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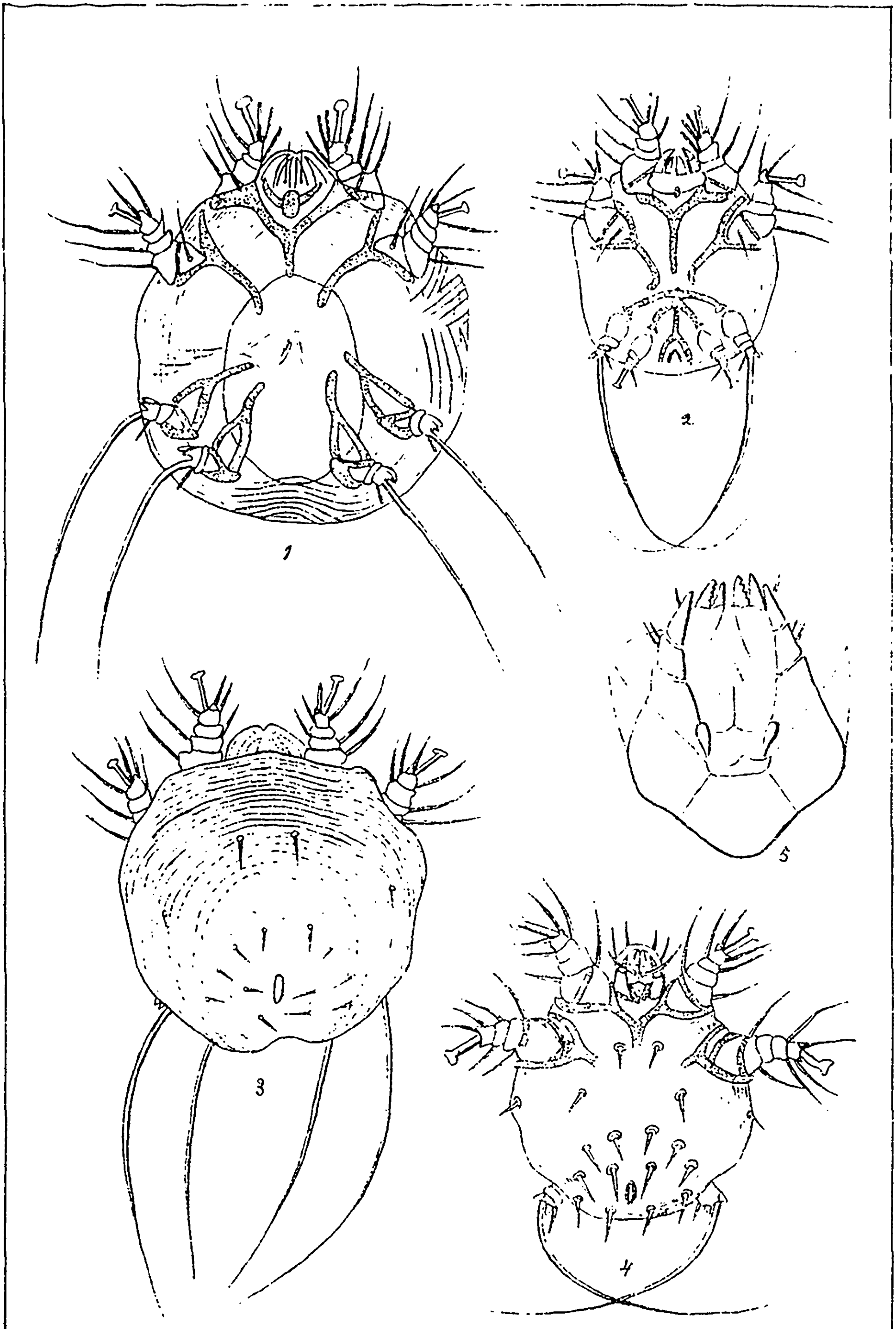

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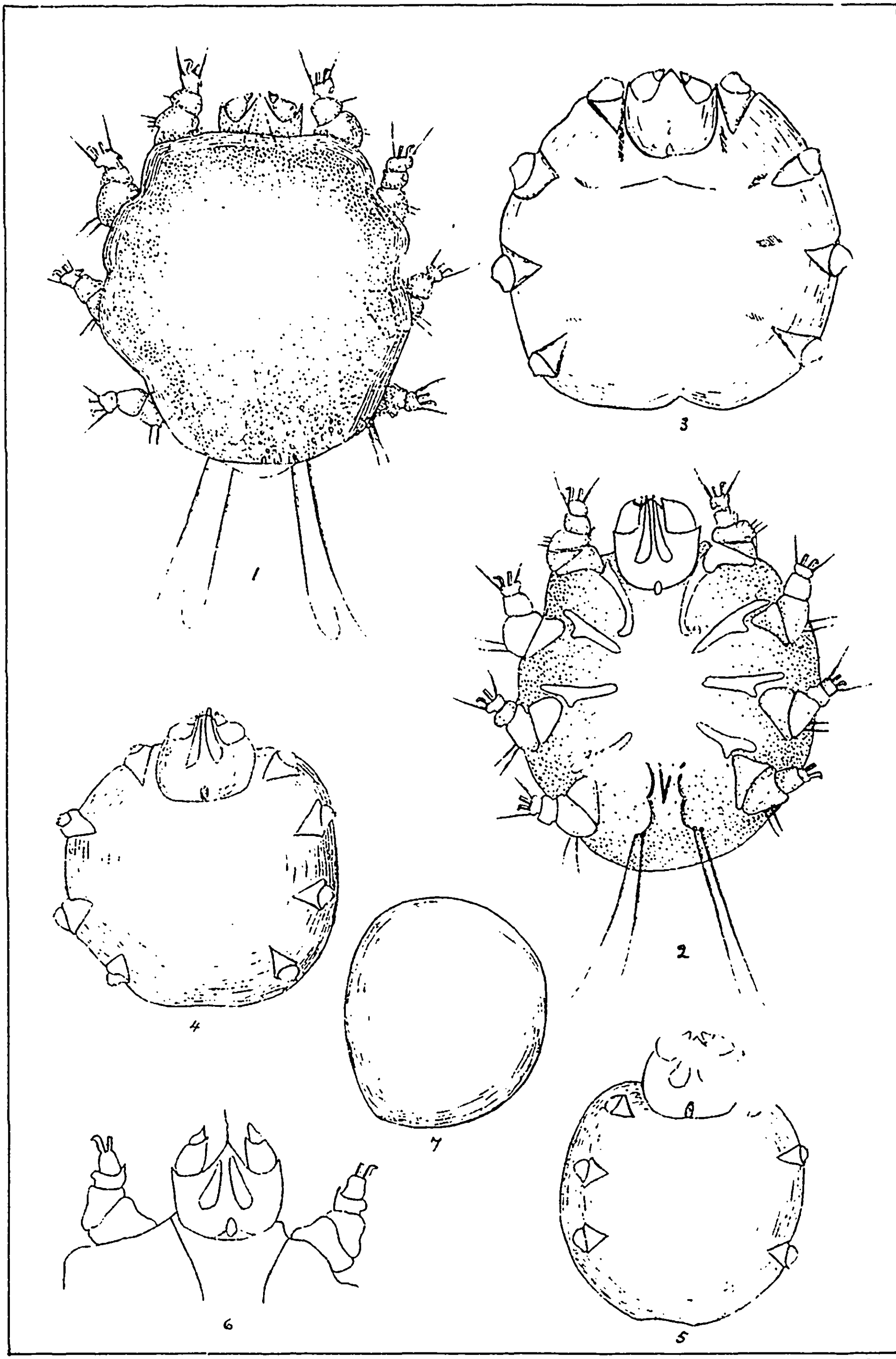

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THE PRESIDENT'S ADDRESS

FOR THE SESSION 1882-3.

BY J. M. BUCHAN, M.A.

[*Read at the Opening Meeting, November 2nd, 1882.*]

LADIES AND GENTLEMEN :

In appearing before you at this, the first meeting of the Canadian Institute during the present season, in order to assist in inaugurating what I trust may be an important and interesting winter's work, I desire in the first place to acknowledge the high honor which my fellow-members have conferred upon me in electing me to the presidency. I regret, indeed, that the duties which that honor imposes have not fallen into abler hands; but in undertaking to attempt to perform them I rely upon the kind forbearance and active coöperation of all who have at heart the welfare of this old, important and useful institution.

The value of associations of the kind of the Canadian Institute is very often not recognized by the general public. Nor is this to be wondered at. Our work is from its very nature not likely to make much noise or attract much attention. Nevertheless we discharge a function, the importance of which will at once be conceded when it is stated. The Canadian Institute serves as a rallying point for cultivators of all branches of knowledge, for original investigators, and for all who without themselves performing original work, or in any special sense cultivating knowledge, desire to afford every aid and encouragement possible to those that do. Here any one who has in any way enlarged the sphere of our knowledge will find some to appreciate and applaud his efforts. We do not, however, confine ourselves to appreciation and applause; as well as we can, we discuss and criticise; and every year a certain number of papers are selected for publication in our transactions. These transactions are sent to other similar societies in exchange for their published proceedings, and in this way our and their knowledge of what work is being done is kept up. We correspond in this way with 114 bodies in various parts of the civilized world. You will find on our tables proceedings and reports from various bodies in the United States of America, Mexico, South America, the British Islands, France, Spain, Italy, Belgium, Holland, Germany, Austria, Denmark, Norway, Sweden, India, Australia, and other countries, giving us information as to what the learned world is doing everywhere in all departments of inquiry. These are of great value to the specialist, inasmuch as they enable him to ascertain what other specialists in his department are doing. We are in this way a member of a great federation of learned societies, each of which, as far as practicable, coöperates with all the rest, and whose work, when summed up, amounts in each year to a great total, however insignificant the contributions of individual bodies may be. The existence of these learned societies is one of the marked features of the history of modern times, and both an index of a great advance in civilization, and an augury of still greater progress.

In addition to encouraging research and the acquisition of knowledge, we undertake to discharge the related function of receiving and caring for objects of scientific, historical or antiquarian interest. We have already accumulated a considerable collection, which we are now engaged in classifying, and we hope ultimately to have here a museum which will be one of the most interesting sights in the city. We have hitherto been prevented from arranging our material by two causes. Before this building was erected we had no room; since its erection we have had no money. We now feel able to attempt to devote a little money every year to this purpose; not as much indeed, as we would like, but still some. I know of no object to which one of our wealthy fellow citizens could better devote a legacy of a few thousand dollars, than to the building up of our museum. And there is a pressing need of a good museum somewhere in Ontario, for one reason. There are scattered over this country an immense number of objects of ethnological and archæological interest, that have recently been obtained from Indian ossuaries which reveal to us the physical character and state of civilization of the aborigines of this country before they came into contact with the white race. Unless some effort is made to prevent it many of the most valuable of these relics will be lost, or destroyed, or carried off to other countries. The Canadian Institute proposes to do what it can to meet this want, and it asks for the hearty coöperation of all who feel the importance of the work.

It is the intention of the Council of the Canadian Institute to arrange for two short courses of public lectures this winter. One of these courses will be scientific, the other literary. What the Council aims at is to perform somewhat the same kind of work as is done by the Royal Institution and some similar societies in London. The Council asks for the cordial assistance of the friends of the Institute in carrying out this scheme, not only on account of the intrinsic desirability of having such courses delivered, but also because it hopes to be able by means of the surplus of receipts over expenses to add to the amount available for improving the museum and library.

I now purpose inviting your attention for a short time to some remarks on the relation between progress in physical science and progress in other departments of thought and action. It is of course impossible for me to do justice to so vast a subject, in the time at my disposal, nor do I flatter myself that I could say very much that is new, if I had time, but I have selected this topic for a few inaugural remarks, because discussion of it, however imperfect, will throw more light on the real importance of societies such as the Canadian Institute than anything else which I could say.

It will in the first place be advisable to obtain a clear idea as to what is meant by the word science. Science originally meant knowledge, but now it means something more. A man may know a great deal about some groups of facts, and yet have no scientific knowledge of them. A savage of three-score-and-ten who has spent his life in hunting will have a great knowledge of animals, but not a scientific knowledge. An accumulation of knowledge becomes a science when it is brought into order by the discovery of great general statements that enable us to arrange the facts, or by the discovery of the laws of certain phenomena. The savage whom I have just mentioned would come to have a scientific knowledge of zoology, if he became able to arrange the animals he knew in certain classes. In proportion as knowledge becomes systematized it becomes science.

In the next place what is meant by physical as distinguished from other science? The physical sciences are those which deal with the material universe; mental and moral science deal with the spiritual universe. The term natural science is now often used as synonymous with physical science. Originally it meant something quite different.

and might have been construed to include much that is now brought under the head of mental and moral science. It meant all science that is not supernatural, that is, all knowledge that is not obtained by revelation from the Deity or by occult dealings with the devil and his agents. It is used in this sense in the charter incorporating the Royal Society granted about the beginning of Charles II.'s reign. The reason of the change in the meaning of the term is to be found in the fact that since that date the progress of physical science has been much greater than that of mental or moral science. In the same way and for the same reason the generic term, science, has come to be commonly used in the specific sense of physical science. There is a latent popular disbelief in the existence of any science except physical science.

There is no race of mankind since history began that is not, and has not been, in possession of some of the facts on which the various physical sciences are based. But progress in physical science depends not so much on capacity for collecting facts as on ability to discover the laws of facts, and this ability has never been manifested to any considerable extent except during the last three centuries and a half, and then only in the limited part of the earth's surface occupied by the civilized European nations. The ancient Greeks, indeed, whose vigour of intellect led them to attempt every department of inquiry, paid great attention to the physical sciences, but their progress was not at all commensurate with the amount of effort they put forth. We have accounts which show that they laid siege to the secrets of nature for about 800 years, or from the time of Thales, about 600 years before, to that of Ptolemy, the astronomer, about 200 years after Christ; but during all this time they did not succeed in establishing one important physical law. It is true that some Greek astronomers broached the idea that the earth is round, and the sun the centre of the system of worlds to which the earth belongs; but not only were these views not established, the contrary notions prevailed. The Ptolemaic system, which obtained universal acceptance until the 16th century, made the sun revolve around the earth. Archimedes, indeed, discovered the laws of the equilibrium of fluids, but he did not succeed in so establishing them as to make them a part of the common mental property of mankind.

The failure of the Hellenic intellect in this department appears to have been due to the adoption of a wrong method. In modern times great progress has been made because the scientific mind has become impressed with the necessity of, from time to time, examining every received theory, in order to ascertain whether it is still in accordance with facts. Thus, the phlogistic theory of chemistry promulgated by Stahl and Beccher was replaced by the oxygen theory of Lavoisier, when the discoveries of Scheele, Priestley, Cavendish and Black, showed it to be no longer tenable; and in our own day a very considerable change in chemical theory and nomenclature has been made, because the facts were found not to agree with deductions from the received theory. Now, the Greeks did not neglect to observe facts, and in truth, all the theories that they formed were based on facts. But they had, as Buckle thinks the Scotch have, a strong bias towards deduction, and having once made a generalization, their tendency was to reason from it and accept the results of this reasoning without ascertaining whether they too were supported by the facts. From this, also, resulted a great indistinctness and haziness in their explanations of phenomena, even when they had by chance obtained some glimmering of the correct view. As in the case of the giant who received an accession of strength when he touched mother earth, it is for the advantage of all theorizers to come down frequently to the solid basis of reality. This tendency to deduction in the Greek mind had, indeed, its good side. To it we owe the geometry of Euclid, which is the logical exhibition of the conclusions implicitly contained in a few definitions, postulates, and axioms. In modern times there has been a close alliance between the mathematicians and the devotees of the sciences of observation and experiment, to their great mutual advantage. But whatever may have been the cause, the geometry of Euclid failed in ancient times specially to promote progress in other sciences.

While the failure of the Greeks to make any great advance in this department has its lesson for us, the fact that they were the only race of antiquity that made great and persistent exertions to solve scientific problems has also its lesson. What was the cause of the great intellectual activity of this race? I believe it to have been due to the same causes that made the Greeks free, whether these were climatic, or racial, or connected with their occupation and mode of life. As compared with Rome or Carthage, Athens and some of the other great commercial cities of Greece were decidedly democratic, the Roman and Carthaginian populations having never been able to shake off the influence of great leading families to the extent to which this was done in some parts of Greece. Rome was, however, freer than Carthage, and accordingly we find that, while in Carthage there was little intellectual activity, apart from trade, in Rome there was some, and in Athens a great deal.

The most interesting part of history is that which throws light upon the ideas and influences that have borne sway over the minds of men. If we could gain a complete knowledge of these, we should easily be able to construct a philosophy of history, for the great movements of every age are due to these springs. The deed always exists in thought before it becomes fact; and, though it would not be correct to say that humanity is conscious of the influences that sway it at any particular time, yet it is true that the historical facts of the next generation have now an immaterial, but no less real existence, in the tendencies of the modes of thinking, feeling, and acting of the present. Buckle has said that Shakspere helped much to make Newton. I think that true, and I think that Newton has in his turn exercised an influence on literature. To Newton, had he been born earlier, both the antecedent discoveries necessary to enable him to perform the work that he did, and the stimulus to do this work, would have been alike wanting. There were undoubtedly very many men of great ability in the middle ages; but not one of them in any way materially advanced physical science during that period of a thousand or more years.

There was, in fact, other work to be done in those times. Out of the disorganization resulting from the break-up of the Western Roman Empire, a new polity was to be developed. New common interests were to be created to bind together the various races and to override the differences which separated them. The history of Western Europe has since that time been increasingly one. In every period since then, and now more than ever, every important internal change in one of the civilized European states is found to affect the rest. In the middle ages, indeed, all Western and Central Europe tended, more and more, to become, and finally became one community, at the head of which was the Pope; and, though his religious headship has long since ceased to be recognized by some of the states, and Russia has forced her way into the circle, there is still a real oneness of civilization and interests. This oneness comes out in a remarkable manner when we consider the general movement of events in modern times, and this it will be necessary briefly to do in order to show the part which has been played by physical science.

