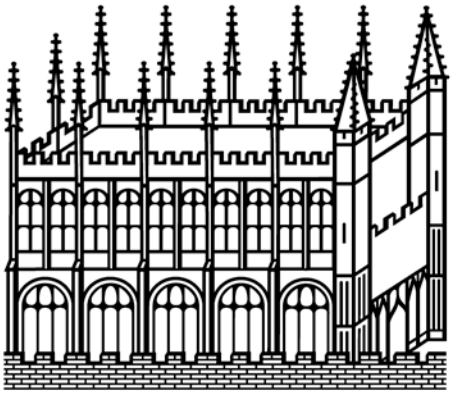

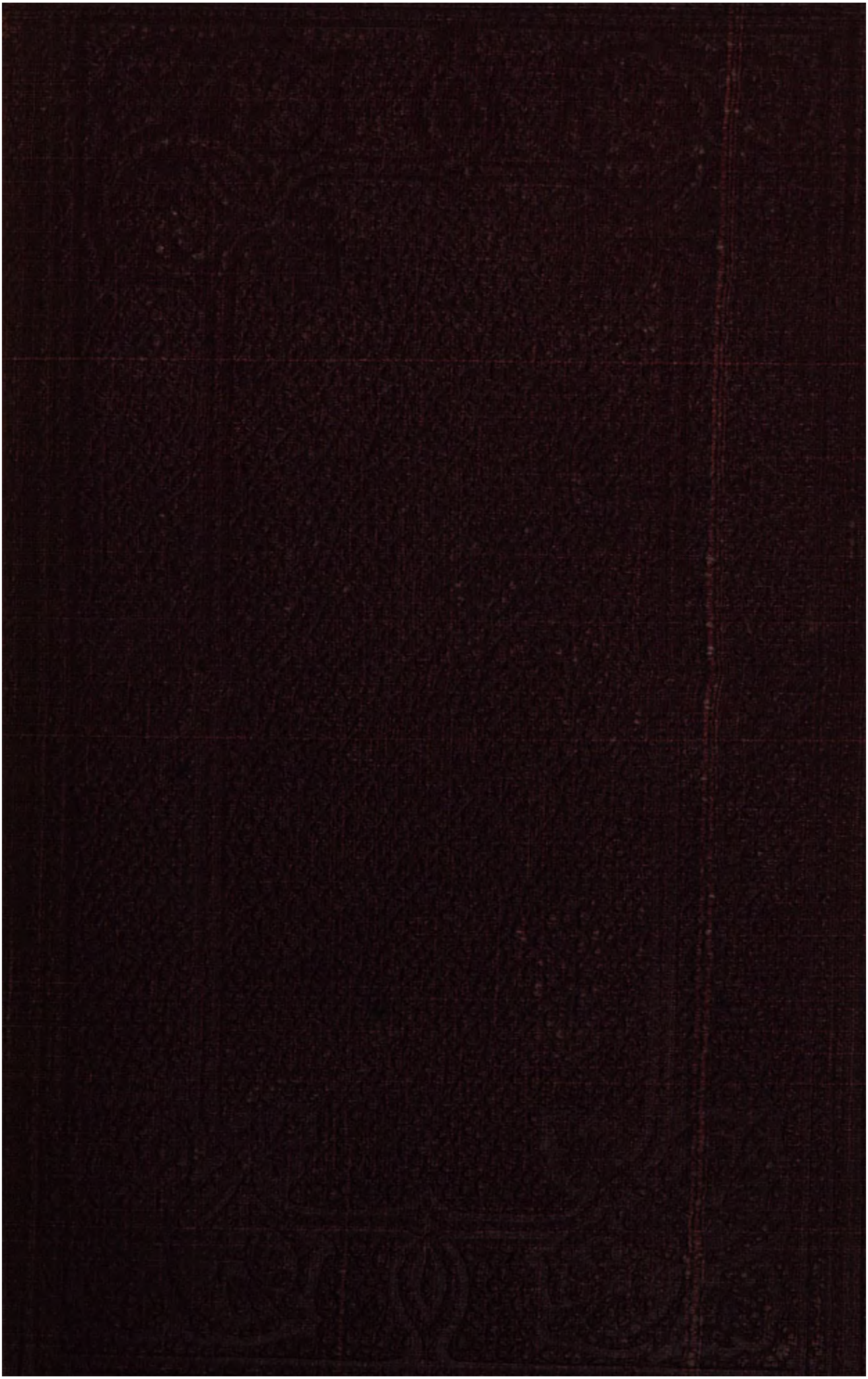

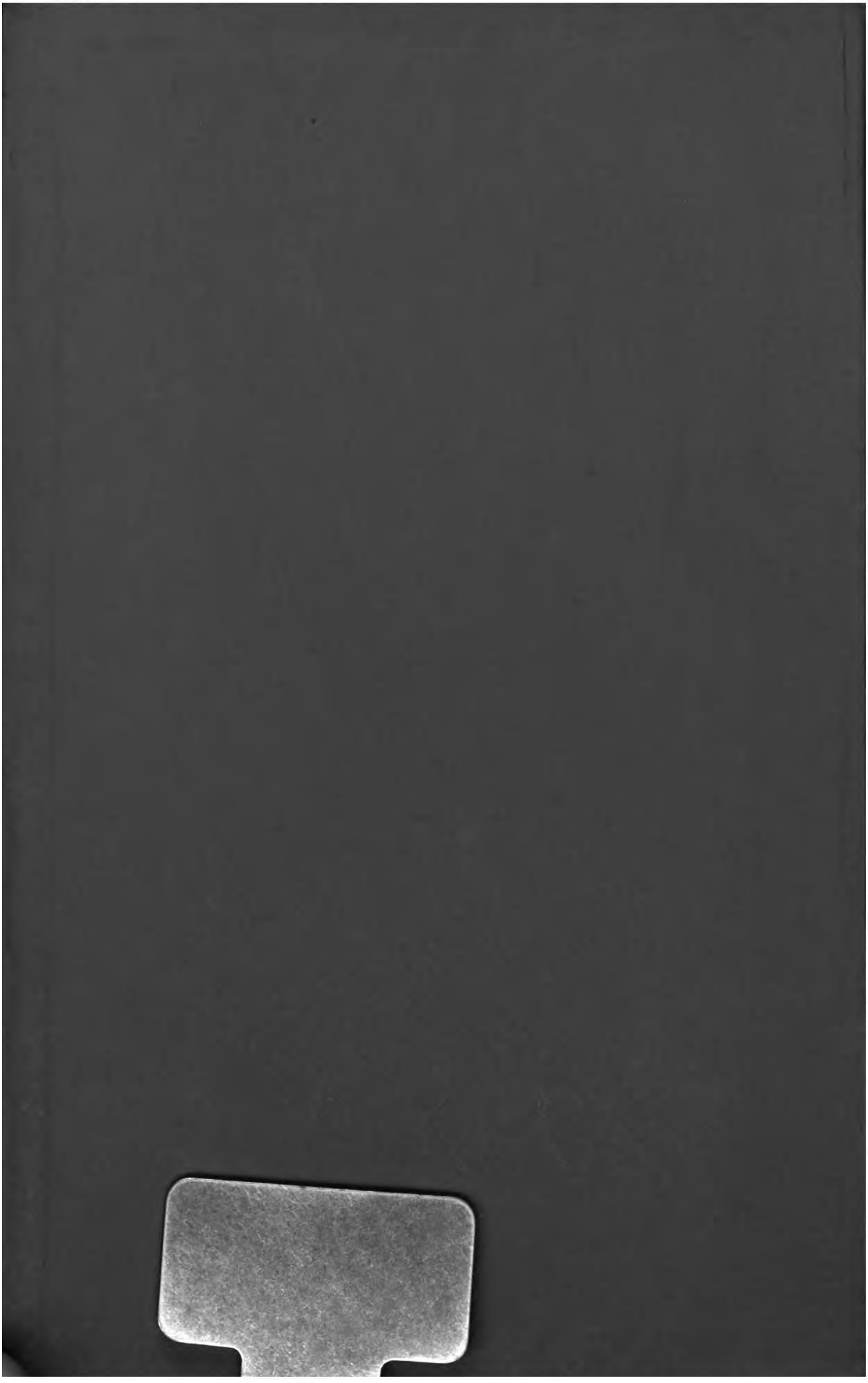

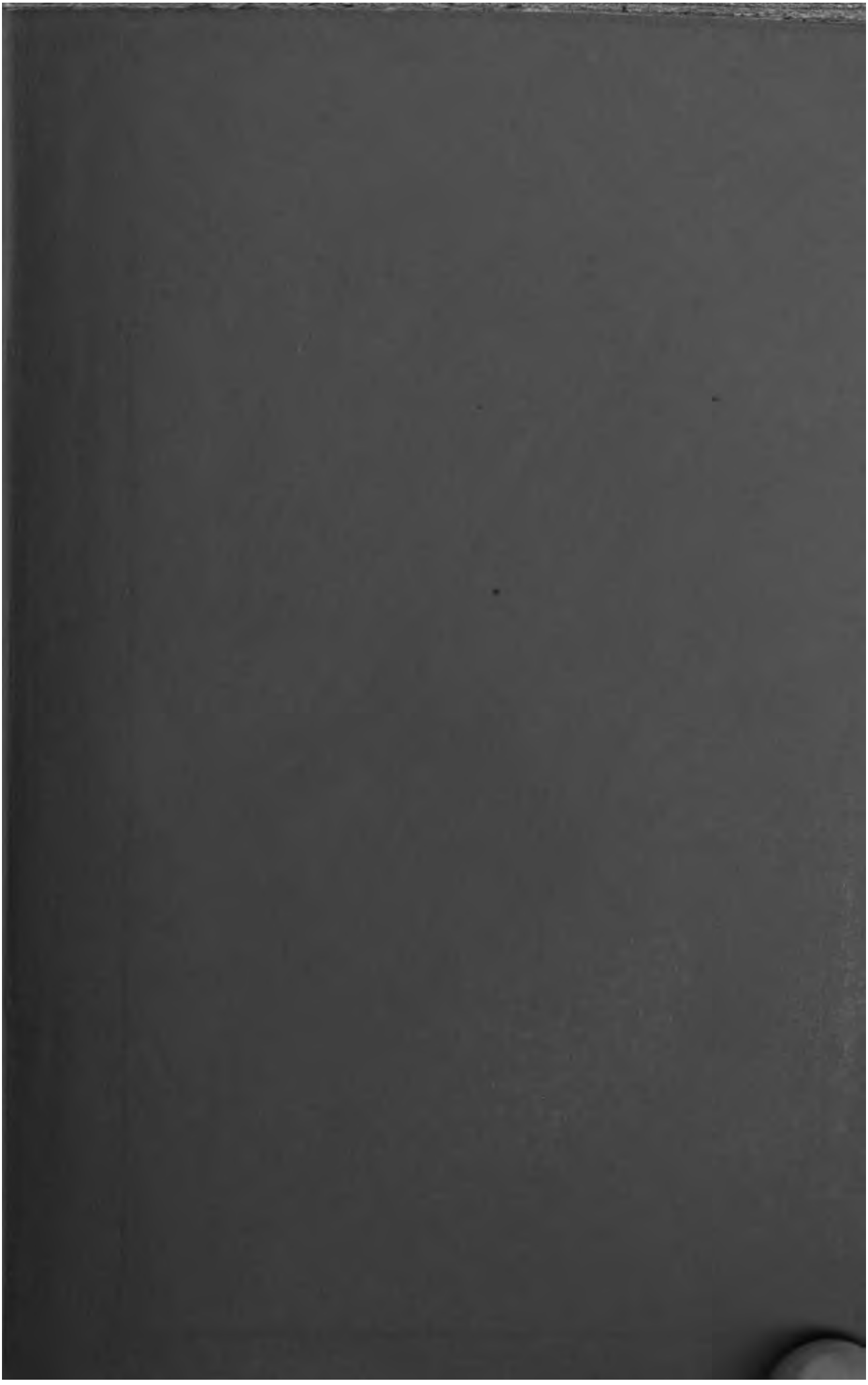

AGRICULTURAL EDUCATION.

Now 'tis spring, and weeds are shallow rooted;
Suffer them now and they'll o'ergrow the garden,
And choke the herbs for want of husbandry.

Shakespeare.

Knowledge and Wisdom, far from being one,
Have ofttimes no connexion. Knowledge dwells
In heads replete with thoughts of other men,
Wisdom in minds attentive to their own.

