrestrial, the oceanic and the aërial circulation, and preside over the constant change and decay by which the surface of the earth is incessantly renewed, and the conditions necessary to organic life are maintained." * Thus the physiological study of the inorganic world, or in other words, its natural philosophy, includes in its scope at once theoretical astronomy and theoretical geology or geogeny.

The two fold division which has been adopted in the scientific class of our new society does not correspond to that which we have just set forth; namely, of natural history on the one hand and natural philosophy on the other; nor yet, as might at first seem to be the case, to the more familiar distinction between inorganic and organic nature. Our section III. has been made to embrace, it is true, much both of the natural history and the natural philosophy of the inorganic world, including besides physic, and chemistry, both descriptive and theoretical astronomy, and mineralogy. This same section has also been made to include

---

* The Domain of Physiology, or Nature in Thought and Language, by T. Sterry Hunt; London, Edinburgh and Dublin Philosophical Magazine ([V.] xii 233–253,) for October, 1881.

mathematic, which in itself, does not belong to the domain of natural science, though in its applications it becomes an indispensable instrument in the study of nature, whether we investigate the phenomena of physic or of chemistry, or seek to comprehend the laws which regulate alike the order of the celestial spheres, the shapes of crystals, and the forms of vegetation.

Section IV, on the other hand, in its department of biology, includes alike the Natural History and the Natural Philosophy of the vegetable and the animal kingdoms. In this same section has, however, been included what we call geology, which is not a separate science, but the application alike of mathematic and of all the natural sciences to the elucidation of both the physiography and the physiology of our planet. So far as geology concerns itself with the history of past life on the earth, or what is called paleontology, it is biological, but in all its other aspects the relations of geology are with section III. The logical result of this complex character of geology should be either the separation of paleontology from the other branches of geological study, which find their appropriate place in our section III, or else the union of the two sections through this their common bond.

It will be noticed that in this brief survey of the field of natural knowledge I have not spoken of the technical applications of science, nor alluded to its important aspects in relation to the material wants of life. On this theme, did time permit, I might speak at length. There are two classes of motives which urge men to the pursuit of knowledge; on the one hand, those of worldly fame or profit, and on the other, the far nobler sentiment which has the finding-out of truth for its object. It would seem as if by a spiritual law, the great principles which are most fruitful in material results are not revealed to those who interrogate nature with these lower ends in view. Newton, Darwin, Faraday, Henry, and such as they, were not inspired by a desire for the praise of men, or for pecuniary reward, but pursued their life-long labors with higher motives, the love of truth for its own sake, the reverent desire to comprehend the hidden laws and operations of the universe. To such and to such alone does nature reveal herself. In the material as in the moral order, the promise of achievement is given to those who strive after knowledge and wisdom irrespective of the hope of temporal reward, and the history of science shows that it is such seekers

as those who have attained to the discovery of those secrets which have been of the greatest benefit to humanity. The admonition is to all, that we are to seek first for truth and for justice, and with this comes the promise that to those who thus seek all other things shall be superadded.

It is good and praiseworthy to labor to extract the metal from the ore, and the healing essence from the plant, to subdue the powers of electricity and of steam to the service of man. To those who attain these ends the world gives its substantial rewards, but far higher honors are instinctively rendered to those who by their disinterested researches, undertaken without hope of recompense, have revealed to us the great laws which serve to guide the searchers in these fields of technical science; to those who have labored serenely, with the consciousness that whatever of truth is made known by their studies will be a lasting gain to humanity. "Thus," to repeat words used on another occasion,* "it ever happens, in accordance with the Divine order, that the worker must lose himself and his lower aims in his work, and in so doing find his highest reward; for the profit of his labor shall be, in the language of one of old, to the glory of the Creator and to the relief of man's estate."

---

* The relations of Chemistry to Pharmacy and Therapeutics, an address before the Massachusetts College of Pharmacy, by T. Sterry Hunt: Boston, 1875