During the middle ages the church was in the van of human progress. She bound together distant lands by the tie of a common belief, a common religious language, a common priesthood, and common prayers. Under her influence all Latin Christians came more or less to feel that they were brethren. Before all the nations of the rude west was placed a lofty ideal of life; and into all were introduced under her auspices some seeds of useful knowledge, of art, of learning, and of refinement. The monks improved agriculture in the north and west; every pilgrim that went to Rome brought back new ideas; and the clergy were the conservers and disseminators of the little knowledge of the time. But perhaps the most important work that the church did in those ages was that which she performed in aid of the abolition of serfdom. For lending her powerful assistance to the cause of personal liberty she deserves the everlasting gratitude of mankind.

With the abolition of villenage the church ceased to lead. Personal freedom led to increased industry, towns sprang up all over Europe, there was a great development of commerce, and wealth increased. Increase of wealth led to a greater diffusion and increase of knowledge; this in its turn led to inventions and discoveries; gunpowder revolutionized war; the printing press multiplied books; the Renascence, or new birth of learning, art, and literature, follows; then comes Luther, and personal freedom has led to a movement for spiritual emancipation.

The revolt of Luther was contemporary with a great outburst of imprisoned forces and a great onward movement of humanity. Before the middle of the seventeenth century four great national literatures had come into being, the English, the French, the Spanish, and the Italian. The northern part of Europe became religiously independent, and this religious independence was conjoined in two cases, England and Holland, with political freedom. The air was full of bold and original speculations, and nature began for the first time in the history of man to find herself interrogated with success. The first great event in the history of science is the establishment of the heliocentric theory by Copernicus. Copernicus was a contemporary of Luther, dying just three years before him, and, though he lived and died in the old faith, was, in his own way, as much as Luther in his, the leader of a revolt against authority. Though he seems to have satisfied himself of the truth of his views early in the century, he did not promulgate them till about 1540. They made their way slowly: it was not until after the middle of the seventeenth century that they were generally received in England. Bacon, the great apostle of induction, never assented to them, and Milton, writing about 1660, bases the machinery of Paradise Lost on suppositions inconsistent with the Copernican theory.

The discoveries of Copernicus were followed by those of Kepler, who established the following propositions regarding the solar system, namely:—

(1) That the orbits of the planets are elliptical.

(2) That the line connecting the sun and any planet sweeps over equal areas in equal times.

(3) That the squares of the periodic times of the planets are in the same proportion as the cubes of their mean distances from the sun. Then follow the discoveries of Galileo, and in the latter half of the seventeenth century Newton appears on the scene to furnish a mathematical explanation of the motions of the heavenly bodies.

About 1584 the laws of the equilibrium of fluids, which had been known to Archimedes, were rediscovered by Stevinus. In 1616 Harvey discovered the circulation of the blood. About 1621 Willebrod Snell discovered that the ratio of the sines of the angles of the incidence and refraction of a ray of light is constant for the same media. During the first half of the seventeenth century the three fundamental laws of motion were established, the most prominent name connected with them being that of a scientific man already mentioned, the astronomer and physicist, Galileo. During the same period Torricelli discovered the vacuum which goes by his name, and Pascal proved that the height of a column of liquid in a tube with a vacuum above it depends upon the weight of the column of air balanced by it. About 1650 Boyle established the law that the density of a gas varies as the pressure, and in 1651 Pecquet, a French physician, discovered the motion of the chyle.

By the middle of the seventeenth century the violent perturbations caused by the great movements of the sixteenth century had for the most part ceased. Italy and Spain, having early rejected spiritual liberty, had fallen into decadence. The Thirty Years' War, the last European religious war, had ended in 1648, leaving Germany exhausted. The defeat of the Fronde and the consequent establishment of a paternal despotism in France, injuriously affected science in that country. With the decline of interest in religious questions a change came over the intellectual temper of Europe. Though, in the north-west of the continent, knowledge was becoming every year more widely diffused, and the spirit of investigation and discovery was very active, there was throughout the entire civilized world during the period between 1650 and 1750 as compared with the periods preceding and following it an absence of lofty dominating impulses.

It is a noteworthy fact that during this period the greatest intellectual activity was manifested in the country which made the greatest political progress, and that the single scientific name of the highest rank, that of Newton, belongs to the same country.

The Royal Society was one of the results of the same intellectual ferment which produced in the political sphere the civil war and the changes in the English constitution which resulted from it, in the religious sphere the first great English sceptics and the break-up of the national church into sects, and in the literary sphere the poetry of Milton. Its inception dates back to 1645, the last year of the civil war, but it was not organized as the Royal Society until the Restoration. It was one of the marks of the beginning of a new age in England--of an age which, accepting as final the solutions of religious and political questions resulting primarily from the civil war, but thrown into their ultimate shape by the revolution of 1688, devoted itself with a single eye to material progress. For about a century, or from about 1660 to 1760, England was almost destitute of enthusiasms affecting great masses of people. The most typical part of this period is the administration of Walpole. An examination of its character reveals to us a slumbering church and a politically apathetic people governed by a corrupt parliament. Manufactures are increasing, the colonies are growing, foreign trade is developing, waste lands are being reclaimed, population is advancing. Everywhere the evidences of a smug material prosperity are to be discovered. It was a prosaic age. It was likewise, in the most literal sense, an age of prose. Between Milton and Wordsworth we had no poetical writer of the first order of merit. More than this, our modern English prose style was then formed. The long, involved, highly eloquent, but strangely worded, and strangely arranged sentences of Milton sound almost foreign to our ears. The new prose style began with Dryden, was improved by the writers of the age of Anne, and perfected by Dr. Johnson. The thorough limpidity of which the new style is capable is, I believe, to a large extent due to the absence of enthusiasms, to the material aims, and to the mainly matter-of-fact scientific discussions of the age in which it was formed. For it was not an age of brilliant scientific speculations, but rather one in which the mines discovered by preceding geniuses were worked, in which facts were collected, in short an age of considerable though not specially brilliant advances upon the past and anticipations of the future.

The character of this period between 1660 and 1760 is the same throughout Western Europe as in England. It is the plain between two mountain ranges, the pause between two pulsations of human progress. It was a period of intellectual ebb. There were undoubtedly great and active minds in all the cultivated European nations; but the work which they performed consisted mainly in extending the application of the laws discovered by the men of the previous epoch and in accumulating new facts. But, though it was a period comparatively infertile in new ideas, it would be a mistake to consider it one of retrogression. It was rather a foundation-laying period, rather the period of the slow germination of the concealed grain.

About the middle of the eighteenth century a change came over the intellectual life of Europe. A new race of writers and thinkers, more numerous than, and as active and able as any the world had ever seen, began to propound new views in every department of human enquiry. To the political thinkers of that age we owe the democratic impulse which within about a hundred years produced the American Revolution, the French Revolution, the change of the Spanish American Colonies into republics. the English Reform Bills, the movements of 1848, the freedom of Italy, the unification of Germany, the abolition of slavery, the great host of socialist movements, the establishment of systems of universal education. To the same movement operating in the moral and spiritual sphere, we owe the overthrow of the Jesuits, the weakening of the alliance between church and state everywhere, the emancipation of proscribed religious minorities, such as the Catholics in England and the Protestants in France, the great tendency to scepticism and atheism which has since prevailed, the great philanthropic movements for the improvement of the treatment of criminals, of the insane, of idiots, of the mute, and of the blind, the attack upon the use of alcoholic beverages, and various other great humanitarian enterprises.

In literature, a new race of poets arose, untrammeled by received traditions as to the form or the subjects of poetry. Germany produced her first and only great poets, Schiller and Goethe; in England the poetical glory of many preceding ages was eclipsed by that which produced Wordsworth, Coleridge, Shelley, Byron and Scott. The modern philosophical method of writing history was developed by Montesquieu, Voltaire, Hume, Robertson and Gibbon. Contemporaneously with all these intellectual and spiritual movements arose a great scientific one. The latter half of the eighteenth century is preëminently an era of the promulgation of great scientific theories and the discovery of great natural laws. In this work the intellect of France, the country which was most powerfully affected by the great upheaval was by far the most prominent. Lavoisier laid the foundation of chemical science by propoundiug his oxygen theory. To Romé de Lisle, we owe the science of crystallography, to the two Jussieus is due the natural system of classification in botany; in zoology, Cuvier originated the idea of types, and the same thinker may claim the merit of being one of the fathers of the science of geology. To Fourier, another Frenchman, we owe the accepted theory of the conduction, to Prevost that of the radiation of heat. Coulomb, one of the greatest names in electricity and magnetism, and Laplace, perhaps the greatest advancer of mathematical astronomy since Newton, were likewise Frenchmen of this age, and to these may be added a whole host of lesser names.

In English-speaking countries the spirit of scientific research was only less active. The names of Black, Cavendish, Priestley, Erasmus Darwin, Smith the geologist, Franklin, and the first Herschel at once occur to every one. More eminent than any of these are Dalton, the propounder of the atomic theory in chemistry, and Thomas Young, the establisher of the undulatory theory of light, both of whom flourished about the commencement of this century. In Italy, the foundations of galvanism were laid by Galvani; in Germany, we have Werner, the geologist, and Goethe, the poet, whose theories on the morphology of animals and plants, show that his scientific was not greatly inferior to his literary ability. From that time the number of scientific workers and scientific societies has steadily and rapidly increased, and while the democratic spirit has been making its way in the political, the scientific spirit has been growing increasingly powerful in the intellectual world.

And there are no signs that either the democratic or the scientific impulse that we owe to the eighteenth century has spent its force. The wave of political liberty still rolls onward, and every year adds some remarkable discovery to the list of scientific achievements. Enough has been said to show that there is a certain sympathy between science and liberty. When the intellect of Europe emancipated itself from authority in the sixteenth century, modern science began; when, in the eighteenth century, the era of democracy set in, a host of new sciences came into existence. In ancient times anything of importance done in science was done by the Greeks, one of the two great free nations. Are these coincidences mere accidents, or do they point to a real connexion between science and freedom? If there is a real connexion, can we to any extent define its nature?

The connexion between science and freedom is, of course, a single phase of that between science and human progress. Let us see whether we can discover how science is related to human progress.

In discussing questions of this kind it is of course impossible to separate completely one element in human progress from the rest, and to point out fully what its reactions have been. The utmost that we can do is to discover some links of connexion. We find for example that in the sixteenth century a great scientific and a great religious movement existed together. From their synchronizing we infer that they were both products of the same general causes, whatever these were. Both were clearly of the nature of revolts against established authority, and to both the principle of the right of private judgment was very important. Up to a certain point the cause of science and that of Protestant theology were the same. But it is impossible not to see that they have long since diverged, and that there is now a certain antagonism between them. There can, of course, be no real opposition between religion and science. All truth is one. But at present certain received theological dogmas and scientific generalizations clash, and until the one, or the other, or both are modified, peace cannot be restored. If, for example, the Deity may send rain in answer to prayer, it cannot be true that "nature is the expression of a definite order with which nothing interferes."

At any rate the great scientific movement of the last 130 years has been attended with a great development of atheism and scepticism and of materialist philosophies. That scepticism, which it is necessary for the succesful student of science to exercise with regard to every supposed discovery, until it is proved beyond a peradventure, has been carried by many into the religious and philosophical spheres in such a way as to lead to these results. The most popular philosophy of the present age on this side of the Atlantic is that of Herbert Spencer. It owes its origin to the speculations of Charles Darwin, and is simply an application of his theory of natural selection to every department of human inquiry. If not in strictness to be called a materialist system, it is so near to being one as to produce all the hardening and narrowing effects of materialism on nearly all those who adopt it.

In so far as the study of physical science assisted in establishing the principle and furthering the practice of the right of private judgment it served the cause not only of religious, but likewise of political freedom. In so far, too, as it substituted for the old idea of a god capriciously ruling the universe, like an oriental sultan, that of a deity guiding it according to fixed laws, it contributed to the setting up of a good model for earthly governments. Perhaps it would be in accordance with fact to go further in the same direction and say that in so far as the advances of physical science have tended to develope the pantheistic idea that God is not a separate entity, but a force pervading the universe, conscious in many living creatures, unconscious elsewhere, it has set before the world a model for democratic government, seeing that in that form the sovereign power is recognized as really diffused through every part of the state. These analogies may seem fanciful, but those who know how the political and religious ideals of a nation react upon each other will not hastily conclude that there is nothing in them.

It will be interesting to note here that the pantheistic view of the universe referred to just now has permeated the writings of some modern republican poets. Shelley, who began with atheism, ended with views which were pantheistic in character, and it is worthy of notice that he was distinguished among the English poets of his age for the interest he took in physical science. One of his contemporaries, Keats, laments in a very beautiful passage that the discoveries of science are lessening the mystery of nature.

> There was an awful rainbow once in heaven.
> We know her woof, her texture, she is given
> *In the dull catalogue of common things.*

Science does not, of course, really diminish mystery; it merely pushes it back. He who possesses a little knowledge is simply the centre of a small circle whose circumference touches the mysterious at every point. Enlarge the circle by increasing knowledge, and a larger circumference affords more points of contact with infinite mystery. Shelley deals with science in a very different fashion from Keats, and has in a few poems, notably in that of *The Cloud*, made his scientific knowledge furnish part of the very web of his fabric. His pantheism appears in expressions such as that in which he represents the sun as saying:

> I am the eye with which the universe
> Beholds itself and konws itself divine.

Emerson, the American poet and philosophical thinker, recently deceased, is remarkably distinguished for the prominence he gives to the poetical aspects of science. For him likewise the pantheistic view of the universe had great attractions. His poems abound in passages like the following in that entitled Brahma.

> They reckon ill, who leave me out;
> *When me they fly, I am the wings*;
> I am the doubter and the doubt:
> And I the hymn the Brahmin sings.

Or like this in the Song of Nature, in which in answer to the question:

> But he, the man-child glorious,
> Where tarries he the while?

He makes her say,

> Twice I have moulded an image,
> And thrice outstretched my hand,
> Made one of day, and one of night,
> And one of the salt sea-sand.
>
> One in a Judæan manger,
> And one by Avon stream,
> One over against the mouths of Nile.
> And one in the Academe.
>
> I moulded Kings and Saviours,
> And bards o'er kings to rule, etc.

Thus expressing clearly the view that the greatest beings that have been upon earth are products of the force of nature.

The pursuit of knowledge of any kind has a levelling tendency. It was by no accident that the phrase, republic of letters, was coined. In literature there is no king. There are no more democratic bodies than companies of learners, and the capacity to appreciate any given book, puts at least for a time, the peasant on the same platform with the prince. In the department of physical science, in particular, a man's standing depends completely on his merit. It affords a very good example of the carrying out of the democratic maxim :

La carrière onverte aux talens.
The tools to him that can use them.

More than this, the very spirit of investigation fostered by the study of the physical sciences is fatal to respect for any authority based on no real claim. When men of science take to politics they generally show decided democratic leanings. Again, the improvements in industrial processes, the labour-saving inventions, the many contrivances for increasing the control of man over nature which have resulted from the discoveries of men of science, have linked them, in an intimate way, with the masses of mankind. They are in fact the high priests of industrialism, which is always democratic.

And this leads me to remark that the cultivation of the physical sciences has been favourable to democracy in another way. It has resulted in the building up of a great learned class independent of the court, the nobility, and the clergy, and without any class interests or class organization that can be inimical to the well-being of the state. The importance of this has perhaps not been sufficiently noticed, if noticed at all.

It remains now to still further remark upon the influence of the scientific spirit upon literature. It has, indeed, affected every branch of it. I have already said that the modern philosophical method of writing history had its origin in the eighteenth century. Since then, the scientific method has demolished many a false historical fabric, and a beginning has been made in the science of comparative politics.

We have ceased to believe in Romulus and the she-wolf that suckled him ; all early Roman history has been re-written ; we are doubtful whether there was a Homer ; William Tell's splitting of the apple with his arrow has been shown to be a myth. The pervading scepticism of the scientific method has caused almost all statements with regard to the past to be subjected to a raking cross-fire. Much has been shown to be unworthy of credence, but the separation of the wheat of history from the chaff, as far as it has been accomplished, has been a work of great value.

In the study of languages also the scientific method has been adopted. But perhaps the most remarkable thing to which attention can be directed in this connection is the rise contemporaneously with the scientific and democratic movements of last century of a race of poets manifesting a sympathy with nature in all her moods never exhibited before. It has often been remarked that the feeling for the beautiful and the sublime in the external world is much stronger in modern than in ancient poets. It has often also been remarked that there was a great revival of the love for external nature in the poets who flourished in England at the end of the eighteenth and the beginning of the nineteenth century. Ruskin, for example, has noticed that the sense of colour is more highly developed in modern than in ancient writers, and in speaking of Scott, he directs attention to the way in which he looks at nature "as having an animation and pathos of its own wholly irrespective of human presence or passion."

It has, I believe, never before been suggested that this is connected with the great development of the sciences of observation. Yet there is some reason for thinking that it is. I must not, however, be understood to say that the greater intensity of this particular poetic feeling is the effect of our scientific progress. It may be to some extent its cause; but it would perhaps be more correct to speak of both as different phases of, and alike due to the influences which have given its special characteristics to the intellectual growth of modern times.

Not only, however, are modern poets distinguished by a deeper feeling for the aspects of external nature; they also observe it with a minute and scientific accuracy. Read, for example, the beginning of Enoch Arden:

Long lines of cliff breaking have left a chasm;
And in the chasm are foam and yellow sand;
Beyond, red roofs about a narrow wharf
In cluster; then a moulder'd church; and higher
A long street climbs to one tall-tower'd mill;
And high in heaven behind it a gray down
With Danish barrows; and a hazel-wood
By autumn nutters haunted flourishes
Green in a cup-like hollow of the down.

What completeness in the details of this picture? You would know the place if you happened to visit it.