Cowper.

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To EDWARD HOLLAND, Esq., M.P.,

OF DUMBLETON HALL, EVESHAM,

Chairman of the Council.

My dear Sir,

You are already aware of the circumstances under which the following Lectures were delivered, and therefore in sending them forth to the Public I need do no more than express a hope that they embody opinions in accordance with those of the Council, and that the system of Education which we are now pursuing will place the College in that position which its object and your indefatigable support of it merit.

I have the honor to be,

Yours faithfully,

JOHN CONSTABLE,

Principal.

The College, Cirencester,

Dec., 1863.

PREFACE.

It is now more than ever a question, "What constitutes a sound Agricultural Education?"

The following Lectures, delivered by the several Professors at the only Institution in England where education in Agriculture is imparted, may help to give an answer to this question.

Under this impression they are sent forth to the Public, by whom they may perhaps be read with interest.

LECTURE I.

Gentlemen,

A well-known writer, in his last published work,* gives it as his opinion that the continued prosperity of a nation depends mainly on the condition of its agriculture; nor have instances been wanting where the highest state of civilization, coupled with the maturity of commerce, has failed to save from decay and ruin the nation of antiquity which has neglected the cultivation of its soil. Indeed, many thinking men are so persuaded of the truth of Liebig's opinion that they regard the future of our own prosperous country with anxiety, seeing as they do that while our population is increasing, and our commerce and manufactures developing themselves, our agriculture is not advancing in an equal or proportionate degree.

It is an admitted fact that the instances are, *comparatively* speaking, few where talent and capital have been embarked in the agricultural profession in the same spirit and with the same extended views as they are in the commerce of

* Liebig's Natural Laws of Husbandry.

the country; nor can it be doubted that we have in this fact a fair index both of the present resources of agriculture and of the estimation in which it is held.

It may perhaps be assumed that it was a reflection somewhat similar to these that urged the original projectors of this College to persevere in its establishment; they were doubtless desirous of elevating the character of the agriculturist by putting within his reach a better education.

Be this however as it may, I am quite sure that those public spirited gentlemen, in whose hands the management of the College is at present vested, have no sordid motives—their object is to advance the study of agriculture, to elevate agriculture in public estimation, to attach to the profession men of intellect and capital, whose training shall fit them, not only for a successful career in the path they have chosen, but also for the exposition of the principle, that intellect and money may be advantageously and successfully employed in the cultivation of the soil. And I think that, without conceit, we may say they are succeeding, though perhaps slowly, yet surely, and that the day is not very far distant when these objects will in a satisfactory degree be attained.

Judging from our career up to the present moment, there may be those who would attribute

to us a signal failure in such laudable efforts; nor would I presume to assert that there have been no grounds in our past errors to justify this lukewarm estimate of our merits; still I am induced to believe that our past has not been one of entire failure, but rather one of moderate success. It is not to be expected that in the conception and carrying out of a scheme such as that embraced by the College, every part should be developed with judgment and prosecuted with success; at the same time, those who have been so persevering in their support of this institution may have considerable satisfaction in the remembrance that the College has been the nursery of one at least whose labours have given an impetus to the reception of scientific truth by the practical farmer. I allude to Dr. Voelcker, our late Professor of Agricultural Chemistry. To his connection with this College, if I mistake not, may be attributed much of his success and usefulness; and it is to be regretted, in a scientific point of view, that circumstances have terminated that connection. And here let me express a hope that our future, in this respect, will tally with the past. We cannot but believe that in the little band who have consented to become our instructors, there will be found an earnestness of purpose, and a determination to act as pioneers in scientific agriculture.

I should be sorry indeed—heavy hearted—did I enter on our new circumstances without a well grounded hope that, by united energies and exertions, some few contributions will be made to the truths of agriculture, some little development of agriculture secured.

This, however, is not the topic on which I have to address you. Such success as this, although much to be desired and striven for, is not the primary object of the institution. Our first object is the education of our students, so that their future career may be successful, and that the intelligence and capital of the country may be attracted to the cultivation of the soil; and it is concerning the methods by which we hope to secure this that I have a few words to say to you to-day.

At the outset, then, let me remark that our College is not merely a place where scientific truths and theories are urged upon the acceptance of the students, but a place where, in its fullest acceptation, education is an object, where we hope to develope the mental, moral, and religious capabilities of youth.

Were this College ever to number among its scholars only those of mature age, had we arrived at the time when none sought information here but those whose minds had been disciplined

by the ordinary educational means of the country, it would only be necessary for us to consider the most efficient means of preparing intellectual food for minds ready to receive it. But such is not the case—we have to educate as well as to instruct; we have to draw out the faculties, and hence our machinery becomes more complex just as our object is more important. We have to form the mind as well as to furnish it. I am well aware that, in the extended sense, education is a life-long object, and that a man may be educating himself to the end of his existence, if the term education be understood in so large a sense as to include all that belongs to the improvement of man, either by the acquisition of the knowledge of others, or the increase of it through his own exertion; but I cannot of course, on the present occasion, treat of education in this extended way. I have to enquire how we can, in a short period, in a community consisting of men and boys, best develope the faculties and form the mind and habits, giving at the same time a *special* education.

And, mentioning this, I state at once broadly the main difficulty of our task. We have to frame a curriculum to meet the wants of old and young; we have to educate and at the same time assist those who are educating themselves.

The studies which the experience of past ages would recommend for the education of the former class are not acceptable to the tastes of the latter; nor indeed would they afford that for which the elder members have joined the College. To educate a youth requires a machinery different from what is required to instruct an educated man. Experience has shown that the studies which are called permanent, in contradistinction to those which are called progressive, are the only studies capable of *fully* drawing out and fixing the faculties of youth. In educating young minds, the attention should be directed as much as possible to fixed studies, such as classical literature and mathematics; because progressive studies, or in other words, the natural sciences, are incapable of forming and developing, in an *equal degree*, the reasoning powers. Natural sciences must be progressive, ever in a state of transition, deriving new truths from experiment and observation, and incorporating these new truths into their new texture. The intelligent student of progressive science should be capable of forming a judgment as to the merit or demerit of any imagined progress in these sciences, and this presupposes a power of reasoning derived from an education of his mental faculties: for example, any of the elder students who have here passed through a course of chemical instruction should,

as intelligent students, be capable of forming a good judgment as to the soundness or unsoundness of any newly propounded chemical theory; but the value of this judgment must depend upon the power of reasoning enjoyed by the particular individual—that is, upon his previous training in abstract science. Of two students, both of whom have an equal and sound knowledge of elementary chemistry, the judgment of the one in any particular case may be valueless compared with that of the other, and the reason is not because one knows less chemistry than the other, but because the one has had his powers of reasoning less fully developed than the other. Hence it happens that the more severely trained by the study of abstract science any mind may be, the more rapid is the advancement made by such a mind when its powers are concentrated on progressive studies.