Read also for example the following passage from Marmion, descriptive of the hero's journey on the day after leaving Norham Castle.

> Oft on the trampling band, from crown
> Of some tall cliff, the deer looked down;
> On wing of jet, from his repose
> In the deep heath, the black-cock rose;
> Sprung from the gorse the timid roe,
> Nor waited for the bending bow;
> And when the stony path began,
> By which the naked peak they wan,
> Up flew the snowy ptarmigan.

There are no generalities here; the description is marked by exceeding accuracy; Scott had himself seen these details with delight and reproduces them with pleasure.

But of all modern English poets Wordsworth is perhaps most distinguished for the love of nature. He spent his life in one of the most beautiful parts of England and composed much of his poetry out of doors. He tried in prose to give expression to his theory of the essential beauty of the commonest sights. His poems show how he loved the external world, not only in its general aspect but in its minute details. They likewise show that he was inspired by a love of nature for herself which was entirely independent of any meaning he saw in her. He says:

> The sounding cataract
> Haunted me like a passion; the tall rock,
> The mountain, and the deep and gloomy wood,
> Their colours and their forms, were then to me
> An appetite, a feeling and a love,
> That had no need of a remoter charm
> By thought supplied, or any interest
> Unborrowed from the eye.

Very many of us now share this mental attitude; but that should not lead us to forget that as a prevailing habit of mind the love of nature has gained greatly in depth and range in the last century. It is only within that period that the love of scenery has appreciably influenced the travelling public. It may be that previously the difficulty of going from place to place was so great as effectually to nip in the bud any nascent taste for natural scenery; but this explanation does not fully account for all the facts. The ancients, like the moderns, were accustomed to go in great numbers to pleasant places that were easy of access; but we do not hear of their going at the expense of great physical discomfort to spend a night on the summit of a frozen Alp, in order to witness the sun rise from it, or doing anything of a similar character. They loved nature in so far as her aspects suggested comfort and enjoyment; but the whole class of poetic sensations based on the feeling of man's oneness with the rest of the universe was almost entirely absent from their souls.

Another important feature in the literary history of the nineteenth century which is, I think, connected with the predominance of physical science in the intellectual world is the production of a considerable mass of verse which may be classed as the poetry of doubt and negation. The leading feature of the poems belonging to this class is that they deal with the religious aspect of the general scepticism due to the scientific method. The prominent English names in this school are Shelley, Tennyson, Arthur Hugh Clough, and Matthew Arnold. Tennyson, indeed, falls into this class not on account of the general character of his works, but on account of one single poem, *In Memoriam*. That, however, is his best. The connexion of the scepticism, which he fights and overcomes in that poem rather by force of will than by argument, with the scientific movement is shown by innumerable passages, many of which have become stock quotations. Here is one of the most familiar:

> Are God and Nature then at strife
>   That Nature lends such evil dreams?
>   So careful of the type she seems,
> So careless of the single life,
>
> That I, considering everywhere
>   Her secret meaning in her deeds,
>   And finding that of fifty seeds
> She often brings but one to bear.
>
> I falter where I firmly trod.

Matthew Arnold has, like Tennyson, fought his doubts and overcome them; but he has arrived at a much less definite belief.

Clough and Shelley both died before reaching any very defined belief. The nature of the former made him a pure doubter; that of the latter an asserter of negations. Shelley is not so much a poet of doubt as of defiance.

No one who narrowly scrutinizes the intellectual influences of our own day can fail to see that that of science is one of the most important. One scientific speculation, that of Charles Darwin on the origin of species, has within less than a quarter of a century completely revolutionized the world of thought. The frequency with which such words and phrases as, development, evolution, survival of the fittest, struggle for existence, etc., are now used in our newspapers and in ordinary conversation, is perhaps the most striking proof of the extent to which the world generally has been unconsciously influenced by him. Nearly all the leading scientific men of the age are Darwinians; the only exceptions are a few of the older men who still keep their heads above the advancing tide. This theory seems to strike at the belief in personal immortality and the other foundations of morals and religion; and some writers, notably Mr. Goldwin Smith, have given expression to the opinion that a day of moral unsettlement and consequent deterioration of human conduct is approaching. They would reëcho what Tennyson has expressed in *In Memoriam*.

> I trust I have not wasted breath :
> I think we are not wholly brain,
> Magnetic mockeries; not in vain,
> Like Paul with beasts, I fought with death.
>
> Not only cunning casts in clay :
> Let science prove we are, and then
> What matters science unto men,
> At least to me? I would not stay.
>
> Let him, the wiser man who springs
> Hereafter, up from childhood shape
> His action like the greater ape,
> But I was born to other things.

Such lamentations appear to have little effect upon the advance of evolutionist views. Like some necromancer whose spells have evoked a spirit which he cannot lay, the activity of the human intellect has developed a system of beliefs with regard to the material universe that seems to threaten the very foundations of society, and we can do nothing but look on. Yet I, for one, have no serious apprehensions. I believe

> That somehow good
> Will be the final goal of ill.

The presence of the religious and moral elements in man is at least as much a fact as the links of resemblance that establish a relation between us and the anthropoid apes. If the analogies of our physical nature connect us with the earth, those of our spiritual nature join us with the skies. The Power that rules the universe governs not only us but everything in it, including the causes and effects of the promulgation of the Darwinian theory, and it seems therefore unreasonable to be over-anxious because we cannot see how the breakers, or appearances of breakers ahead are to be avoided. We are looking at a single scene of the great drama of human progress, and though I do not know what is going to happen in succeeding scenes and acts, I have an abiding faith that what does happen will be right.

But, if the great advance of science has produced some effects that seem of doubtful benefit, of what incalculable value has it not been on the whole? It has in may ways mitigated or nullified pain; it has procured for us innumerable physical comforts; it has lengthened life; it has built up the confidence and increased the energy of man by causing him to believe that his control over the forces of nature may be indefinitely increased. But on these things I shall not dwell for science has won greater victories. Its discoveries have furnished subjects of contemplation that have solaced innumerable spirits in the hour of misery, that have elevated the mean, and given breadth to the narrow, that have shamed men out of selfishness, and added a new force to every lofty and honorable impulse. In comparison with the vast extent of the physical universe how small is my material being, but how grand that part of my nature that makes me intellectually monarch of all that the mental eye can see. Into remote spaces whence it takes light millions of years to come, I range in thought; I view the smallest object visible under the most powerful microscope and yet see further with the eye of the mind; I trace the history of the earth from its original completely molten state down through successive stages of cooling to the present, and onward through innumerable æons in the future, by virtue of my power of intellectual vision. In presence of the sublime conceptions to which such excursions into the infinite realms of time and space give rise, one learns to look down on the petty annoyances of the day, one rises superior to temptations, nature becomes a temple, and life a poem.

SOME NEW

EMENDATIONS IN SHAKESPEARE.

BY E. A. MEREDITH, L. L. D.

In 1623, just seven years after Shakespeare's death, John Heming and Henry Condel "set forth" the first collected edition of the poet's plays—the famous "First Folio," so frequently referred to by Shakespeare commentators. In their preface to "The great variety of readers from the most able to him that can spell," as they quaintly phrase it, they say, "you have been abused with divers stolen and surreptitious copies maimed and deformed by the frauds and stealth of injurious impostors:" "whereas," they add, "those now offered to your view are cured and perfect of their limbs, absolute in their members, as he (Shakespeare) conceived them." After deploring the fact that Shakespeare had not lived to set forth and oversee his own writings, they add, by way of further recommending the accuracy of their own work, "We have scarce received a blot on his papers." From this it would naturally be supposed that the editors enjoyed the special advantage of printing from Shakespeare's own manuscript—a supposition the more likely, as the editors had been his intimate companions and were privileged to speak of the poet as their "friend and fellow." As a matter of fact the editors of the "First Folio" do not appear to have had any such advantage, for Professor Dowden, perhaps the highest authority on such a question, assures us that "several of the plays in the 'First Folio' are in fact printed from earlier Quartos, while in other cases the Quartos gave a text superior to the Folio."

If Heming and Condel were the first Shakespeare editors to mourn over the corruptions and mutilations which the text of their author had undergone, they most certainly were not the last. From that day to this these corruptions have not ceased to perplex the editors of Shakespeare and to furnish an inexhaustible field for the ingenuity of his innumerable commentators

If we are correct in ascribing to Shakespeare the well-known epitaph on his tombstone cursing any one who should disturb his bones, we cannot but regret that the poet who concerned himself so much about the safeguarding of his earthly part, should have taken so little thought about his literary remains. Never, perhaps, were literary pearls cast before swine more recklessly than by Shakespeare. Referring to the infinite variety of influences which contributed to the corruption of Shakespeare's plays, Johnson truly says, "It is not easy for invention to bring together so many causes concurring to vitiate a text." Illiterate copyists, blundering printers, stupid players, all took part in the work of destruction. Small wonder that so large an amount of alloy has come to be mixed up with the pure gold of Shakespeare. The wonder is rather that the mutilation and destruction was not more disastrous and complete. In the work of reverently restoring the original text of our poet, of recovering his lost pearls, all the great English commentators from Rowe and Malone down to our own time have lent their willing aid. Specially during the last quarter of a century has the work of restoration been helped forward by such scholarly critics as Dyce and Staunton, to say nothing of the ingenious Collier, of somewhat questionable honesty.

Although much has been done, still very much remains to be done before the text of Shakespeare can be purified altogether of its dross. There is still no lack of confessedly spurious passages to provoke and reward felicitous conjecture. The present paper is my second contribution to this pious work.[1] The emendations which it contains, original so far as I know, will be found, it is hoped, to clear away some of the errors of copyists and printers. The textual changes are for the most part slight, sometimes merely the alteration of two or three letters or the transposition of two consecutive words.

Turn we to "The Tempest," usually placed first in the old editions of Shakespeare, although it is now universally admitted to have been one of his latest plays, in Professor Dowden's opinion possibly his very latest. Act II., sc. 11—*Trinculo loquitur*—He has come upon the monster Caliban stretched upon the ground partly

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[1] A paper on the same subject was read before the Literary and Historical Society of Quebec, and published in the Transactions of the Society for April, 1863.

hidden by the logs of wood which he had been carrying to Prospero's cave, and which he had thrown down in terror on seeing Trinculo.

"What have we here—a man or a fish—dead or alive? Were I in England now, &c., then would this monster make a man. When they will not give a doit to relieve a *lame* beggar, they will lay out ten to see a dead Indian." I venture to suggest that Shakespeare wrote *live*, and not *lame*. The two words, if carelessly written, look very much alike, but *live* seems the natural and true word, and gives force to the contrast which the jester Trinculo wishes to draw, viz.: That the English sight seer would spend ten times as much on seeing a *dead* Indian as in relieving a *live* countryman.

The opening speech of Ferdinand in the 3rd Act of the same play contains a line which has been a veritable enigma for the critics. Ferdinand, being commanded by Prospero to pile up a number of logs at his cave, enters carrying one. Pausing in his work he thus soliloquizes:

> "There be some sports are painful,
> But these sweet thoughts do even refresh my labour;
> Most busie least when I do it."

The last line is hopelessly meaningless. To quote Staunton: "It is the great crux of the play. No passage of Shakespeare has occasioned more speculation, and on none has speculation proved less happy. The first folio reads, 'most busie lest when I do it.' The second, 'most busie least when I do it.' Pope prints, 'least busie when I do it.' Theobald, 'most busiless when I do it.'"

All will agree with Staunton that none of the emendations proposed are very happy, and it were prudence, probably, not to attempt to solve a difficulty which has baffled so many. It seems to me, however, clear that "most" and "least" cannot stand together in the line, and that one or the other was written as a gloss for the one which Shakespeare wrote. Either "most busie when I do it," or "least busie when I do it," is intelligible. "Most busie," however, would refer to "these sweet thoughts" of which he has just spoken, and "least busie" to his feelings when at work. "Studio fallente laborem." I am disposed to believe that Shakespeare wrote:

> "But these sweet thoughts do even refresh my labour;
> Most busie—when I do it."

These sweet thoughts being most busy when he was employed at work. Some actor or copyist not understanding busie as referring to these "thoughts," probably wrote "least" as a gloss in his copy, and both words were by the printer incorporated in the text.

It is not a very uncommon thing for a gloss or a stage direction to find its way from the margin into the text. We have an illustration of the latter, if I am not mistaken, in the commonly received reading of a line in the opening scene of the second Act of Henry V., Corporal Nym, loquitur.

> NYM.—"For my part I care not, I say little;
> But when time serves there shall be smiles."

The last word in the second line, "smiles," was, I take it, a stage direction at the end of the line. Nym. merely says "there shall be ——," *without saying what.* It is *his "humour" to "say little,"* but he "smiles" significantly, as though he could say a good deal if he would. The line as usually given, "we shall have smiles," seems weak and not in Nym's vein.

By the way, I am not aware whether it has been suggested, that Corporal Nym, whose "honesty" was of the Falstaff type, derived his name from an old and now utterly obsolete English word "Nimm," to *take.* The name being thus an index to the character, as in the case of "Pistol," "Quickly" and "Doll Tearsheet" in the same play.

In first part Henry IV., in the last line (Act III., s. 11), in Prince Harry's speech, "If not the end of life cancels all *bands.*" I think we should certainly read *bonds* for *bands.* Cancelling *bands* is hardly intelligible, but *cancelling bonds* is technically correct. Shakespeare uses the same phrase twice elsewhere. In Richard III., we have "cancel his *bonds* of life," and in Cymbeline, "cancel these cold *bonds.*" Oddly enough in the previous part of this very speech the Prince distinctly speaks of other legal instruments:

> "Percy is but my factor. Good, my lord,
> To *engross* up glorious *deeds* in my behalf."

In this connection I need hardly mention that the frequent and correct use by Shakespeare of technical legal phrases has been adduced as an evidence that Shakespeare must have spent some years as a clerk in a lawyer's office.

In Richard II. there are two or three of the finest passages in the play in which I venture to suggest emendations. The first occurs in the splendid and patriotic speech which Shakespeare puts into the mouth of old John of Gaunt, when on his deathbed, he utters his last warning counsel to the weak young king, Richard II. (Act II. s. 1.) It is the oft-quoted speech beginning, "Methinks I am a prophet, new inspired," then follows his magnificent description of England:

> "This sceptred Isle,
>
> . . . . .
>
> This fortress built by nature for herself
> Against *infection* and the hand of war."

Staunton objects, rightly I think, to the word "infection," because, as a matter of fact, England in Shakespeare's time was not preserved by her insular position from pestilential contagion. But apart altogether from this very matter of fact argument I cannot bring myself to believe that Shakespeare ever thought of regarding the "silver sea" in which England was set, the "triumphant sea" as it is called in the same speech, as a "cordon sanitaire" to protect the country from the plague! This were on a par with using "Imperious Cæsar dead and turned to clay, to stop a hole to keep the wind away." Farmer, feeling the necessity of an emendation here, proposed the word *infestion*—a word not found, so far as I know, anywhere else either in Shakespeare or any other English writer. "Invasion" was, I believe, the word written by Shakespeare. "Against invasion and the hand of war" brings the line into harmony with the whole speech.

In King Richard's speech, in the same scene, he is made to say:

> "Now for our Irish wars;
> We must supplant these rough rug-headed kernes,
> Which live like *venom* where no *venom* else
> Hath privilege to live."

"Living like venom" appears to me harsh and forced, if not obscure. I suspect Shakespeare wrote "vermin" not "venom," alluding to the legend, popular then as now, that St. Patrick had "banished all the vermin" from the Island of Saints. It may be noted too that Richard proposes to deal with the "Irish kernes" very much as the Saint had done with the Irish vermin, namely, "supplant them," or, in other words, exterminate them—a mode of dealing with the Irish which has probably suggested itself to the minds of many of the English rulers of Ireland since King Richard's day.[1]

Turn we now to what Professor Dowden calls the "dark and bitter" comedy of Measure for Measure, a play which enjoys the unenviable distinction of having more manifestly corrupt passages than any other of Shakespeare's plays, excepting perhaps "Cymbeline." Claudio when deprecating the cruelty of the Duke's Deputy in enforcing against him the penalty of an obsolete statute, in consequence of his having had a child by Juliet says, Act I. s. 3:

> "And the new Deputy now for the Duke,
> Whether it be the fault and glimpse of newness,
> Or whether, &c."

The meaning of *glimpse* in this line I fail to see, and would suggest that Shakespeare must have written not *glimpse* but *gloss*—*gloss of newness* is most natural in speaking of the sudden accession of new dignity to the Deputy. It is worth noting too that in several other passages "gloss" and "new" are brought into close conjunction by Shakespeare.

In Much Ado, we have "*new gloss* of your marriage;" in Macbeth, "be worn now in their *newest gloss*;" in Othello, "content to slubber the *gloss* of your *new* fortunes."

Gloss written or printed with the long *s* might readily be mistaken for glimpse, especially when the former word was spelt with an *e* at the end, as it certainly was by Shakespeare.

In Claudio's speech, immediately preceding the one in which this line occurs, I would suggest the omission of "the" in the fourth line, which now stands:

> "Save that we do *the* denunciation lack."

"The" is not necessary here for the sense and spoils the rythm of the line, and I believe we are justified in suspecting any line in Shakespeare which is unrythmical as being corrupt.

[1] Since writing the above my attention has been called to some passages from the literature of Shakespeare's time. which certainly support the present reading.

> "That Irish Judas,
> Bred in a country where no venom prospers
> But in his blood."
> *Dryden.*

And in Pier's Ploughman we have

> "Of all freting venymes, the vilest is the Scorpion,"

Where "venym" is clearly used as the animal not the poison.

I cannot help referring to a remarkable instance which this play affords of a corrupt passage being retained in the text long after the obviously true reading had been suggested. See III. Act, s. 2 :

ELBOW.—" He must before the Deputy, &c.
The Deputy cannot abide a whoremaster."
DUKE (*who is now aware what a hypocrite the Deputy is*) says :
" That we were all as some would seem to be,
Free from our faults as *faults from* seeming free."

The last line is sheer nonsense, and the ingenuity of all the commentators from Warburton to Staunton has failed to extract any sense from it. The simple transposition of *faults* and *from* in the latter part of the line makes the whole passage perfectly clear, and gives exactly the idea in the mind of the Duke, namely, that Angelo *was not as faultless as he seemed to be*. The same opinion of Angelo is expressed by the Duke in other passages of the play :

" Hence we shall see
If power change purpose what our seemers be."

And again, when he says :

" O, what may man within him hide,
Tho' angel or the outward side."

When it occurred to me many years ago thus to correct the line, I jumped at once to the conclusion that the suggestion had never been made before. For if made I thought it could not but have been immediately adopted. What was my surprise then to find that the suggestion had been actually proposed by Hanmer, a very sensible fellow by the way, more than 100 years ago. The correction has not even now been generally adopted in the recent editions of Shakespeare, which aim at special accuracy in the text. The celebrated "Globe" edition of Shakespeare, published within the last twenty years, marks the passage with an obelus (†), indicating that it is a corrupt one for which no admissible emendation has been proposed.

Let us take up now the tragedy of Macbeth, and turn to the king's speech (Act I., s. 4), which he addresses to Macbeth returning after his victory :

" O worthiest cousin.
. . . . . .
Would thou hadst less deserved
That the proportion both of thanks and payment
Might have been *mine*."

"For *mine*," says Staunton, "which no one can for a moment doubt to be a corruption, we would suggest that the poet wrote *mean*, *i.e.*, equivalent, just and the like, the sense being, that the proportion of thanks and payment might have been equal to your deserts." I cannot think Staunton as happy as usual in this emendation. The word Shakespeare wiote here was, I suspect, "more," not "mine," or "mean." The substitution of more makes the passage clear. Had Macbeth's deserts been *less*, the proportion of the king's thanks and payments would certainly have been *more*. What immediately follows confirms this correction, for the king goes on:

> "Only I have left to say,
> *More* is thy due than *more* than all can pay."

As an instance of the absurd rubbish, absolute jargon, which the printers were ready to give as Shakespeare, I may cite a line from a speech of the witty Mercutio as it is given in all the old editions but one—

> "Cry but 'ah me'—Provant but love and day."

The true reading being—

> "Appear thou in the likeness of a sigh,
> Speak but one rhyme and I am satisfied,
> Cry but 'ah me,' pronounce but *love and dove*."

The *ah me* is the sigh, *love and dove* stands for the rhyme. Oddly enough, "ah me" is the very first word which Juliet speaks or sighs as she enters in the next scene.

It is no part of such a paper as the present to lay down any general canons of criticism on the subject of Shakespearean emendations. But the following *dicta* will, I venture to think, be accepted by most Shakespearean students:

1. That the sole object and justification of any emendation in the text of Shakespeare, should be to eliminate any thing which Shakespeare did not write, and to substitute if possible the *ipsissima verba* of the author.

3. That any passage which is obscure and unintelligible may be assumed to be *corrupt*.

3. That any line which is not rhythmical may be suspected not to be Shakespeare's.

The first and second of the foregoing propositions will, I think, commend themselves to most Shakespearean scholars. The second is in truth a corollary of the proposition, which is I think unquestionable, "That nothing which is obscure is Shakespeare."

As to the third, it is only another way of stating that Shakespeare was such a master of rhythm, his musical ear was so correct, that he could not write any thing which was harsh or unmusical.

When, therefore, we are startled by any line which lacks the usual melody and rhythmical flow of Shakespeare, we cannot but regard it with grave suspicion, and if we hesitate to pronounce it as *ipso facto* corrupt, we must at least place it in the category of those which are *soupçonnes d'être suspects.*

But besides the obscure and unmusical lines there are no doubt many others which are corrupt. The accomplished editors of the Cambridge Shakespeare truly remark: "There are many passages, easily construed and scanned, and therefore not generally suspected of corruption, which nevertheless have not been printed exactly as they were written. Some ruder hand has effaced the touch of the master." Some of these unsuspected corruptions have been dealt with in this paper.

When I consider the scholarship and learning expended during the last quarter of a century, both in Europe and America, upon the works of Shakespeare, the volumes which have been written on his genius, mind, art and influence, the subtle sometimes perhaps too subtle—analysis to which the principal plays and characters have been subjected, to say nothing of the recent contribution to Shakespearean literature in connection with what has been well called the Bacon-Shakespeare craze, I cannot but be sensible of the comparatively humble field of enquiry to which my Shakespearean labours have been directed. Indeed, I feel that to speak of what I have done as "labour" at all may be to give to it a dignity to which it has no claim. But if it may be so designated, it has assuredly been a labour of love, where the labour was its own reward. If I could hope by my suggestions to remove even one or two of the blemishes or obscurities which mar and disfigure the bright page of Shakespeare, I shall have the further satisfaction of feeling that I have done something to mark, however feebly, my gratitude for the infinite enjoyment and instruction which I have derived from his plays.

THE
NASAL REGION IN EUTAENIA.

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The original object of the present paper was a description of the Organ of Jacobson as it obtains in Eutaenia. During the progress of my studies in that direction, however, new features and modifications of previously described structures in the nasal cavity, lachrymal duct, and on the palatal surface, were observed, and I felt compelled, in consequence, to abandon that limit, and to include below a description of the whole Nasal Region.

The material for study consisted of a series of sections from an embryo-head, 6 mm. in length, of Eutaenia sirtalis, and several series from the nasal region of adult forms of the same species. In addition to these, I have examined many of the parts in question in fresh state in salt solution, and also when macerated. A number of macerating reagents were employed, but treatment with Müller's Fluid and subsequent staining with an alcoholic solution of Eosin, gave the best results.

I must here express my sincere thanks to Prof. Wright for the kind advice and assistance received from him on points of this work, and especially on the Organ of Jacobson, the structure of which I have studied with him in his own laboratory. I am also indebted to him for several of the drawings accompanying this paper.

The roof of the mouth in the adult possesses several strongly marked ridges and depressions. Of the former there are two on each side of the middle line, that over which the maxilla lies being the most prominent throughout. It runs parallel with the lip, and does not unite with its fellow of the opposite side in front. The palatine ridges commence some distance behind, are parallel to each other, and bound a depressed palatal surface. Between the maxillary and palatine ridges of each side lies another longitudinal depression whose surface is striated, the course of the striation being obliquely backwards and inwards across the axis of the depression. (Fig. 1.) It is due to a folding of the mucous membrane into crypts. The middle palatal depression is bounded anteriorly by a raised portion of the palate from which a crest, large, rounded in front, is continued, diminishing in height as it proceeds backward. Behind the palatal depression lies the choanal region, oblong in shape, and much deeper than the rest of the upper surface of the mouth. It contains the somewhat crescent-shaped choanae and the choanal cul-de-sac, the latter to be found between two folds separating the choanae, diverging and flattening out posteriorly. At a point on the middle palatal depression on each side of the palatal crest, opposite its posterior termination and adjacent to the palatine ridge, is to be found, in hardened specimens, a very delicate groove, containing the openings of the Organ of Jacobson and the lachrymal duct.

The corneous matter covers the edge of the lips to the lateral border of maxillary ridge. At this junction of the corneous and maxillary regions the apertures of the ducts of the upper lip gland are found.

In a transverse section of the nasal region of the adult, through the middle of the Organ of Jacobson, the latter is situated immediately above the palatine ridge and the middle palatal depression on each side of the middle line, and placed adjacent to the inner wall of the nasal passage, which is here inclined outward and downward. Laterally from the Organ of Jacobson and under the nasal passage lies a cavity with its transverse axis horizontal, which may be termed the maxillary sinus. Above it Müller's Nasal Gland covers the lateral wall of the nasal passage. (Fig. 2, *Mg.*) Immediately above the inner corneous portion of each lip is seen the upper lip gland with several lobules. Below, the maxillary and palatine ridges are strongly marked, and the middle palatal surface has a distinct crest. (Fig. 2, *m*, *p*, and *pc.*)

The vomer is double, each half forming a capsule for the inner and a portion of the under and upper walls of the Organ of Jacobson of its side, and consisting of three portions, a basal not quite horizontal, a thin vertical plate concave on its outer face, and a cupped crest. The inner edge of the septomaxillary, appearing in section as if turned under on itself, rests on the cup of this crest, and the septomaxillary is continued from here outwards between the Organ of Jacobson and the nasal passage. Under the latter, it gives two plates, one to proceed down the outer surface of the Organ of Jacobson, the other, to proceed in opposite direction, on the outer wall of the passage and terminate in the middle ot its height. The lower plate is found in other sections to enter the pedicle (Fig. 2, *pd,*) of the Organ of Jacobson, and partly fuses there with the basal portion of the vomer. In the section represented it does not so enter, its place being occupied by the cartilage which passes out from the pedicle and lines the outer under face of both plates of the septomaxillary, and ultimately in sections behind this reaches the turbinal ingrowth, with the cartilage of which it unites. (Figs. 2, 3, 4, *tb.*) The upper half of the pedicle is filled with cartilage throughout, (*tb'* 2, 3.) The turbinal cartilage extends over the nasal cavity to connect in front with the wing of the nasal septum, which terminates inferiorly with a rounded edge between the cupped crests of the vomer of each side. (Figs. 2, 3, 4. *Sept.*)

In a section through the anterior termination of the maxillae, the latter with the premaxilla form a horizontal plate with a plate of cartilage. also horizontal, in its centre. In a section behind this the cartilage is concave on its upper face, and the osseous piece above it, is the ascending process of the premaxilla. Below, are two basal pieces, not distinctly separated from each other, or from the maxillae now somewhat laterally. Behind this again the cartilage takes a U form, the wings of which give off on each side a nearly vertical transverse plate, forming a prenasal wall, and reaching the cheek in front of the anterior nasal opening. Between the wings of the main cartilage, now the nasal septum, the ascending process of the premaxilla extends and forms a vertical plate. (Fig. 6, *pra.*) Immediately behind the transverse prenasal wall of each side, the septomaxillary commences rod-like, and separated from the similarly shaped vomer by a thin sheet of cartilage continuous with the transverse prenasal wall. The basal portions of the premaxilla (*prb*) do not extend much further behind this point. The septomaxillary becomes flattened as it proceeds backward, its transverse axis directed outward and downward, and applied in this manner to the wall of the nasal cavity. It is still separated by the cartilage, above described, from the vomer. When the Organ of Jacobson is reached, the septomaxillary has acquired considerable thickness and forms its anterior wall, while the cartilage enters the pedicle, in the anterior half of which the two mentioned bones fuse, although incompletely. The septomaxillary undergoes another change in form at the hinder half of the Organ of Jacobson it gradually loses the prolongation on the outer and under surface of the Organ, which is there replaced by the vomer. It also rises and becomes more closely applied to the nasal wall. On the other hand, the cupped crest of the vomer becomes prolonged outward under the septomaxillary and parallel with it. This portion of the vomer is much fenestrated to allow a passage to the Organ of Jacobson for the olfactory nerve bundles. Below, the basal portion reaches outward, and finally unites with the superior prolongation on the outer surface of the Organ.

The vomer thus surrounds and envelopes the posterior, as the septomaxillary does the anterior, termination of the Organ of Jacobson, behind which it divides into two portions, the inferior quickly disappearing, the superior losing its horizontal process rises, and with its fellow of the opposite side forms a capsule for the lower half of the nasal septum, now oval in section. Approaching the choana of its side, it descends again to apply itself to its inner wall, and terminates by sending a plate outward over the choanal roof to unite with the palatine bone.

As before stated, the wings of the nasal septum pass out over the nasal cavities down their sides to connect with the turbinal cartilages. The latter are provided in their front half with a concavity on the outer face of each, to which the Nasal Gland of Müller accommodates itself. This concavity deepens as the cartilage is followed backward, the edges approximating and forming ultimately behind a closed tube, containing a separate portion of the gland. (Fig. 4, *Mg'*). This tube ends blindly with the turbinal ingrowth.

In front a plate of cartilage, continuous with the turbinal, passes around the nasal opening, and is connected with the transverse prenasal wall. (Figs. 6, 7, *nc*, *nc'*.) Below, the turbinal is connected with the cartilage of the pedicle of the Organ of Jacobson by a narrow transverse plate passing under the septomaxillary. This transversely directed plate of cartilage is continued backward into two pieces, which in a transverse section containing the opening of the Organ of Jacobson are arranged, one immediately under the outer half of the latter, the other some distance laterally. (Figs. 3, 4, *lc'*, *lc''*.) These are the lachrymal cartilages, and are described below in connection with the lachrymal duct.

The nasal bones immediately succeed the ascending process of the premaxilla. They reach down between the wings of the nasal septum, and do not pass out farther than the superior border of Müller's Gland. Posteriorly, each have a process directed downward to unite with the process of the inner edge of septomaxillary, when the plate of the latter disappears behind. (Fig. 4, *na.*) This inferior process is continued into the rostrum of the frontal bone of the same side.

In the same section as at first examined, viz., that through the middle of the Organ of Jacobson, the mucous membrane of the roof of the mouth differs in structure at the following points:

(*α*) At the inner surface of the lip, where large nucleated cells are overlaid by a corneous stratum; the cells at the base, while of the same size and shape, are more granular in contents.

(*β*) In the immediate neighborhood of the furrow, in which the ducts of the upper lip gland open; there the corneous layer is replaced by flattened, apparently squamous, cells overlying a layer of small oval cells. This is the structure of the membrane on the middle palate and in the dental pits.

(*γ*) In the palatine crypts, where goblet and ciliated cylindrical cells alone are found, the latter being to all appearance the more numerous.

(*δ*) At the passage from one palatine crypt to another, where the membrane is formed almost wholly of ciliated epithelium cells, with here and there a goblet cell.

The furrow to be found limiting the inward extension of corneous layer of the lip receives at regular intervals the apertures of the ducts of the upper lip gland. From here the ducts lead upward and outward and break up into a number of acini. Immediately above the lobule thus formed are to be found the sections of preceding or succeeding lobules, three or four in number. The cells of the acini in the uppermost lobules are of larger size than those of the lower. The nucleus in each is generally situated in the outer half of each cell, the contents of which are more or less granular, and slightly pigmented, giving to the gland, as a whole, a yellowish tinge. When removed in a state of active secretion, the cells of the gland are found to be extremely granular. As these approach the main duct they elongate and become cylindrical. The acini are compressed against each other, thus becoming polygonal in section and are separated by small quantities of nerve fibres and connective tissue.

The gland extends from the transverse prenasal wall to a point immediately behind the fleshy union of the jaws. The lobules are larger and reach higher as they are followed backward.

A large gland fills up the space between the cartilaginous prenasal wall and the apex of the snout. It is termed the "snout gland," and and is shown by Reichel to be but a separately developed portion of the upper lip gland. Its ducts open in the depressions placed laterally from the head of the palatal crest. This shows it to be a paired gland, but the acini of lobules from one side are directed in every manner amongst those of the other side; as Reichel points out, they are quite separate at an early stage. The cellular structure is very similar to that of the upper lip gland, and possesses also the yellowish tinge. The lobules reach up nearly to the posterior end of the ascending premaxilla.

The Nasal Gland of Müller is situated on the lateral wall of the nasal cavity, from which it is separated by the turbinal cartilage, and the septomaxillary; as already described, it conforms itself to a concavity on the outer face of turbinal cartilage. As the concavity deepens to form a tube, a portion of the gland is included in it to its blind termination. It does not reach farther behind than the turbinal ingrowth, and anteriorly than the Organ of Jacobson. The duct, however, is continued, first on a level with the turbinal ingrowth, then on the lower outer surface of the nasal wall, which position it keeps till it reaches the anterior nasal opening, on the lower posterior edge of which is found its flask-like aperture. Fig. 7 is a representation of a transverse section at this point, with *ap* the aperture over a broad groove, which in front of this forms the floor of the nasal cavity.

The cells of this gland are provided with large distinct nuclei and a protoplasm but little granular and staining very deeply. Their shape is generally cubical, approaching to cylindrical. The acini are arranged in horizontal layers separated by connective tissue, nerve fibres and capillary vessels, and are perfectly circular in transverse section. The main duct is continued behind, about the centre of the gland.

The mucous membrane lining the floor of the nasal passage is folded in a remarkable manner, reaching out into and narrowing its lumen; its constituents are ciliated cylindrical cells and goblet cells. Below these is found a layer of cells whose characteristics change with their situation, oftenest of small spherical form and granular contents.

The olfactory portion of the wall of the cavity may be divided for the purpose of description as follows:

(*a*) The mucous stratum, lying adjacent to the cartilaginous plate; it is constituted of large pigment cells, nerve fibres and capillaries, forming a plexus, which surrounds the branch tubules of Bowman's glands.

(*β*) The sensory stratum, resting on *a*, which is composed mainly of the nuclear portions of the sensory cells, arranged in 8–10 layers. The central processes of these are much more delicate than the peripheral, and in many places in my preparations are seen to be continuous with olfactory nerve fibres. The peripheral processes exhibit a marked wavy contour, and in specimens, subjected to the action of Müller's Fluid, appear possessed of granular contents. Outside and beyond the cells of *γ*, these abruptly become slender, forming the so called sense hairs, (the Riechhärchen of Max Schultze) directed into the nasal cavity. These, when examined in salt solution, exhibit considerable movement, their axes becoming every now and then wavy. At their origins are to be observed delicate swellings. The nucleus of the sensory cell is perfectly spherical, and, like the protoplasm surrounding it slightly glanular.