In an institution like this, where the students remain for so limited a period, it is impossible to introduce the study of classical literature, but we cannot insist too strongly upon as close and extensive a study of mathematics as the circumstances of each student will admit of.

In forming in a youth the power of reasoning, which in after life shall enable him to collate facts and data most suitable for his own career,

we do far more for him than if we merely burden his memory with the theories of progressive science, which future discoveries may compel him to modify; and therefore I hold that so long as the age of our students compels us to *educate*, our system would be radically defective if the study of abstract science did not form a considerable part. I am quite aware that the discipline of mathematics is not popular with our youth; it has not, I grant, much tendency to improve the taste or soften the manners; but if defective in some respects, it has advantages of the highest order. To quote the words of a learned divine,* "It is of singular use in preserving our youth from error in every subsequent path of knowledge—it will teach them to arrange, methodise, and connect their thoughts, to examine the arguments of others with nice and critical penetration, pursue them through a long series of propositions, and discover whether any links in the chain of proofs be wanting—it will teach them to distinguish sense from sound, ideas from words, hasty and peremptory decisions from just and legitimate conclusions." This cannot be said of the study of natural science; the objects of abstract science are so definite, our notion of them so distinct, that we can reason about them with an assurance that the words and signs used are full and true represen-

* Bishop Porteus.

tatives of things signified; but it is widely different with the words expressing natural objects, and therefore with the study of natural science. Take, for instance, the word "iron" to illustrate our meaning:—"the vulgar, who regard this metal as incombustible—the chemist, who sees it burn with the utmost fury—the poet, who uses it as an emblem of rigidity—the smith and engineer, in whose hands it is plastic and moulded like wax into every form—the jailor, who prizes it as an obstruction—the electrician, who sees in it only a channel of open communication by which that most impassable of obstacles, the air, may be traversed by his imprisoned fluid—have all different and all imperfect notions of the same word. The meaning of such a term is like a rainbow, everyone sees a different one, and all maintain it to be the same."* On the contrary, in the study of abstract sciences, such as arithmetic, geometry, algebra, the mind is accustomed to the strict use of language; no two men can have different conceptions of a circle or an angle, of a square root or a quadratic equation, and hence the mind, being accustomed to the strict use of language, acquires a proper and dignified carriage, which could never be secured by having always to pick one's steps among obstructions and loose fragments.

I hold, therefore, that the early cultivation of

* Sir John Herschel.

man's reason must be principally secured by a diligent study of abstract science.

I am fully aware that in the opinion of many, the natural sciences, chemistry, botany, geology, &c., have of late made such rapid strides, as to afford the students of them a healthy discipline of mind, and thus are worthy, independently of their practical utility, of being regarded as proper mediums for the education of youth. And I should be sorry to say that I differ from this view, especially when addressing those whose attention is so largely directed to these sciences; but as long as these sciences are progressive, the study of them as a means of education must ever be *secondary* to the study of abstract science. I use the word *secondary* advisedly, for I think it most desirable that progressive science should be more generally taught in our educational establishments than it was a few years ago, but this only when a due proficiency in the permanent educational studies has been secured.

Nor does this view militate against the opinion that the object of education is to teach men to judge for themselves. On the contrary, it is *because* I believe that the only true preparation for thinking soundly and judging rightly is to be found in the study of a science which is definite that I advocate the study of mathematics prepa-

ratory to or in conjunction with the study of progressive science. It is *because* I wish you to be capable of judging for yourselves in the various points of progressive science, which may now or in your future years be brought under your notice, that I wish your minds disciplined and strengthened by an acquaintance with permanent studies. For that students must so judge is evident to all who think on the subject. In sciences rapidly progressive, and therefore varying from time to time in their current doctrines, the intelligent student, whether he attend lectures in the educational period of his life, or after it is concluded, must judge for himself, and his progress will greatly depend upon his power of judging wisely.

It cannot be doubted that progressive sciences may discipline, and, in many important ways, improve the mind; in fact, do much for it which abstract science cannot. I merely assert that, inasmuch as they are mutable from time to time, and ever doubtful on some points, the study of them is not the *best* preparation for thinking soundly, and therefore should not be the *only* basis of education.

And here let me recall to the recollection of some of you the parting advice of your late Professor of Chemistry, which was, to encourage all young people to study assiduously abstract science

—he having found in his past experience that the best foundation for the study of chemistry was the study of mathematics.

In the curriculum, therefore, which is framed for your use, besides Arithmetic, Mensuration, and Surveying, certain parts of mathematics are introduced, which seem to have only a remote bearing on the future of an agriculturist—I allude to Euclid, Algebra, Trigonometry. These studies, although their direct use is by no means unimportant when the value of a knowledge of mechanics and the steam engine is considered—are embodied with the hope that by their means your minds may be better prepared for the study of natural science, and be better fitted for every duty in after life, where judgment and accuracy are required.

The connection which each natural science has with agriculture I shall leave to be fully discussed by those able men whose talents and energies will be devoted to your advancement, and I doubt not that each will show you how your future may be benefited by a knowledge of the science he is prepared to teach.

From Mr. Morton you will learn how we propose to put you in possession of the theories of agriculture.

And here let me remark, that an unparalleled opportunity will be afforded of hearing the opin-

ions of some of the most eminent agriculturists of the present day. Never before has so complete and extensive a course of agricultural lectures been delivered as that which will be delivered this Session; and I sincerely hope that it is one by which you will all benefit. There cannot be a doubt that where the judgment is in any degree trained, there must accrue an immense advantage from hearing the opinions of eminent men on the same subject, even if they differ, when those opinions are based on practical experience.