(*γ*) The superficial stratum, composed of cylindrical epithelium cells with oval nuclei lying between the peripheral processes of *β*. The central ends of these are very delicate, and are not branched. I have not observed any longitudinal striation on their surface. Forming the outer terminations of these cells and encasing the delicate swellings of the sense hairs, is seen, with favorable light, a distinct border structure, corresponding to a *membrana limitans olfactoria.* Through this the protoplasm of the cylindrical cells sends out excessively fine cilia which are seen in their entirety in salt solution, but when macerated, too often form only a granular precipitate at the border of the cell. They do not reach nearly the same length as the sense hairs, and exhibit a very slow movement, their axes remaining perfectly straight all the while. Sometimes these are obscured by the mucous and mucous cells from the adjacent glands.

At the junction of the olfactory with the mucous portion of the nasal wall a great development of Bowman's Glands is to be observed; their size here is extraordinary compared with those of other portions. They are composed of cells of two forms, those in the depth of the gland being large and almost spherical. As they approach the aperture of the gland they gradually become smaller, assuming a rhombohedral form. The large cells in ordinary stained preparations do not show nuclei, but after a stay in Müller's Fluid the nucleus is found adjacent to the wall of the now perfectly spherical cell. The opening of the gland takes place at an indentation on the surface of the membrane.

The following account of the structure of the Organ of Jacobson based partly on my preparations, was contributed by Prof. Wright to the *Zoologischer Anzeiger* (No. 144), and will serve to explain his figures (Nos. 8, 9, 10):

"The Roof.—Immediately within the osseous capsule which the Vomer forms for Jacobson's Organ lies a somewhat scanty mucosa which is largely occupied by olfactory nerve-bundles: it is more richly pigmented than the corresponding layer in the nasal cavity, its blood-vessels are of larger calibre, and it is destitute of Bowman's Glands. Most of the elements of the mucosa are continued inwards towards the lumen of Jacobson's Organ between its cellular columns which are thus isolated from each other by pigmentary connective-tissue and capillary vessels. Very few of the olfactory nerve-fibres appear to run in the partitions thus formed, the bundles entering the outer ends of the cellular columns almost entirely. The capillaries arrived at the deep surface of the *Neuro-epithelium* form there a plexus, the polygonal meshes of which are occupied by the inner ends of the cellular columns. This plexus obviously corresponds to that on which the Neuro-epithelium in the nasal cavity rests; but there is no intervening basement membrane, for a reason which will be presently apparent. The *Neuro-epithelium* (inside the plexus) is only 33 μ high, and the greater part of this belongs to the superficial stratum (as defined above), while only one or two layers of cells corresponding to the nuclear are to be detected. These latter cells, however, differ in form, according as they stand opposite a node or a mesh in the capillary plexus; in the former case they are shorter, and their deep processes are bent in such a manner as to pass around the vessel, in the latter case they are more fusiform and they retain this shape for three or four layers while passing through the mesh in the corresponding cellular column. With the exception of these spindle-shaped cells which form their inner ends, the cellular columns are formed entirely of cells, completely resembling those of the nuclear stratum in olfactory epithelium of the nasal cavity; *i. e.*, they possess rounded nuclei (6—7 $\mu \times 5 \mu$) surrounded with very scanty protoplasm prolonged into processes at either end. The highest columns measure about 300 μ.

The Floor.—The following structures may be traced from roof to floor.

(1) The layer of ordinary cylindrical epithelium cells which are now only 15 μ high and bear short cilia; between the bases of these are wedged small rounded cells forming rarely more than one layer; these rest on

(2) The capillary plexus, which is directly continuous with that mentioned above; the rest of the mucosa is occupied by

(3) The abundant pigment cells which spread out at the junction of floor and roof to surround the cellular columns in the mode described above."

Prof. Wright's and my own studies further on the same subject have given the following:

The sensory stratum is divided into (1) the cellular columns already mentioned, oblong in section in the body of the organ, but at its posterior termination, polygonal, completely surrounded by the constricting plexus at all but one point, where their cells pass gradually over into those of (2) the sensory portion adjacent to the superficial stratum, and consisting of two or three layers. The cells of the second portion of this stratum do not exhibit any difference from the sensory cells of the nasal passage, except that the nucleus in each and the portion of the cell containing it are more or less fusiform. In those of the columns, however, the central and peripheral processes are undistinguishable, so far as shape is concerned, both exceedingly delicate and wavy in their course. When the columns, macerated in Müller's Fluid, are teased out, minute portions will be frequently seen through which the delicate processes pass in every direction. The nucleus in each is large, distinct and quite spherical, with little protoplasm surrounding it. Through the point of the connection of the columns with the rest of the sensory cells, their peripheral processes reach down between the latter to the lumen of the organ and terminate like them.

The terminations of the sensory cells in the lumen are knob-like and about one-fourth the length of the sense-hairs in the nasal passage. With such a length all capability of movement is absent. There is no swelling to be observed at the base of each.

In the superficial stratum the cells have the same shape as in the nasal cavity. They are provided with the same distinct border structure, through which the sensory terminations push. Of any prolongation of the protoplasm of the superficial cells beyond this border structure no convincing proof has been met with as yet. In several cases a faint striation parallel with the cylindrical cell was observed at its border. This was replaced by a delicate granular precipitate in macerated specimens. The number of cases in which such a striation was observed, were few in comparison to the amount of material examined. It is, however, quite probable that the cylindrical cells are provided with cilia as excessively fine as these of the nasal cavity.

The border structure must be regarded as the homologue of the *membrana limitans olfactoria* of the nasal cavity.

The contents of the nerve-bundles near their origin from the olfactory lobes have a gelatinous appearance, with delicate lines to indicate a division into fibres. Each bundle is provided with a thin cellular sheath, which in cross sections is seen to strike in to form still smaller bundles. The fibres which appear more distinctly some distance down the bundle are non-medullated, but provided with a distinct sheath in which are to be observed here and there spindle-shaped cells, giving often the appearance of swellings on the course of the fibre. In the immediate neighbourhood of the sensory stratum either of the Organ of Jacobson or of the nasal cavity, these appear to be wanting. The diameter of the nerve threads here compared to those of the bundles farther up, would seem to indicate that these are primitive fibrils formed by the division of the contents of the main fibres. These primitive fibrils, if they are such, show no varicosities and give no evidence of any sheath like that possessed by the main fibres beyond having a sharply defined boundary. These fibrils are seen in such a condition when the sensory cells are pencilled out from cellular columns, leaving only a few fibrils. They terminate as far as I can make out from my preparations at the central processes of the censory cell. The process and the fibril are of equal diameter. In sections from the embryo the fibrils appear to end in the nuclear portion of the sensory cell, and then a central process is not percievable. It is impossible to say whether the latter is a structure distinct from the nerve fibril; on the other hand, I have no hesitation in saying that the both are continuous.

The bundles may divide for both the Organ of Jacobson and the nasal cavity. Those for the former are arranged in a fan-shaped fashion. The smaller bundles for the nasal cavity strike in at every angle through the mucous stratum, bending around capillaries and crypts of Bowman till they reach the sensory stratum.

The nasal cavity, in front of its anterior opening, is of the shape represented in Fig. 6. The groove to be found on its floor here runs backward through the opening on the cheek posteriorly. (Fig. 7, *gr.*) Behind this the passage takes a $\widehat{V}$ form, whose lumen the turbinal ingrowth tends more and more to diminish, and is practically divided by it into two channels, one, the upper nasal chamber, to a great extent lined by the olfactory membrane, and communicating over the rounded edge of the turbinal with the mucous or lower nasal chamber, whose size is diminished by the mucous folds. The inner wall of the mucous chamber runs into a tube prolonged forward on a level with the Organ of Jacobson, and ending blindly immediately behind it. The tube is succeeded by a groove of the same calibre, which, with its fellow of the opposite side, narrows considerably the fleshy septum. The canal and groove are lined with folded mucous membrane. With the termination of the turbinal the passage becomes smaller and descends to the roof of the mouth to end in the choanae. These, observed from below, are slightly crescent-shaped, and are separated by folds (*Fig.* 1, *chf.*) which contain between them the choanal cul-de-sac, ending blindly in front over the middle palate. The choanal depression is somewhat narrowed below by a fold on each side from the palatine ridge.

It is necessary to add some further details concerning the general histology of the nasal cavity, in addition to what is given above, for one section of it.

In the groove in the floor of its cavity, in front of the nasal opening, the cells of the lining membrane are, passing from its base upward, oval and granular, then large and polyhedral, and covered by a layer of flat corneous cells, the latter several layers thick near the posterior termination of the groove. The whole offers no contrast to that found just inside the lips, except in the size of its constituent cells.

The cavity anteriorly to the Organ of Jacobson is very poor in olfactory epithelium. The mucous membrane is but little folded, and the cylindrical cells with thick cilia appear to wander into the olfactory portion.

Above the Organ of Jacobson the mucous folds of the lower chamber seem to fill it out completely, while the olfactory epithelium does not reach that development which obtains behind. For there the turbinal is of its greatest transverse length, and its rounded edge, like the inner and upper walls of the upper nasal chamber, is lined by well developed olfactory membrane. The superficial and sensory portions of the same are wanting in the floor of the upper chamber. Coincident with the disappearance of the turbinal behind, the olfactory epithelium becomes scanty again, and on the roof and floor of the passage, in the immediate neighborhood of the choana, is replaced by mucous membrane, that lining the roof abounding in goblet cells, while the majority of the constituents in the floor are formed by ciliated epithelium cells, which are also abundantly found on the palate immediately anterior to the choanae. In the choanal depression, minor folds of the membrane are very abundant. The two large ones separating the choanae enclose a cul-de-sac. whose lining membrane contains a profusion of goblet cells, which, however, give place to ciliated epithelium cells at the opening.

The Organ of Jacobson (Fig. 2, *J. O.*) is with its pedicle of semicircular shape in transverse section, the cellular columns of its roof appearing to radiate about the crescentic lumen of the canal, and to form the greater portion of its bulk. These are of greatest length on the inner and upper side at the opening, behind which they are found on all sides of the now oval lumen. (Fig. 4.) The crescent form of the canal in front is due to the growth inward on its floor of a projection from the palate, and filled out with cartilaginous and parosteal structures as described above. For want of a better term I have called it the pedicle. (*pd.*) It bears a marked resemblance to the turbinal, this similarity being somewhat strengthened when one considers the connection of their cartilages, and that the Organ of Jacobson and the upper nasal chamber are functionally alike. The inner wing of the lumen of the canal becomes prolonged downward between the pedicle and the basal portion of the vomer. and opens in the groove to be found on the border between the middle palate and the palatine ridge. (Fig. 3, *Jop.*) This groove can without much difficulty be seen in hardened specimens, and in fresh ones only when the upper jaws are pressed upward, thus separating the palatine ridge and middle palate and exposing the groove. Behind this opening the pedicle disappears and leaves the canal oval in section. (Fig. 4). On its further course the columns arrange themselves on its under side, and are continued for some distance behind its blind termination.

The lachrymal duct opens on the inner wall of the same groove in which the Organ of Jacobson opens. (Fig. 3, *Lop.*) It runs behind under the organ as far as it is continued behind, when it gives a sharp turn outward toward the palatine bone. A longitudinal section of the duct is illustrated in Fig. 11. There *a* represents the basal portion of the duct which lies partly under the vomer and partly beside the palatine bone, and ends blindly behind (*b*). The main duct is continued upward and outward over the palatine, where a slight prolongation forward is found (*c*), and which appears in section in Fig. 4. A similar prolongation is found on the level of the turbinal, the cartilage of which furnishes a ledge on which the duct rests for a short distance, after which it is completely surrounded by the lachrymal bone for a portion of its course. As it approaches the eyeball it lowers to its anterior angle, and takes a sharp turn inward and upward to terminate in its gland, situated on the inner surface of the eyeball, and separated from its fellow of the opposite side by the basisphenoidal rostrum.

The cartilages (Figs. 3, 4, *lc'*, *lc''*) which have been termed lachrymal above, are but backward continuations of the transverse band connecting the turbinal cartilage with that of the pedicle of the Organ of Jacobson. When the lachrymal duct has reached the palatine bone, they apply themselves to its outer and under wall and fuse, forming a plate continued behind with the blindly ending basal portion of the duct. The plate behind the latter becomes flattened horizontally, and terminates in front of the choana of its side.

The sections from the embryo head reveal some important points which may be summarized here.

The roof of the mouth exhibits in the main the features of the adult palate. No glandular structures are present, there being but an involution of the lining membrane to form the future upper lip gland. (Fig. 5, *gl.*) The opening of the Organ of Jacobson is situated in the groove to be found laterally from the choanal depression.

The Organ of Jacobson has the same form as in the adult. The cellular columns number about twenty in each section, while in the adult the number reaches sometimes as high as sixty. But the remainder of the roof, of which they are the constricted portions, is much thicker, and in it 8–10 layers of cells may be counted. Neither these nor those of the columns are possessed of peripheral processes, at least such are not demonstrable. Fibres arising from the inner surfaces of the olfactory lobes pass down the sides of the septum, enter the outer ends of the columns, and terminate at its cells. The whole roof does not exhibit, in addition to the division into columns, any difference from that lining the upper nasal chamber. Its floor is lined by two layers of interfitting columnar cells.

The continuity of the cartilage of the Organ of Jacobson with that of the nasal cavity, which only a study of many sections of the adult shows, is demonstrated by one, or at most two sections, from the embryo head. Fig. 5 is a representation of one of these. The cartilage there seen on the lateral wall of the upper nasal cavity passes down into the turbinal, bends and forms a loop, which is the origin of the closed turbinal tube containing in the adult a portion of Müller's Nasal Gland. It is continued downwards, and after giving off a thin sheet, which is deflected between the Organ of Jacobson and the nasal wall, the main portion reaches the maxillary cartilage, bends horizontally inwards to the pedicle of the Organ of Jacobson, where it turns upward and ends in a thickened rounded edge. I have not found any thin plate separating the nasal wall from the Organ of Jacobson in the adult.

EXPLANATION OF PLATE I.

FIGS. 1, 8, 9, 10 were executed by Prof. Wright. The others were drawn by myself from photographic representations or by means of the camera.

GENERAL.

Ch. .. Choanae.
Chf. .. Choanal folds.
Mdp. .. Middle palate.
M. .. Maxillary ridges of the palate.
P. .. Palatine ridges bounding the middle palate.
Pc. .. Longitudinal crest of the middle palate.
Pa. .. Palatine bone.
Mx. .. Maxilla.
Gls. .. Upper lip gland.
Mg. .. Lateral Nasal Gland of Müller.
J. O. .. Organ of Jacobson.
J. C. . Canal of the Organ of Jacobson.
Pd. .. Pedicle projecting into the floor of the Organ of Jacobson.
Vo. .. Vomer.
Tb. .. Turbinal cartilage.
Tb'. . Cartilage of the pedicle of the Organ of Jacobson.
Sept. .. Nasal septum.
Spx. .. Septomaxillary bone.
Spx'. .. A portion of the vomer replacing the septomaxillary.
Na. .. Nasal bone.
Pra. .. Ascending process of the premaxilla.
Lc', lc''. .. Lacrymal cartilages.
Lop. ... Opening on the mouth of the lachrymal duct.
Lc. .. Lachrymal duct.
Op J. .. Groove into which the canal of the Organ of Jacobson opens.
Olf. .. Olfactory lobes.

Nc, nc.' .. Cartilage surrounding anterior nasal opening.
Tr. .. Transverse plate of cartilage passing from the pedicle of the Organ of Jacobson to the turbinal cartilage.
Unc. .. Upper nasal chamber.
Lnc. .. Lower nasal chamber.

FIG. 1.—A view of the roof of the mouth in Eutaenia sirtalis; several times magnified.

FIG. 2.—A transverse section of the nasal region through the middle of the Organ of Jacobson. x 20.

FIG. 3.—One half of a transverse section of the nasal region through the openings of the Organ of Jacobson and the lachrymal duct. x 20.

FIG. 4.—A transverse section some distance behind that represented in Fig. 3. x 20.

FIG. 5.—One half of a transverse section of the nasal region of an embryo head 6 mm. in length of Eutaenia sirtalis. x 50.

FIG. 6.—A transverse section of the nasal cavity anterior to the external nasal opening. x 30.

FIG. 7.—A transverse section of the nasal cavity containing the aperture of the duct of Müller's Nasal Gland. x 30

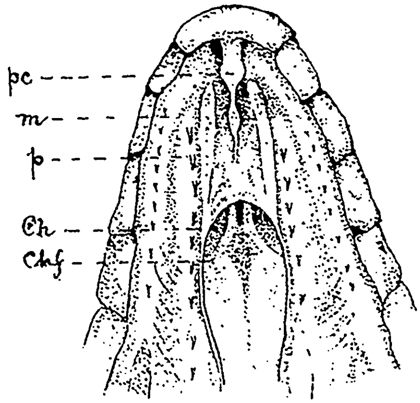
FIG. 8.—A portion of a transverse section of Organ of Jacobson in an adult Eutaenia; *J. C.* the canal of the Organ separating roof and floor; *a*, capillary vessel descending between columns, one of its branches passing to the left around the point of passage of the censory cells adjacent to superficial cells over into those of a column. Separating the columns also is seen pigmentary tissue. Above, the mucosa contains a nerve bundle cut across and a large capillary. x 250

FIG. 9.—A portion of the foregoing—*a*, superficial cells; the peripheral processes of the sensory cells pass down between them and through the "border structure"; *b*, sensory cells opposite a node (*d*) of the capillary plexus; *c*, those opposite a mesh of the same and passing over into *b'* those of the columns. (The outer ends of the sensory processes and of the superficial cells are represented diagrammatically.) x 700

FIG. 10.—A transverse section of the posterior ends of the cellular columns of the Organ of Jacobson in an embryo Eutaenia. The plexus separating the polygonal areas is not shown. x 200

FIG. 11.—A longitudinal (diagrammatic) section of the lachrymal duct; *a*, the basal portion found under the Organ of Jacobson and continued into *b*, ending blindly; to the walls of this latter the fused lachrymal cartilages are applied; *c*, a swelling of the lumen of the duct over the palatine bone; *d*, the portion on a level with turbinal. The gland is supposed to be seen through the eyeball.

NOTE—In the figures the shaded portions represent membrane bone, while the dotted protions are intended to designate cartillage.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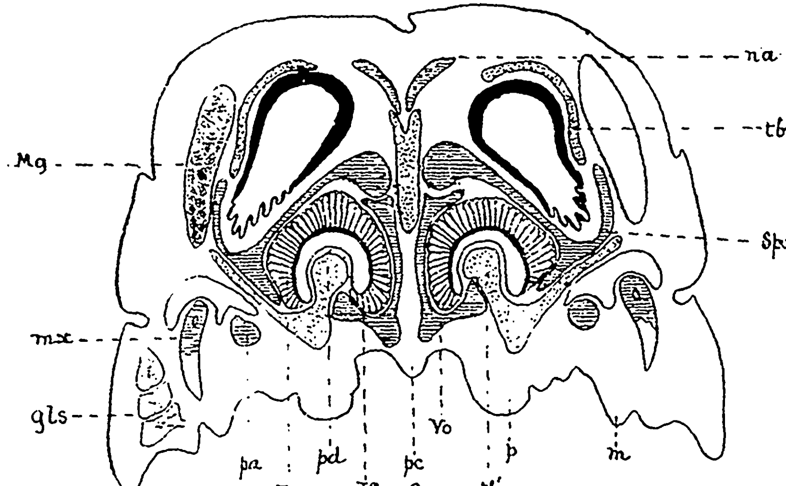
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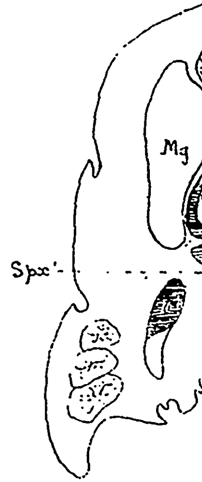
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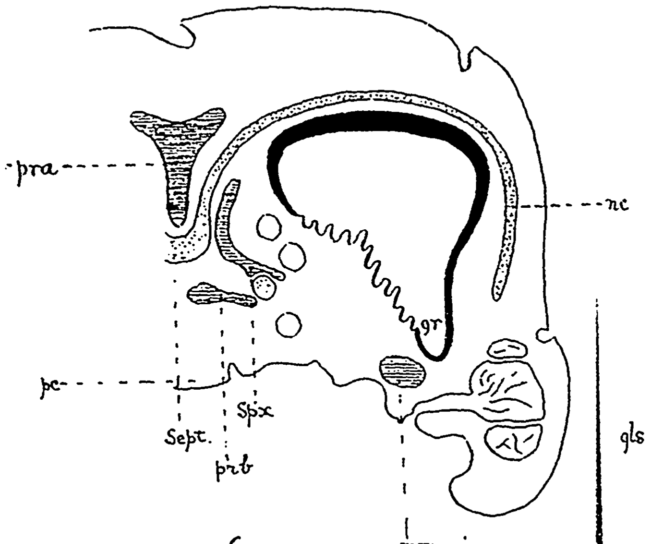
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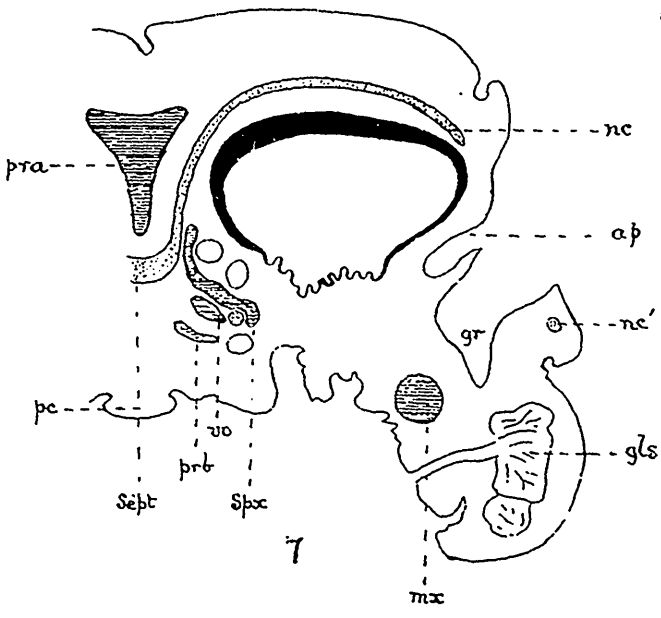
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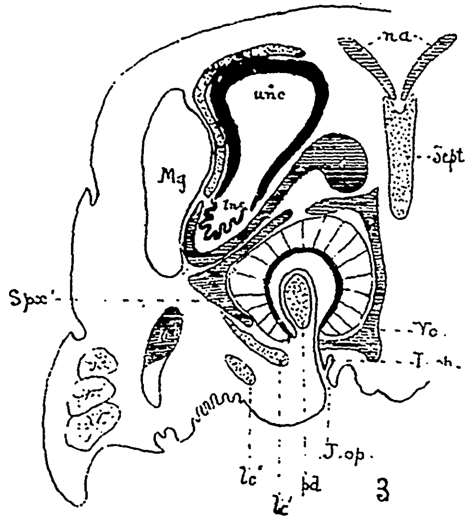
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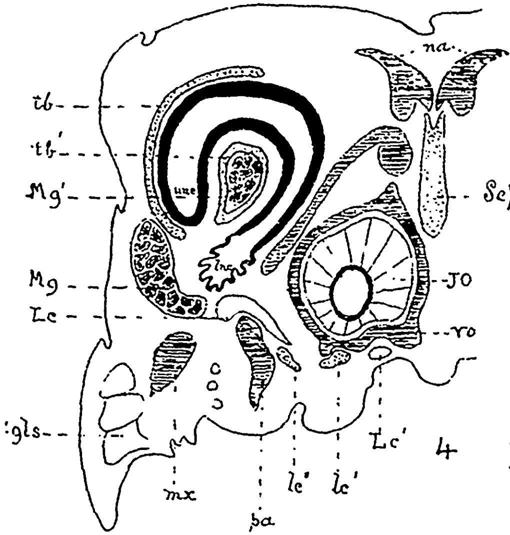
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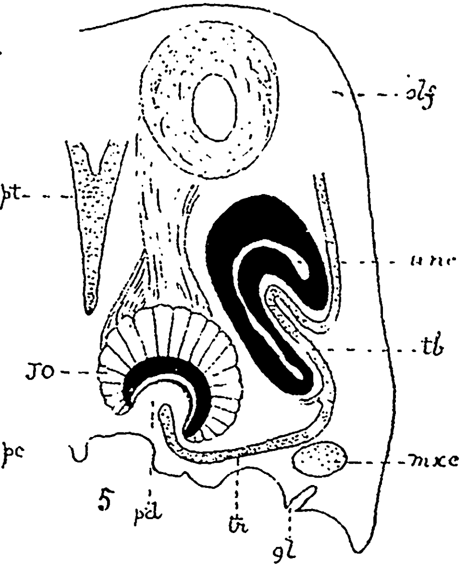
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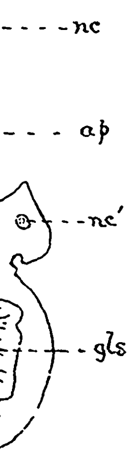
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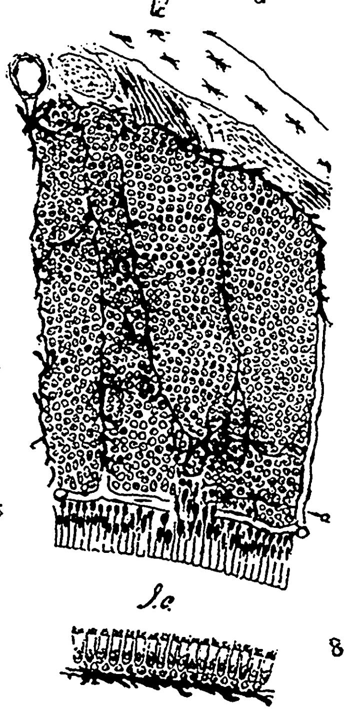
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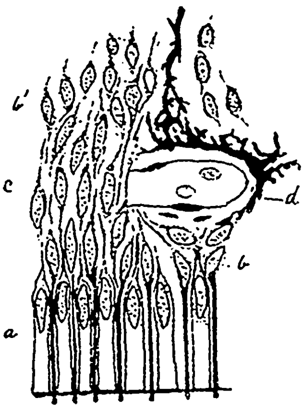
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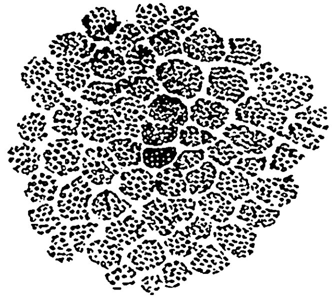

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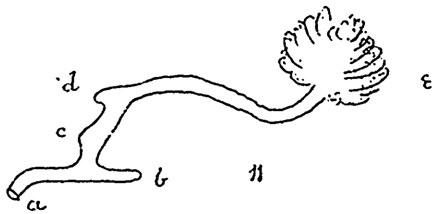
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11

THE PRAIRIE CHICKEN,

OR SHARPTAILED GROUSE.

(Pedioecetes Phasianellus). (Baird).

BY ERNEST E. T. SETON.

For brevity I may describe it as a *grouse*, mottled above and white below, pretty much like all the family, but *unlike* in having the tail feathers very stiff and so short that the upper coverts ending in a point project beyond the quill feathers. Hence the name "Sharptail," or more commonly "Pintail," though throughout this country it is most known as the "Prairie Chicken."

To avoid that most tedious and thankless task, a detailed verbal description, I forward herewith a stuffed specimen, a female, but there is little difference between the sexes. The males have bright yellow bare skin over the eye (not *red*, as say Wilson and Audubon), and on each side of the neck a bare airsac, blue, and about the size of a pigeon's egg. These connect with the mouth, for they can be inflated by blowing down the throat. When the bird is quiescent they are merely sunk under the surrounding feathers, which are not in any way specially developed to hide them, as in the Ruffed and Pinnated Grouse. In the breeding season they are in a state of chronic inflation and brilliancy.

The females differ only in having their bare skin ornamentations much less (not absent, as I have seen stated). The young of both sexes are indistinguishable from the female or the male in non-breeding season, except that they are a little smaller, and have the hair-like feathers on the feet shorter and more marked with dusky.

In the feathering of the legs this grouse comes just between the Ruffed Grouse of the South and the Ptarmigan of the North, as does the bird itself geographically. The feathering stops at the base of the toes, but by reason of its length the toes are half hidden.

Their toes, as in all grouse, are notably pectinated. Not having heard of any use for these combs, I append a few observations. In early spring they begin to drop off, just an odd one adhering here and there. In a week or two they are all gone, and during the summer the toes are clean and smooth. After the second or third week of the young one's lives, (that would be mid-August or earlier) both young and parents begin to show a row of growing scales along each toe. These grow with the growth of the chicks, and by October the birds are full grown, as are their toe combs and those of the parents. Then, since these combs exist only in winter, it is natural to suppose they are meant to act as snowshoes, and to stay the bird from slipping on the crust and icy limbs of the trees whose browse forms its winter food. These snow combs continue in perfection during the six months of winter, but with the first return of warm weather they are shed.

The tail feathers, of which I have already spoken, are worthy of notice. They are exceedingly stiff and I may say sonorous. When the male is strutting before the female, or when either is shot and dying, the tail is rapidly opened and shut, the stiff quills making a loud noise like a porcupine's quills, or like shaking a newspaper. The muscles for expanding the tail seem to be very largely developed.

The chickens winter in the dense bush, but in spring, ere yet the snow is gone, they scatter over the prairies, where alone they are found in summer. They are now very shy, for only the shy and wary ones have successfully run the gauntlet of such winter hunters as owls, foxes, wolves, martens, Indians, etc.

Their advent on the still snow-covered plains might be reckoned premature and fatal to many, but they find a good friend in the wild rose. It is abundant everywhere, and the red hips, unlike other fruit, continue to hang on the stiff stems, high above the damage of wet and earth. It grows most abundantly on the high sandy knolls, where the snow is thinnest, so here the grouse meet and are fed. In this section of the North-West stones or gravel are almost unknown, so birds requiring such for digestive purposes would be in a dilemma, but that the stones in the rose hips answer perfectly, thus the hip supplies them with both millstones and grist at once, the flesh at the same time receiving a most delicate flavor. While from the same cause the gizzard of a newly-killed grouse is of a most pleasing odor of rose.

It is difficult to over-estimate the importance of the rose to this and other birds. I append a table of observations on the crops of grouse. I regret that it is not complete for the year :—

April................	Rose hips,	birch and willow buds.
May	"	sand flowers, etc.
June......	"	grass and various.
July	"	stargrass seed, etc.
August..............	"	grass and various berries.
September	"	" " "
October	"	grass, berries, etc.
November	"	Arbutus berries, browse, etc.
December	"	Juniper " " "
January	"	browse and equisetum tops, etc.
February and March..	Not observed.	

This is, of course, a mere list of staples, the grouse being quite omnivorous, but throughout I found, that, of their food, hips formed a large part, for they are always attainable, even in winter, through their two valuable qualities, of growing where the snow is thinnest and not falling when ripe.

After the hips, their most important food, in May, is the sand-flower, which whitens the prairies with its millions, spreading from the great lakes to the Rockies. This plant is for the time the food of all creatures, the grass not yet being grown, so on it buffaloes, deer, horses, cattle, crane, grouse, geese, gophers, and all but carnivorous animals subsist. The receptacle is large and fleshy and apparently very nutritious. To the taste it is very pungent, so it may hasten the breeding season of the grouse, etc.

During spring and summer the grouse are assembled every morning on the top of some chosen hillock in companies of half-a-dozen or more. Here there is a regular performance called "Partridge Dance," the birds running about, strutting and crowing in an extraordinary manner. I refer the reader to Wilson, as his account thereof is more detailed than any I can give. I may state, however, that he says these dances terminate when all are paired, whereas I find them to continue until the young are hatched, and, indeed, I begin to have little faith in the pairing at all, as this "hillock dance" appears to be the common nuptials of the tribe, and it is difficult to see how the males and females can both be there (the males are most indefatigable in their attendance) if the males have anything to do with the eggs.

During the dance, the males strut as do most gallinaceous birds, with feathers all erect, the wings spread (not touching the ground), tail spread and upright, the head nearly touching the ground, the sacs on the neck inflated and displayed to their utmost; thus the bird runs a few yards uttering a sort of bubbling crow, which sounds as if it came from the air-sacs; after this they relax for a few moments, then repeat the performance *ad lib.* When disturbed they immediately take wing and scatter (not hide in the grass (Wilson), uttering as they rise a peculiar vibratory "cack," "cack," "cack," almost like a cough. This is nearly always uttered simultaneously with the beats of the wings, and so rarely heard except then that I at first supposed that it was caused by them, but since have heard the sound both when the bird was sailing and on the ground, besides seeing it whirr up without the note. They have also a peculiar call note, a whistle of three slurred notes. In the fall their common note is a sort of whistling grunt, which is joined in by the pack as they fly. The "crow" is heard only in spring, the grunt only in fall, but the cackle and the whistle always.

Their flight is very strong and rapid, so much so that they can in winter escape by flight from the white owl. When sprung they rise with a loud whirr, beating rapidly but soon sail, flying and sailing alternately every fifty or one hundred yards.

The hen nests in the long grass tangle, generally near cover or on the edge of timber. The nest is a slight hollow arched over by the grass, lined only with a few straws. She lays eight to sixteen eggs no larger than those of a pigeon. Just before being laid they are of a delicate sky-blue, on exposure they soon become a deep chocolate with a few dark spots. In a fortnight they are gradually changed to a dirty white, partly by bleaching, partly by the scratching of the mother's bill in turning them. Common as addled or infertile eggs are in the barnyard, I never in nature found more than one, and that was of the present species. I found the nest in June; it had eight eggs (less than the complement); I left it untouched, and some weeks after returned to find all had hatched but one; this, on inspection, proved to be non-fertile. Assuming that they really and faithfully pair, it is accountable by supposing that the male was killed and the female laid her last egg unimpregnated and carried out her duties alone.

The young are hatched in about twenty days (?) and are covered with yellow down. From the first, like all their kind, they are strong and able to help themselves. By about the tenth day, though still weighing under two ounces, their wings are large and strong, so that when the startled mother rises with a "whirr" there are a dozen little "whirrs," and away she flies followed seemingly by a flock of sparrows, but they are only her young, still clothed in the yellow down all except the wings which shew the long strong quills of flight. When half grown they are readily mistaken for young turkeys. At about two months they are full grown but still with the mother. At this time the family generally numbers from four to six or eight individuals, but the average number of eggs is about twelve, so we can imagine the numbers that fall victims annually to their natural enemies. It is noticeable that all summer I never found grain in their crops, so that they cannot be injurious to standing grain; indeed, I have never seen them in it. But now that the young are grown, they find their way to the stacks so regularly and pertinaciously that they form a considerable item in the autumn dietary of the farmer, while they can only damage the grain that is exposed on the very top. They continue on the plains and about the farms until the first fall of snow, which immediately sets them *en masse* to the timber. In summer they rarely perch on trees (even at night, for they sleep squatting in the grass), but now they make them their favorite stations, and live largely on the browse there gathered. This is the time for the sportsman, for they are fat and well flavored. Any small clump of birch or willow is sure to contain some dozens every morning. As the winter advances, they cease to come on the plains, their haunts then being sparsely timbered country, especially if sandy and well supplied with rose bushes. They now act more like a properly adapted tree-liver than a ground-dwelling "Tetrao," for they fly from one tree to another, and perch and walk about the branches with perfect ease, seeming to spend much more time there than on the ground. When in a tree they are not at all possessed of that feeling of security from all hunters, which makes the "Ruffed Grouse" so easy a prey to pot-hunters, when so situated the "Pintail" on the contrary is very shy and disposed to fly at 150 yards.