"Lecturers in general aim to present their subjects in some striking as well as instructive form, containing the results of extensive reading and careful thought; and there is a charm belonging to such lectures, when delivered by able men, which often takes strong hold of the mind of an intelligent student, and imparts to him a fervour of thought and a largeness of comprehension which cannot be communicated in any other manner. To attend, therefore, such lectures is an event which stimulates and expands in an extraordinary degree the minds of the more intelligent youths, and to have the opportunity of listening to such is a very happy circumstance in any one's education."*

The means of conveying all our instructions will

* Dr. Whewell on Cambridge Studies.

be by lectures and by examinations, written and vivâ voce.

And here again the same difficulty as regards the mixed ages of our students presents itself.

Lectures occupy more the place of stimulants, incentives to study, for educated men than means of education; so that when applied to youths who are in process of mental training they have to answer a double purpose, they have to develope and to inform.

"There are, however, two defects connected with instruction by means of lectures. The one is, that frequently lectures convey no knowledge which is not to be found in published books, and sometimes in published books in a better form. The other is, that they convey little knowledge to unintelligent or inattentive students, such as must occur in every large body of young men. The first defect is in a great measure compensated by the feeling of sympathy in a common intellectual object which a large lecture room inspires, and by the advantage of receiving that view of the subject which a thoughtful man has himself derived from all that has been written or done up to the time of his lecturing."* Against the possibility of those who profess themselves students not profiting by instruction imparted in lectures, we seek to guard

* Dr. Whewell on Cambridge Studies.

ourselves by catechetical lectures and weekly examinations, which shall test the student's proficiency in the educational studies to which he is directed.

And let it be borne in mind that although these examinations are a check on our younger students, and afford an index to us of their advancement, they are not valueless even for elder members. I grant that the older we become the less are we inclined to submit to the ordeal of an examination; but I am sure all who have thought upon the subject will agree that there is no method better adapted for assisting any one in acquiring knowledge than subjecting him to periodical examinations. Examinations, no less than lectures, are means of education, contributing to the development and instruction of the mind; and therefore here, as at the Universities, although one object of examinations may be to satisfy our minds as to the progress of the younger members of the College, I trust that you will remember that we consider the more important object to be the satisfying the minds of the elder students themselves, the making plain to them what parts of the lectures their minds have laid hold of and appropriated, and to what extent they are acquiring the knowledge for which they joined the institution.

And let me also observe, that if the advantages be great of written examinations, the benefits are hardly less of those conducted vivâ voce. In the vivâ voce examinations, not only knowledge is required but presence of mind, rapidity of thought, decision and clearness of expression — qualifications most desirable and worthy of cultivation. Added to this, special difficulties and points of importance naturally become prominent in habitual subjects of all examinations, and are thus rendered familiar to the minds of students. And I think that I appeal to the experience of some here when I say that another advantage which the oral examination has over the examination on paper is the vivid and lasting impression which it leaves on the mind of the examinee.

I would, however, add one observation by way of caution. Should examinations—that is the passing good examinations—be made the object of our study, they will be apt to exercise an injurious effect on the mind. Ever remember that the knowledge which, in such examinations as we have to speak of, the student brings out of his acquisitions, he is required to produce, or recommended to produce, in order that he may be prevailed upon to acquire it. In the student's individual purpose it may be the object of study to obtain prizes, but in the purpose of the educator it is the object of prizes to induce study.

It is always found that knowledge, which has been acquired for the special purpose of examination, is apt to be shallow and imperfect, to pass from the mind when the occasion which prompted the effort is over.

On consideration, therefore, it must appear that for a system of lectures and examinations to be well suited to the end in view, there should exist a correspondence between the teaching of lecturers and the views of examiners; if this be not the case, both the objects of examinations to which I have adverted will be lost; examinations will not test the progress of our younger students, nor will they enable the elder ones to estimate their own advancement, and thus not only will the educational legislators be at fault, but the students themselves will be dispirited.

In our system we have introduced the principle of emulation, and having done so, it is important that we should so control it that the energy of our students may not be directed merely to our examinations, and to the mode of succeeding in them, to the exclusion of a comprehensive grasp of the subjects taught. And yet, at the same time, owing to our complex object, there must be a certain correspondence between the teaching of lecturers and the views of examiners; for although the lecturer may be said to have fully done his

duty to the elder members when he has stimulated them to an earnest study of the subject on which he lectures, it would hardly be otherwise than a failure if the attention paid by younger students did not directly assist them in their examinations. Emulation—desire of distinction—are overwhelming forces when brought into competition with other motives, and experience teaches us that youth will not in general expend much energy on the acquisition of knowledge which offers no immediate recompense. So that while we hope our examinations will be such as to encourage a comprehensive study of the subject, we shall endeavour to make them also a fair index of the attention bestowed on the lectures.

And this is just the point in our new system where we expect to meet with some little difficulty.

Among the various talents which have been placed at our disposal in the agricultural department, it cannot but be that we shall meet with some conflicting opinions, so that the perfect agreement between lecturers and examiners, which is found when the same individual occupies both posts, cannot exist; and indeed so considerable a difficulty is this, that I should have been loath to venture on the experiment which our new programme publishes, had I not relied with confidence on the able help which has been so handsomely and

readily offered by Mr. Morton, than whom it would be difficult to find any one, I will not say more qualified, but equally qualified for the duties he has undertaken. By his aid, working in unison with those other gentlemen who have kindly promised to deliver lectures on agriculture, I have a belief that the experiment we are entering on in our agricultural department will prove eminently successful.

Nor in this general exposition of our system of teaching must I fail to mention the arrangements which are made to secure, as far as possible, a knowledge of the practical details of our farm management; these consist of an adaptation of the methods usually adopted by intelligent and educated farmers in the training of their pupils. You will be required not only to keep a daily record of every operation, to see the operations in progress, to value them, to make yourselves conversant with the management and feeding of the stock, but you will also be expectcd to have a thorough knowledge of the farm accounts, which are open to the inspection of all. This, if combined with some experience in the judgment of stock, to be gained by constant attendance on the Farm Manager's instruction on the Farm and at markets, will furnish the necessary complement to your scientific teaching. Everyone must be aware that we

no more can learn agriculture efficiently without daily observation on a farm, than a chemist can learn chemistry without a laboratory, or a musician music without an instrument. Accordingly, on those of you who may have come to us ignorant of the elements of agriculture and of the commonest field operations, I would especially urge sedulous and immediate attention to the *daily work of the Farm;* but in saying this I would not have you imagine that I limit the value of such attention to the novice. Who will pretend to say that the most observant life will extract the knowledge which is to be gleaned from a close observation of nature?

Let it however be borne in mind that we do not at this College make any extravagant pretensions; although in the Lecture-rooms you will find teachers who, having dedicated their lives to special studies, are in a position to give you, with peculiar point, the results of their labours; and on the Farm one not more qualified than he is ready and anxious to help all who are trying to help themselves; yet we do not profess to make farmers after a two years' course. There is no royal road to agriculture, and we should be professing to have found one did we pretend to turn out students after so short a stay with us capable of managing a farm to a profit. We hope, by our

system, to lay a good foundation on which each student may build effectually for himself. The principles of farming may be taught—how to put these principles into practice each man must *learn for himself*. Some may acquire this in a shorter period than others—one man's powers of observation may be great, and from early and constant use may enable him to amass an amount of practical detail which it will take another a much longer period to secure. In a College system it is not possible to do more than to put a student into the way of obtaining this practical knowledge for himself; neither the length of our course, nor the circumstances under which students are placed (diligent students of difficult sciences), will admit of that constant and close attention to practical detail which alone enables any one to cultivate land with pecuniary success; and therefore, although we consider that no student does his duty who does not spend some hours of each day on the Farm, observing the operations and collecting those details which he is expected to acquire and to produce afterwards in examination; yet we are quite sensible that however perfectly our system is worked, we can never hope to make in a two years' course, a previously uninstructed youth, a farmer. At the same time, we have every reason to believe that we can so teach

him that after another two years' residence with an experienced farmer, having learnt with us how and what to observe, he may start in business on his own account with a tolerable chance of success.

And let me add that, from past experience, we know that our course of study has proved most valuable in numerous instances where men who, having learnt practical details elsewhere, joined us to acquire a knowledge of the natural sciences, and to observe how those sciences were applied on our own farm.

The College was established for the scientific education of the farmer, and it will answer its purpose thoroughly when our students are men (not boys) of intelligence and agricultural knowledge, who come to the College with the same purpose, as I say, many of our former and present students joined us.

I speak thus plainly and strongly because, by some, our College is regarded as a mere scientific school, where practical detail is placed in the background, and where students consequently are more likely to obtain a distaste for the real work of the farmer than to have the taste fostered and intensified; while, by others, it is spoken of as a place where idle young men are allowed to roam over a farm, and to gather agricultural information as best they can. How far these inferences are

correct those who have been educated here are able to decide, and you yourselves will be no imperfect judges. At the same time, let me say that it is hard to be condemned for leaving undone what every other institution in the world leaves undone. Can any institution—does any institution fit its students for successful employment in the profession for which it nominally educates them—does a military college—does a school of medicine or a school of engineering—does a university? In each of these cases the place of education can only prepare a young man for the after instruction of himself. It cannot so educate him as to guarantee that he shall in after life put in practice in *the right way, at the proper time,* the information with which it has charged him. In short, the work the College professes to undertake is,—1st, to instruct its students in the principles of Agriculture, Chemistry, Botany, Veterinary Surgery, Surveying,—disciplining, at the same time, the mind by making these studies as severe as possible; 2ndly, to foster habits of industry, order, punctuality—in fact, those habits which make a man of business successful in whatever calling his talents and knowledge may be engaged; 3rdly, to induce habits of observation and attention to the details of farm practice, by a daily and careful attention to the work on the College Farm.

And although a want of result may in some cases have been apparent, yet we have the satisfaction of knowing that, in numberless instances, where our students have been painstaking, the training they have here received, combined with much practical work elsewhere, has been of the greatest possible advantage to them. One remark more on this topic and I have done. It is my own experience, that the diligent students of science have invariably been also the diligent observers of the farm practice—have stood high in the Farm Manager's examinations, as well as those of the several Professors; and I think that in the quotation which I now give, from the writings of one of the most accomplished and successful farmers of the present day, my remarks are fully borne out.

"But the mere possession of capital does not qualify a man for being a farmer, nor is there any virtue inherent in a lease to insure his success. To these must be added probity, knowledge of his business, and diligence in prosecuting it. These qualifications are the fruits of good *education*, in the fullest sense of that term, and are no more to be looked for without it than good crops without good husbandry. * * * * But the great difficulty at present lies in finding appropriate occupation for such youths betwixt their fifteenth and twentieth years. In many cases the sons of

farmers are during that period put to farm labour. If they are kept steadily at it, and are made proficient in every kind of work performed on a farm, it is a good professional training as far as it goes. The more common one—at least as regards the sons of the larger class of farmers—which consists of loitering about without any stated occupation, attending fairs and markets, and probably the race-course and hunting-field, is about the most absurd and pernicious that can well be imagined. Such youths are truly to be pitied; for they are neither inured to bodily labour, nor afforded the benefits of a liberal education. It need not surprise any one that such hapless lads often prove incompetent for the struggles of life, and have to yield their places to more vigorous men who have enjoyed the benefit of 'bearing the yoke in their youth.' Unless young men are kept at labour, either of mind or of body, until continuous exertion during stated hours, confinement to one place, and prompt obedience to their superiors, have ceased to be irksome, there is little hope of their either prospering in business, or distinguishing themselves in their profession. Owing to the altered habits of society, there is now less likelihood than heretofore of such young persons as we are referring to being subjected to that arduous training to bodily labour which was once the universal

practice, and hence the necessity for an appropriate course of study to take its place. * * * * It is also common for such youths to be sent to Edinburgh for a winter or two to attend the class of our accomplished Professor of Agriculture, and perhaps also that of Chemistry and the Veterinary College. This is well enough in its way; but yet there is wanting in it an adequate guarantee that there is real study—the actual performance of daily mental work. * * * * After enjoying the benefits of such a course of training as we have now indicated, young men would be in circumstances to derive real advantage from a residence with some experienced practical farmer, or from a tour through the best-cultivated districts of the country." *