Like most wild animals, they have a foreknowledge of storms, and when some firewood hunter returning from the woods reports that "the chickens are going into the bush," *i. e.*, leaving the open timber and going into the dense fir coverts, the hearers make ready for a severe storm.

Like most of the grouse family, this in winter spends the night in a snow-drift. Out on the plains the wind has pounded the snow into drifts of ice-like hardness, but in the bush it continues soft (this very softness affords another security to the chickens, through its causing the wolves and foxes to quit the bush for the winter though they live there by preference the rest of the year.) In the evening the chickens fly down either headlong into a drift, or run a little then dive. Each makes his own hole. They generally go down six inches or so, and then along about a foot. By morning their breath has formed a solid wall in front of them, so they invariably go out at one side. In Ontario, the non-conductive power of snow is not as likely to be manifested as here, so to illustrate: For weeks, the thermometer being at 20 below zero F.) six inches of snow on one-quarter inch of ice kept the water beneath above 32° F. Without the snow the same ice increased in a day to a thickness of two inches. Likewise, under 10 inches of snow the ground continued unfrozen after the thermometer had for a month ranged from zero to 40 below. Thus we can readily understand that under six inches of snow and one inch of feathers the chickens do not mind even 50° below zero. The great disadvantage of the snowbed is that they are so liable to become the prey of foxes, etc., whose sagacious nostrils indicate the very spot beneath which the bird is sleeping I am almost inclined to think that this is the only way in which a fox has a chance of securing an old chicken, so wary are they at all times. As the winter wanes it is not uncommon for the land to be visited by a fall of snowy sleet; this drives the chickens at once into the snow drifts, and as the sleet freezes it imprisons them and in this way very many perish. In the spring the melting snows leave them exposed, but they are now little else than bones and feathers. There is little else to note about the bush or winter half of their lives. By spring, many of them, by continually pulling off frozen browse, have so worn their bills that, when closed, there is a large opening right through near the end. As the winter wanes, with their numbers considerably reduced, but with the fittest ones surviving they once more spread over the prairies, at first, in flocks, but soon to scatter and enter on their duties of reproduction.

There is another heading under which to discuss the Prairie Chicken, viz., its fitness for domestication. An apparently necessary and most profitable adjunct of every farm is a stock of poultry. But my experience with four varieties of poultry goes to shew that the winter here is far too severe; late chickens are sure to die, while old ones are almost sure to be badly frost-bitten about the head the first winter, and even lose their unprotected toes and legs in the same way. Their feathers, for want of the regular dust bath, etc., become very deplorable and stick so in points and lumps that they lose half their non-conducting power. From this it is evident that the farmer wants a fowl that is without such unnecessary and delicate appendages as combs and wattles, has its legs and feet well protected from the frost, is able to stand any amount of cold, having feathers of duck-like density. The abundance of hawks renders it also desirable that the bird be inconspicuous, not bright colored or white like the common fowls. All this seems to point very clearly to the Prairie Chicken. In addition to these it has the great advantage of maturing early; in ten weeks a Prairie Chicken is full grown, while a common fowl takes thrice as long. The grouse weighs only about three pounds, yet it yields more solid meat than a five-pound chicken, and it can fatten on what the chicken will scarcely look at, having also the advantage of being able to take at one meal enough to last it all day, if necessary, such is the size of its crop. Its flesh is of a most delicate flavor, no barn-door fowl being at all to be compared with it, though this might be one of the first things to be lost in a state of domestication.

I cannot say I know it to be capable of domestication; indeed, I know one man who kept one six months, and at the end it was as wild as at first, but this was caught when full grown. Yet Audubon tamed the Pinnated grouse with little trouble, as did Wilson the quail. And I have little doubt that in a generation or two this would become manageable. The number of eggs laid would, doubtless, increase if eggs were cautiously removed, though, I confess, I found them rather jealous, for, on taking six eggs out of a nest of fourteen, the rest were deserted. These six eggs were hatched by a hen, but earlier than her own eggs, and I found the young grouse all crushed. Wilson says, all attempts to raise the young have failed probably for want of proper food. Perhaps he is right. The situation of the Prairie Chicken's nests here, together with what little I know of the mode pursued in the Old Country for raising young pheasants, induce me to believe that young Prairie Chickens could be successfully reared in a paddock, with a dry sandy soil and plenty of anthills and rose bushes. Ants and ant eggs are the best of food for these delicate creatures.

It is hardly likely that any Manitoban farmer will try to domesticate them, when they are abundant in their wild state, especially as they cannot be expected to compete with the common fowls as egg-producers. It is also extremely unlikely that they will ever be killed out, for notwithstanding the absence of respect for game laws, even in the old settled districts the chickens are as thick as ever, for there is all over a great deal of land that will never be brought under cultivation and it is exactly suited to the chickens.

Yet I think the experiment worth trying, and if any of the gentlemen of the Society have a suitable piece of ground and inclination to take the trouble, I will endeavor in the spring to find him the necessary stock to start with.

February, 1883.

BIOLOGICAL
STUDY OF THE TAP WATER
IN THE SCHOOL OF PRACTICAL SCIENCE, TORONTO.

BY GEO. ACHESON, M.A.
Science Master in Toronto Collegiate Institute.

The object of this paper is to give the results of investigations into the biological nature of the suspended matter in the tap-water of the School of Practical Science. No pretence is made of being exhaustive, for the work has only been carried on at intervals, and observations for any definite length of time have not been continuous. The results therefore are fragmentary, but may serve as a basis for future and more extensive research. A thoroughly systematic examination of the water should include not merely the determination of the animal and vegetable species which are to be found in it, but the physiological influence which these organisms exert, and their importance from a sanitary standpoint. This subject accordingly may be dealt with from both a morphological and a physiological point of view. It is with the first of these aspects only that the present paper is concerned. In regard however to the physiological and hygienic aspect it may be briefly observed, that the purity of water does not depend merely on the quantity of organic matters which it contains; for, if these be living vegetable growths containing chlorophyll, they have a beneficial influence on the water, by supplying oxygen to it and removing carbon dioxide, provided, of course, that their presence in large quantities does not counterbalance their salutary effects. On the other hand, there are organisms which, even if present only in small numbers, exert a very prejudicial influence, and which, if undoubtedly recognized as constantly occurring, should mark a water as unfit for use.

To obtain matter for examination two methods may be employed. One is to tie a muslin bag to the tap and allow the water to run in a slow stream for a few hours; then, taking off the bag, rinse it in a small quantity of water, which, on being allowed to settle for a few minutes, will afford an abundant supply of sediment. The other plan is to open the tap to the full extent and allow it to run for a short time, so as to stir up whatever sediment may be in the pipe; then a tall glass cylinder is filled, and a watch-glass attached to a piece of platinum wire, by which it can be raised, is let down to the bottom of the vessel. The whole lightly covered is put aside for 24 hours to allow it to settle, and after this the water is siphoned off almost down to the watch-glass, which can then be raised without disturbing the sediment which it contains. This latter method possesses the advantage that the same quantity of water is always taken, and thus the amounts of sediment at different times can be compared; while it is almost impossible to fix a tap to run continuously at a given rate, owing mainly to variation in the pressure of the water in the pipes.

A little of the sediment obtained in either of these ways was transferred by a pipette to a slide, and examined with a Hartnack Objective No. 8 and No. 4 Eyepiece. This combination has a magnifying power quite high enough for diagnosing the most of the forms; though on one or two occasions a No. 10 Immersion was used.

The actual amount of suspended matter present in any definite quantity of the water varies very considerably, and depends upon several conditions, among which some of the most noticeable are the season of the year, the amount being greater in winter and spring than at any other time; the prevalence of stormy weather; the quarter of the city from which the water is taken; and the tap itself; for, if the water be drawn from a pipe which is seldom used, it is sure to contain more sediment than that from one in constant use, as it settles when allowed to rest for some time. There is no doubt also that organisms are often found in the mains which are not found in water taken directly from the lake. This, together with the fact that the number of individuals of some species is greater in the water of the mains than in that of the lake, may be explained on the supposition that the former habitat affords them a better food-supply, consequently they multiply more rapidly. The exclusion of light also seems favorable to the development of certain forms. Another marked result of these investigations has been the conclusion, that many of the forms seem to have a preference for certain times of the year, being much more abundant then than at any other time; but the exact harvest time of each particular form has not been accurately determined, since the observations have not been sufficiently close. For the same reason, although the comparative frequency of most of the forms met with can be indicated generally, their relative abundance or scarcity at any particular time cannot be stated with any degree of accuracy.

To the foregoing general remarks is now added an enumeration of the different organic species which from time to time I have found in the tap water of the School of Practical Science, with brief notes on some of the more interesting forms, and a more detailed account of one or two which I believe to be hitherto undescribed.

DIATOMACEAE.

The Diatoms are noticed first because by far the greatest part of the sediment consists of them, and because in the number of species they greatly exceed any other group. The diagnosis of species unless one is a specialist in this department of microscopy, is not a very easy matter, especially if the literature to which one has access is not very extensive. Accordingly a slide was prepared and sent to Prof. H. L. Smith, of Hobart College, Geneva, N. Y., who kindly named the following species:—

Melosira Crotonensis, *Tabellaria fenestrata*, *Cyclotella Kutzingiana*, *Cyc. operculata*, *Cyc. astrea* (a variety of Stephanodiscus Niagarae), *Stephanodiscus Niagarae*, *Fragillaria Crotonensis*, *Frag. Gregoryana* (= Dimeregramma Grunow), *Frag. Capucina*, *Synedra radians*, *Synedra longissima*, *Synedra ulna*, *Cocconema parvulum*, *Coc. cymbiforme*, *Coc. gibbum*, *Cymbella dicephala*, *Navicula radiosa*, *Nav. carassius*, *Nav. Rheinhardtii*, *Nav. Saugerii*, *Nav. cryptocephala*, *Nitzschia lineata*, *Surirella pinnata*, *Sur. lineata*, *Cocconeis Thwaitsii*, *Coc. placentula*, *Cymatopleura (Sphinctocystis) solea*, *Pleurosigma Spencerii*, *Gomphonema tenellum*, *Gomph. acuminatum*, *Gomph. constrictum*, *Gomph. sp.?* *Amphiprora ornata*, *Odontidium mutabile*, and *Encyonema caespitosum*.

In addition to the above the following have also been noticed:— *Tabellaria flocculosa*, *Asterionella formosa*, *Meridion constrictum*, *Actynocyclus Niagarae*, *Nitzschia sigmoidea*, *Tryblionella gracilis*, *Epithemia turgida*, *Cymatopleura (Sphinctocystis) elliptica*, *Eunotia didyma*, *Melosira varians*, and *Melosira dentata*, *n. sp.*, with characters as follows:—Filaments, slender; frustules, scarcely twice as long as broad, divided in the centre by a double line; extremities of the cells dentate: breadth, 0·0075 mm. —0·009 mm. Fig. 1.

The two species, *Rhizosolenia Eriensis* and *R. gracilis*, are also present, the former always and the latter quite frequently. As *R. gracilis* has only lately been described by Prof. Smith, by whom it was first discovered in filterings from the Niagara River water supply at Buffalo, its characters are appended:—"Frustules small, slender, round or but slightly compressed; annuli. obsolete; body, smooth; fifteen to twenty times as long as broad; imperfectly siliceous; calyptra, conical; bristle fully as long as the body, or longer; often slightly curved, and, with the calyptra, rigidly siliceous; length, ·004″—·008″." It can be readily distinguished from *R. Eriensis* by its curved bristle, and by the absence of the markings which are so characteristic of the latter species.

It might be observed here in passing that the above are the only two fresh water species of *Rhizosolenia* as yet known, all the others being marine. The presence of these two species, together with others of genera, such as *Stephanodiscus* and *Actynocyclus*, mostly marine, would seem to point to the fact of the connection at one period of the great lakes with the ocean, and the survival of a few marine or brackish forms, which have been able to accommodate themselves to the altered conditions of their habitat.

Desmidiaceae.

Desmids as far as at present known are all inhabitants of fresh water, and, as stated by Wood in his "Fresh Water Algae," prefer "that which is pure and limpid." They have been found in stagnant water, but never in that actually putrid. Next to the Diatoms they are the commonest vegetable forms to be found in the filterings from our water supply, and they seem to be most plentiful in the latter part of winter and during spring. The commonest representatives of this family are several species of *Closterium*, some of which I have not been able to determine.

In every gathering are to be found considerable numbers of a form which is figured by C. M. Vorce in a paper on the "Microscopic Forms observed in the water of Lake Erie," and called by him *Clos. Venus*, but which is much smaller than the form described by Wood under this name, the diameter as a general rule being not more, and often less, than 0·0031 mm. (= 0·00015″). In shape they vary considerably, being more or less lunately curved, semi-circular, bent into a loose spiral, or sometimes resembling very much a pair of cow's horns; extremities greatly attenuated. On one or two occasions a larger form was observed, which agreed very closely in characters with these smaller ones. The frond was lunately curved, varying to sigmoid or spiral; distance between the extremities about 30 times the breadth; upper margin very convex, lower very concave; no central inflation; tapering gradually to an acute point at the extremities; contents granular. Diam. 0·0038 mm. (= 0·000155″). Habitat, Lake Ontario, Fig. 2.

In one gathering a fine living specimen was noticed which in most of its characters seemed to approach more nearly to *Clos. parvulum, Naegl.*, than any other, though in some respects it resembled *Clos. Venus* as described by Wood. In size however it differed from both of these. The diameter was found to be 0·0186 mm. (= 0·00074″), and the length about 8 times as much. The measurements given by Rabenhorst for *Clos. parvulum* are diam. max. 0·00026″—0·00062″, and length 6–8 times as much; and according to Wood the diameter of forms referred by him to this species is 0·0008″. *Clos. Venus* has a diameter of 0·0004″, and is 8–12 times longer than broad. The general appearance of the form was very similar to that of *Clos. parvulum* as figured by Wood, and as the actual size of any species can hardly be regarded as fixed within narrow limits, it has been referred to *Clos. parvulum.*

Another interesting form which is nearly always present approaches in some respects the description of *Clos. setaceum*, but is not accurately described in any work at my command; accordingly I propose for it the name *Clos. filiforme*, with specific characters as follows:—

Closterium filiforme, n. sp. Frond very slender, greatly elongated, each extremity being a colourless beak as long, or nearly as long, as the body; filiform, cylindrical, smooth, not lunately curved, belly not inflated, gradually attenuated towards the apices, which are rounded and slightly curved downwards; vacuoles 3–8 in each limb in a single series. Breadth 0.0062 mm- (= 0·00025″), length 0·4154 mm.—0·62 mm. (= 0·0166″—0·025″), or say 60–100 times the breadth. Habitat, Lake Ontario, Fig. 3.

Clos. Griffithsii has also been observed. Other Desmids were *Staurastrum gracile, Staur. punctulatum*, and a species of *Cosmarium*, probably *Cos. cucumis.*

Other Chlorophyllaceous Algae present were *Protococcus sp.?* *Chlorococcus sp.?* diam. of cell itself being 0·0176 mm., and of cell together with its hyaline coat 0·0264 mm. *Ankistrodesmus* (*Rhaphidium*) *falcatus*, *Scenedesmus quadricauda*, *Pediastrum sp.?* *Pediastrum Boryanum*. The forms included in this latter species vary somewhat from the description given by Rabenhorst and Archer. The coenobium is circular in outline, cells in a single stratum, arranged in three rows round a central cell (1 + 4 + 10 + 15); inner cells variable, 4–6 angled, concave at one side; peripheral cells convex on the inner side, on the outer side notched and tapering into two long subulate points. Diam. of peripheral cells 0·0065 mm. (= about $\frac{1}{4000}$").

I have also seen another species of *Pediastrum* which is not described in any work to which I have had access. The cells are in a single stratum, and in two rows round a central cell (1 + 6 + 12); inner cells polyhedral, 4–6 angled; peripheral cells pentagonal; external angle produced into a single process about as long as the diameter of the cell. Diam. of coenobium 0·0434 mm. (= 0·00173"), and of peripheral cells 0·0124 mm. (= 0·0005").

Spirogyra sp.? Sterile joints 10 times as long as broad; spiral single with 4 turns; cell wall at each end produced. Diam. 0·0124 mm. (= 0·0005"). Fertile joints not observed.

PHYCOCHROMACEAE.

Belonging to the Phycochroms there were a few forms observed, viz.:—

Gleocapsa sparsa, which is probably only a zooglaea stage of Sirosiphon; *Merismopedia nova* (*sp.?*); and at least two species of *Oscillaria*, which have been referred to *Os. nigra*, *Vauch*, and *Os. chlorina*, *Kützing*, the former being quite common during the month of March, more so probably than at any other time.

SCHIZOPHYTAE.

Under the name Schizophytes are included all the organisms commonly known as Bacteria, together with a few parallel green forms, multiplying chiefly by transverse fission, though in some cases spores are formed. These organisms at best have but a doubtful reputation; and if Intermittent and other malarial fevers, Anthrax, Diphtheria, Septicaemia, Pyaemia, Tubercle, and other virulent contagious diseases are produced directly by these forms, it is quite proper that we should be very careful that the water we drink is free from them if possible. If we look for natural water however which is absolutely free from Bacteria, probably we shall look in vain. But we must remember that all forms of Bacteria are not capable of producing disease, even if some are, or at any rate that they do not do so under ordinary circumstances, but only in particular and well-marked conditions of the organism or organ attacked by them. We must not be surprised then to find Bacteria in our water supply. I have observed even in fresh filterings all the common forms, micrococci, rod-like forms, vibrios, spiral forms, and zooglaea stages. But if the filterings be allowed to stand exposed to the air for a few hours, it is amazing how rapidly they increase in numbers, and after a day or two the whole becomes converted into one mass of Bacteria in all stages, growing at the expense of the other organisms, and eventually leaving nothing but the siliceous frustules of Diatoms, and whatever other matter like this defies their digestive power. Probably there is no place where they thrive better, and where they exist in greater numbers, than in the School of Practical Science; for they are certain to be found there in everything which is not positively destructive to them. There is no doubt then that their presence in such abundance in sediment which has been allowed to stand for some time exposed may be in great measure accounted for by germs getting into it from the atmosphere, as well as those already there multiplying.