From all that I have said, you cannot have failed to gather that in our system of education we not only esteem the discipline and knowledge which the studies of this place afford, and the practical knowledge to be obtained from the instruction of the Farm Manager, but that we place much weight upon the formation of habits of business and observation. Agriculture must be different from every other occupation if success in it can be secured by intellectual efforts alone; there are qualifications more important than mental powers,

* Wilson's British Farming.

such as industry, punctuality, habits of order, carefulness — indeed I have little hesitation in saying that when most of these are wanting failure must inevitably follow. The portioning out of your time, the rules and regulations, have all been framed with a view to the promotion of these qualities. We should rejoice to see the majority of you regular, punctual, attentive to details, and lovers of cleanliness and order; for in the race of life results nearly always depend upon minute circumstances. In your own future profession, for example, you may find a man gravitating gradually to poverty, not because he is ignorant how to cultivate his soil and rear his stock, but because he is idle, careless in his bargains, not exact in his accounts, and indifferent to the minutiæ of his labour. Hence it happens that many a retired tradesman becomes a most successful farmer, because he brings to his new occupation just those qualities of which I am speaking; in his shop, success has been secured by order, exactness, and regularity—attention to minutiæ—and in his farming the same habits contribute greatly to his success. And, therefore, suffer me to assure you that a regard for the formation of these qualities in each of you weighs with the authorities of this College in all their regulations. Impressed, as I trust we are, with a sense of our responsibilities,

and with the important influence which the time you spend here will have upon your future, our object is not merely to keep you in subjection, and prevent extravagant outbursts of youthful folly, it is so to train you that the habits you acquire, as well as the knowledge you secure, may be of lasting good—and a happy thing would it be for us, as a little christian community, if you all would recognise our efforts in this light.

And if intellectual power be so abortive, as regards influence and success in this life, without the moral qualities of which we have spoken, what is it likely to be when uninfluenced by a ruling principle? "I can imagine," said a late scholar, "a beautiful ship at sea, with all her sails set, in perfect order, and even capable of withstanding the storm; there may be every requisite on board in complete arrangement, she may have hands sufficient to man her; but if that ship be without a rudder, she will be driven about at the mercy of the ocean, and have nothing to guide her to the haven where she would be; and such is man without a ruling christian principle."* I am happy in the thought that the supporters of this Institution have other objects than the mere furnishing of intellectual food to the students. I am happy in the thought that here we profess *to educate;*

* Archbishop Sumner.

were it otherwise—did our duty to you commence and end with training the intellect—this would be no place for one who, like myself, has solemnly dedicated his powers to a higher service. The very selection of a clergyman to rule over this community is an acknowledgement that not merely morality is to be inculcated, but that christian doctrine is to be the groundwork of our operations. I cannot believe that a minister of Christ is placed here as Principal merely to add respectability to the Institution, and to secure for it public confidence; rather I am convinced that it is the wish of the Council that his best energies should be directed to an endeavour to influence the little community confided to his care, not only by the words of human wisdom, but by the words of eternal life. How much there is in that word "educate." To educate you is to train you for success—for success in the little or great sphere you will occupy in life—but can there be success, unless, in all our connections, we fulfil our destiny, even making "one little spot of earth the greener for our life"? Loud is the talk in this day of the power of knowledge, as if of itself it could regenerate society; it may enlarge a man's conceptions, but it cannot, it does not, warm his heart; it does not bind him to his fellow creatures. There is the concurrent evidence of all antiquity as to the

inefficiency of secular knowledge to purify the morals, or secure the happiness of a nation; and history, furnishing us with examples of what human nature may become, and what human passions may lead man to perpetrate, when they have cast off the restraints of religion, would seem to prove that knowledge without such principle may give to the ferocious only a greater power for evil; that it may, perhaps, only add to the ferocity of the tiger the means of rendering that ferocity irresistible. When, however, by the sovereign grace of God, the will once moves, however feebly, in the right direction, when the heart once loves the light, though still encompassed with darkness, narrowness, and obstructions, then secular knowledge may open new windows for light to stream in by. You, to be successful in your future careers, must go forth, not only equal to the demands made upon your intellectual acquirements, but equal to the demands which God makes upon your services for the advantage of the locality in which He may place you; small, comparatively speaking, will be the benefits which you derive here if they only enable you to accumulate money and leave it to others to spend, without equipping you for the real battle of life—even the increase of human happiness by the spread of God's truth—the elevation

of human character by the inculcation of pure and unselfish aims. Our prayer is, that while your hearts are fresh and young, you may seek to have them set on some high purpose, which may be blessed to the good of your fellow creatures; and not remain satisfied, as alas too many are, to creep into comfortable homes, closing ears and eyes to the ignorance and evil beyond them. And should any influence here at work tend to foster these good aspirations, and strengthen you to act them out in life, we can say truly, you need no higher honour and we no better reward.

LECTURE II.

Gentlemen,

You are here to acquire the knowledge and the skill by which agriculturists turn land to profitable account. It is certainly true of the lectures on Farm Practice to which you may listen either here or in the field; and I dare say that the Professors of Botany, of Chemistry, and of other sciences related to agriculture, will say the same of the instructions which they may offer to you; that if they do not really help you to the profitable management of the land which you may hereafter hold and cultivate, they will fail of their intended purpose. It is as agricultural students that you attend these lectures, and you expect to obtain from them that which will assist you to earn a livelihood as farmers.

I do not know that it is necessary either that you should consciously retain this expectation throughout every sentence that you listen to, or that we should be prepared to show of every bit of information that is given how *it* will help to "pay the rent;" but it is nevertheless important

that the main object of your practice and your studies here should be always kept in view; and that the agricultural relations of every topic that is here discussed should be borne in mind. I may say this without exceeding the province of a mere lecturer on farm practice, for his labours are lightened, made easier and more efficient, by the agricultural light which his students may be at the same time obtaining from all the sciences represented at an agricultural college.

Little indeed falls to be done by me and by those who will succeed me here, except to relate and describe the circumstances, order, methods, and results of farm management; but it is certain that when men come new to these studies all this is learnt and understood most easily and best by the man of liberal education, who has acquired or is acquiring that general insight into agriculture which is conferred by the various sciences. And not only so, but these studies do in such a case result in an altogether different rank and style of man. The very same course of experience and instruction which makes one man a good farm labourer, may make another a good farm manager, and a third an influential and successful agriculturist. The very same course of experience which makes one man a good common soldier, may make another a good regimental officer, and a third a

great commander. Of course one would not say that there is no difference in the training which results in these three varieties and orders of men, but the practical training must be the same in all. They differ mainly in their several degrees of that larger, more liberal, and scientific education, to the importance of which the mere lecturer on farm practice thus has a right to call attention.