Adopting the view held by Billroth, Nägeli, Cienkowski, Ray Lankester, and Zopf, that all the forms usually described under the generic names Micrococcus, Bacterium, Bacillus, Leptothrix, Cladothrix, Vibrio, Spirillum, Spirochaete, &c., are only development stages of Schizophytes, in opposition to that of Cohn and others, that they are distinct species without morphogenetic connection, all the forms observed have been referred to the two species, *Cladothrix dichotoma, Cohn*, and *Beggiatoa alba, Vauch.*

Concerning the first of these two Zopf remarks, that "what the common bread mould (Penicillium crustaceum) is among the aerial mould fungi, *C. dichotoma* is among the aquatic fungi, and therefore it might be quite properly denominated the 'water-fungus' ('Wasserpilz') par excellence."

There are Leptothrix forms besides the ordinary Cladothrix filaments, which, by the breaking up of the threads, produce micrococci and rod-like forms. The cocci are circular in outline, and have a diameter equalling, or at most double, that of Micrococcus prodigiosus, Cohn. In from 24 to 48 hours these micrococci develope into rod-like forms (Bacterium, Bacillus), which again give rise to Leptothrix, and by branching to Cladothrix filaments. These filaments are often rolled into a loose spiral, and these spirals give rise to Vibrios, Spirillum—and Spirochaete—forms. All the forms already mentioned may pass into a zooglaea or resting stage.

Beggiatoa alba goes through pretty much the same modifications. There are Leptothrix-like filaments of considerably larger size than those of Cladothrix dichotoma, Bacillus, Bacterium, and Micrococcus forms. Spiral forms are also developed, which however I have never seen in any of the sediment I examined, all the spiral forms noticed having been referred to Cladothrix.

In the study of these organisms it will be found of great advantage to stain them first with rose-aniline, or iodine.

Before proceeding to enumerate the species belonging to the Animal Kingdom, a form must be described which I am puzzled to know where to locate. I have only noticed it occasionally; and I am inclined to regard it as a Desmid.

The body is spheroidal, in optical section broadly oval, surrounded by a firm cytioderm; color, bright green; chlorophyll, disposed in two lenticular masses; vacuoles, four; body surrounded by 7—9 (?) stiff, colorless, more or less curved bristles (setae), coming off radially, and 3—5 times the long diameter of the body in length. Three individuals gave the following measurements:—

Diam. (1). 0·0093 mm. by 0.0124 mm.
(2). 0·01142 mm. by 0·01428 mm.
(3). 0·0121 mm. by 0·0154 mm.

Habitat, Lake Ontario. Fig. 4.

Wood describes a globular form of *Scenedesmus* with radiating bristles, to which the organism above described is possibly allied.

In addition to the foregoing species the vegetable kingdom is represented by starch grains, spores of fungi, and occasionally some remains of the higher plants, such as pollen grains, cuticle of aquatic plants, woody fibre, &c.

PROTOZOA.

The animal forms belong mostly to the Protozoa, being nearly all included in the groups Rhizopoda and Flagellate Infusoria.

Rhizopoda.—Among the Rhizopods were noticed at least two species of Amoeba—*A. proteus* and *A. radiosa*, but not very frequently; on several occasions also *Difflugia globulosa*, *Actinophrys sol*, and *Acanthocystis turfacea* (*sp ?*).

Flagellata—Belonging to the Flagellata Infusoria there are a few interesting forms, some of which I shall notice in detail.

Monas lens is occasionally seen, but by far the commonest species is *Dinobryon sertularia*, and a brief description of this beautiful animalcule will not be out of place. In the spring and early summer they are to be found in large numbers in every filtering, but in autumn and through the winter they are rarely met with.

In the classification adopted by W. Saville Kent, in his "Manual of the Infusoria," they are placed in the *Order Flagellata Eustomata*, and *Family Chrysomonadidae*. The characters of the order are as follows: "Animalcules possessing one or more flagelliform appendages, but no locomotive organs in the form of cilia; a distinct oral aperture or cytostome invariably developed; multiplying by longitudinal or transverse fission, or by subdivision of the whole or part of the body-substance into sporular elements;" and of the family: "Animalcules bi-flagellate, rarely mono-flagellate, social or solitary, free-swimming or adherent, naked, loricate, or immersed within a common mucilaginous matrix or zoocytium; endoplasm always containing two lateral, occasionally green, but more usually olive-brown or yellow differentiated pigment bands; one or more supplementary eye-like pigment spots frequently present," and, as far as at present known, they all inhabit fresh water.

The genus *Dinobryon* consists of animalcules with two flagella, one considerably longer than the other; attached by a contractile ligament to the bottom of a colorless horny lorica, the individual loricae being connected together so as to form a colony or compound branching polythecium; endoplasm containing two lateral green bands, and a conspicuous eye-like pigment spot situated anteriorly.

In the species *D. sertularia Ehr.* the individual loricae are perfectly hygaline and transparent, and are shaped in general like an inverted cone, though they are seldom seen perfectly symmetrical, but usually more or less twisted and deformed, especially at the posterior end; the mouth is everted, and below this anterior rim there is a slight constriction, then a slight expansion, below which it tapers to the posterior pointed end; they are joined into colonies by the posterior end of one lorica being attached to the interior face of the rim of the one immediately below it, without any intermediate pedicle; very often the ends of two loricae are inserted into one, and this produces dichotomy. Empty loricae like this are found in large numbers, either connected or floating free during the time of the year already mentioned; but in many cases the zooid itself is to be seen attached by its delicate transparent ligament to the bottom of the lorica, and rarely exserted. In shape the zooids are elongate-oval, with the two flagella coming off quite close together from the anterior end, and on a little lip-like projection is situated the reddish eye-spot. According to Stein, the oral aperture is close beside the point of insertion of the two flagella. By the aid of these flagella they propel themselves rapidly through the water with a rolling motion, and as they sail across the field of the microscope, with their shapely loricae, oval green bodies, red eye-spots, and rapidly vibrating flagella, they present one of the most beautiful objects to be seen in the miscroscopic world. The length of the separate loricae as given by Kent is $\frac{1}{1200}$″, and of the contained zooid $\frac{1}{2000}$″; but these measurements have always been found too small. The average length of the lorica is 0·033 mm. (= 0·0013″) and of the contained zoid 0·0132 mm. — 0·0176 (= 0·000528″ — 0·0007″).

On one occasion two separate zooids were seen in one lorica, one in the usual position at the lower end, and the other just at the mouth partly extruded. This most probably was the result of fission, and the newly formed zooid had not yet secreted its protecting calyx.

The spheroidal encystments recorded by Bütschli and Stein have also been observed. They are to be seen at the mouths of otherwise empty loricae, and also floating free. They are of a yellowish-brown colour, and consist of an outer dense cuticular cyst enclosing a smaller more or less eccentric one with protoplasmic contents. No eye-spot was observable. At one point on the outer capsule there is a little conical protuberance standing out prominently from the rest of the circumference, and on the opposite side of the inner cyst there is a similar projection. Stein figures these as occurring about the same place on both cysts, but in all that I observed they were on opposite sides, and on the outer cyst there was only one. The diameter of the outer cyst in several instances was found to be about 0.0155 mm., and through the protuberance 0.0217 mm.; and of the inner 0.0124 mm. Figs. 5, 6.

Dinobryon stipitatum, Stein, was also present once or twice. This species differs from the one just described in the greater proportionate length of the loricae, which are trumpet-shaped, widest at the mouth, and tapering off into the acuminately pointed posterior end, being about 7 or 8 times as long as their greatest breadth. The zooids very much resemble those of *D. sertularia*, but are more elongated, and occupy the anterior half of the lorica, being attached by a thread-like ligament to its lower side wall. A large amylaceous more or less spheroidal body is situated near the posterior part of the endoplasm. The length of the lorica according to Kent is $\frac{1}{300}$″.

Two or three other species of Flagellata have also been seen, though rarely.

One, belonging to the *Choano-Flagellata*, *i.e.*, monads with a collar surrounding the single flagellum, I have referred to *Salpingoeca fusiformis, Kent.* Kent gives the following characters for this species: "Lorica sessile, sub-fusiform, or vase-shaped, widest centrally, tapering equally towards the two extremities, but expanding again anteriorly into a somewhat prolonged and everted neck; contained animalcule flask-shaped as in *S. amphoridium, J. Clark*, but of larger size. Length of lorica $\frac{1}{1600}$″. Hab., fresh water, solitary."

This form was seen only on one occasion, attached to a frond of Rhizosolenia Eriensis. The lorica was empty and corresponded closely with the above description. In another part of the field however I found what probably was the zooid of this species which had been set free, though it is possible that it might have been *Monosiga socialis, Kent*, with the description of which it closely agreed. The body was somewhat pyriform, widest posteriorly, with no pedicle; a single long flagellum surrounded by a collar. Length of the body 0·0062 mm. ($=\frac{1}{4000}$″), breadth 0·00465 mm. ($=\frac{9}{50000}$″).

On one occasion I got a glimpse of a colony which I think belonged to the family *Codonosigidae* of this order. Unfortunately I lost sight of it, and never succeeded in finding any of the same kind again. It was probably a species of *Asterosiga*, in which the monads are arranged in a stellate fashion.

Another form has been doubtfully referred to the *Flagellata-Pantostomata*, family *Bikoecidae*, which includes sedentary animalcules with an anterior lip-like prominence, either solitary or in colonies, secreting separate horny loricae, mostly stalked; flagella two, one long and one short; no distinct oral aperture. In certain of its characters this form resembled *Bicosoeca lacustris*, *J. Clark*, and in others *Stylobryon petiolatum*, *Duj. sp.*, while in general appearance it was very like a large Dinobryon. I was unable to make out whether there was a distinct oral aperture or not. The individuals as far as observed were solitary, and characterized as follows:—Lorica sub-cylindrical, a little more than twice as long as its greatest breadth, with a pedicle of about equal length, widest posteriorly, slightly everted anteriorly, tapering towards and conically pointed at the posterior extremity; zooid broadly ovate, plastic, with an anterior lip-like prominence, occupying the posterior half of the lorica, to the bottom of which it is attached by a contractile thread-like ligament on which it rotates; flagella two in number, one long and one short, inserted at the base of the lip-like prominence; endoplasm containing two lateral greenish-yellow bands, and a reddish eye-spot situated anteriorly at the base of the lip-like projection; contractile vesicle single, located posteriorly. Length of the lorica 0·0314 mm. ($= \frac{1}{800}''$), and of the contained zooid 0·0171 mm. ($= \frac{17}{25000}''$). Hab., fresh water, Lake Ontario. Fig. 7.

Kent regards *Stylobryon petiolatum* as undoubtedly a compound modification of *Bicosoeca lacustris*, and possibly the form above described is a variety of the same species, considerably larger than the one described by H. James-Clark, if it is not a species of *Dinobryon*.

The *Cilio-Flagellata* are represented by a species of *Peridineum* not determined.

Infusoria Ciliata.—Belonging to the Ciliated Infusoria there is a large species of *Vorticella* frequently seen, either attached or free-swimming; *Stentor* is rare; also a few *Holotrichous* and *Hypotrichous* forms, free and encysted are to be found occasionally.

METAZOA.

The other animal forms which have been noticed are not very numerous.

VERMES.—The worms are represented by the *Nematoid Anguillula fluviatilis*, which is not very common; and by one or two species of *Rotifera* belonging to the family *Brachionidae*, in which there is a carapace and one or more eye-spots. These are *Anuraea stipitata*, and another species with the back of the carapace ornamented with facets, as well as furnished with teeth in front. A species of the genus *Brachionus* itself has also been observed.

ARTHROPODA.—The *Crustacea* are represented by at least two species, *Cyclops quadricornus* and *Daphnia pulex*, or a nearly allied form. Cyclops especially is common both in the adult and larval stages.

Belonging to the *Tardigrada* I have noticed a species of *Macrobiotus* rarely present, probably *M. Hufelandii.*

Epithelial cells, bristles of crustacea and insects and other fragments are to be found among the debris which is always present in considerable quantity, and which is generally described as "flocculent matter." It consists mainly of broken Diatom frustules, as a good deal of it remains after boiling in nitric acid, partly also of decomposed organic matter in a fine state of division, as well as a small quantity of mineral matter.

The bearing which the foregoing observations have on the question of the purity of Toronto's water supply may now be briefly alluded to. Judging from the miscroscopical examination of the suspended matter in the water, I would characterize it as one of the purest of natural waters, inasmuch as it is almost entirely free from any organisms which are either themselves directly injurious, or which, by their presence, would show that water containing them must necessarily be injurious. The great bulk of the sediment consists of vegetable matter, and that in a living condition. The animal forms are chiefly Flagellate Infusoria, which are inhabitants of fresh water, not depending for their food on dead, decaying, and poisonous matter.

The absolute amount of sediment in the water I cannot accurately state; but the chemical analyses show the amount of albuminoid ammonia to be very small (averaging ·003—·007 grains per gal.);

and I have found it necessary to run the tap a considerable time to collect any appreciable quantity.

As already stated, my investigations have been confined to the tap water in the School of Practical Science; and, while admitting that other taps in different parts of the city would probably give different results as to quantity, yet I think the quality would be found to be practically the same.

APRIL 7th, 1883.

EXPLANATION OF THE FIGURES IN PLATE.

FIG. 1.—*Melosira dentata, n. sp.*, filament of 4 frustules.

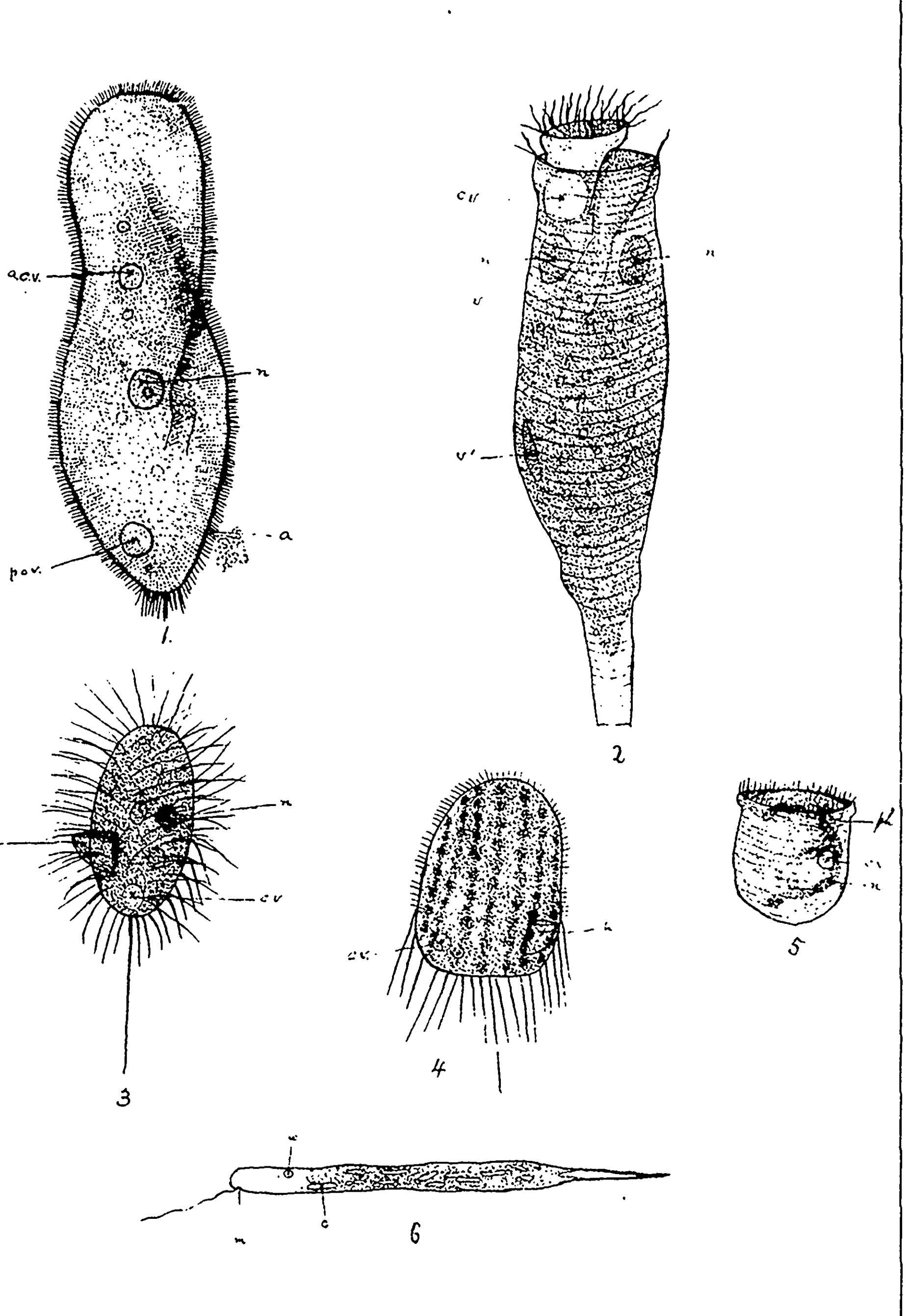
FIG. 2.—*Closterium, sp. ?*

FIG. 3.—*Clos. filiforme, n. sp.*

FIG. 4.—Unknown form—probably a Desmid.

FIGS. 5, 6.—Encysted forms of *Dinobryon sertularia, Ehr.*

FIG 7.—Flagellate Infusorian allied to *Bicosoeca lacustris, J. Clark*, and *Stylobryon petiolatum, Duj.*; *e*, eye-spot; *cv*, contractile vacuole; *lb*, lateral bands.



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INDEX.