It is among the objects of this preliminary lecture to discuss the several qualifications which a farmer must possess before he can enter into business for himself with any prospect of success. Practical skill is unquestionably the most important of these qualifications; but certainly I shall not attempt to enforce the need of it by anything like disparagement of the advantages of general intelligence and scientific knowledge.

I have, however, in the first place, to remind you that whatever else you have or want, you must have this PRACTICAL SKILL in order to succeed in agriculture or in any other art. The general officer and the agriculturist alike need this as the very foundation of their professional education. It is impossible to speak too strongly on this point. Every art—that of agriculture as one—consists of course in the doing of a series of operations in the right way, and the ability to do things in the right way is just what we call skill. An intelli-

gent man is not thereby an agriculturist even though his intelligence includes agriculture within its scope. He must have this skill, without which his agricultural intelligence will be useless, before he can take a farm with any prospect of success.

How is this skill to be acquired? There is no other way than simply by observation and practice. An art cannot be learned from the description of it. It must be seen in operation; and it must be practised. Herein lies the immense advantage possessed by him whose natural tastes impel him to the careful observation and mastery of farm details, or whose boyhood spent upon a farm has given him this knowledge and mastery almost without his knowing it. Let me tell you a story in illustration of this:—

A young man fresh from the University, who had taken cordially to the position of a country gentleman—and, among other occupations, had adopted that of agriculturist—was riding round his land one morning with a neighbour of long experience and well-proved practical ability and judgment as a farmer. He listened with docility and good-will to the instruction and advice that were given to him; and, struck by the wisdom and good sense of his companion's discourse, he at length exclaimed, "Ah Mr. ——, I wish I knew as much as you do." "Make yourself perfectly

easy on that score, my dear fellow," was the reply —" *You never will.*" The one was fresh from the schools, and the other had spent all his life in the fields, and yet there was neither mock modesty in the speech of the one, nor arrogance in the answer of the other. Mr. —— did not finish his reply:—"I have been accustomed," he might have said, "to be amongst plants and animals, constantly riding and walking on the soil which supports them both, since I was a child. Ever since I can remember I have had to do with the tillage of the land, the cultivation of crops, the management of live stock. There is not an aspect of weather, land, or life, so far as the live stock of the farm are concerned, which I have not habitually witnessed, realized, and studied. That of which instances and striking cases may be observed by you is foreseen or recognised by me in its first beginnings almost as if by instinct. Long familiarity with the details of my occupation, beginning, too, with the mind of a child which has hardly any other impression on it to weaken the sensitiveness with which its early knowledge is received, gives me, almost unconsciously, and without the effort of any special attention such as you must exercise, those intimations of fitness or of unfitness, of quality and condition, whether of soil, or crop, or animal, on which the right

direction of our business of course depends." Mr. —— was perfectly correct; it is an immense advantage to an agriculturist, as to the follower of any other occupation, to learn that occupation young; and the reason is that the skill which he thus acquires grows naturally with him, and is thus more perfectly acquired than it can be in any other way.

Gentlemen:—*It is impossible for you to accept too unreservedly, or too confidently, the assertion that a personal acquaintance with details—accurate knowledge of every particular regarding those processes and operations which make up the daily practice of the farm—in other words,* PRACTICAL SKILL *is essential to your professional success.*

And all this, as I have said, is only to be acquired by close personal observation.—There is a story, I see, going the round of the papers just now about Bewicke, the celebrated naturalist and artist. He was asked, how it was that his engravings of birds were so much truer to nature than those of other men. He replied:—"I suppose I must have just looked harder than other men at the birds when sketching them." The late Lord Ducie used to say, "A young man will never be a farmer unless he can enjoy to sit for two hours on a hurdle and look at a sheep." Bewicke and Lord Ducie were of one mind on this subjeet; and

every other sensible man will agree with them. It is only by close and careful observation that skill, whether as a farmer or an artist, is to be acquired.

I need not tell you that this Institution gives you capital opportunity for acquiring, by this close and careful observation, the skill as well as the intelligence which you will need as farmers. A large farm, with considerable variety of soil, under vigorous management affords all the scope of this kind which any one can desire; and one of your most useful opportunities of professional education here (dependant however for its efficiency, like all the others, altogether on your own determination to make use of it) is that afforded by the daily routine of farm operations on so large a scale, carried on directly under your observation.

Next to practical skill, I would rank BUSINESS TACT and ability among the essentials to professional success; and this again is to be acquired only by experience. The profits of farming, like those of every other business, are made in the market-place as well as in the field—they hinge upon your ability and judgment in your dealings with other men, whether your servants or your neighbours. However skilful in the management of land and crops, in the management of a flock or of a herd, a man may be, he needs sufficient

shrewdness in dealing with his equals as well as ability to direct his inferiors, before he can attain full success in farming. Indeed, this shrewdness, or common sense, as it is called, rather because it is commonly needed than because it is commonly possessed, is required in every relation which you will as farmers sustain. I remember, after relating the story which I have just told you, about the young landlord and the practical farmer, to one who was consulting me about the agricultural education of a son, we afterwards conversed on this second point—the necessity for skill and tact in dealing with men. And I told him of one whose career, terminating in great ability as a farmer, had led him through active service in various public offices, and in many different countries, until while still a young man he had, with only the advantage, I believe, of general country knowledge, taken a farm and managed it successfully—the inference being, of course, the great superiority in shrewdness, general intelligence, and common sense which such an education must have over that of the young man who is kept labouring all his life in the same parish and almost in the same set of fields, acquiring merely manual dexterity. His reply was, "I can see the force of that, but I can also see that it is the exact antipodes of what you have been telling me before." He was entirely

mistaken. It is no such thing. These advantages of practical skill and of business tact, respectively, different as they may be, are certainly not opposed to one another. They may be both possessed by the same individual. They *must* be both possessed by him in order to the full attainment of agricultural success. You may in your own persons unite the skill of the common labourer, the shepherd, and the cowman, with that general intelligence and quickness in business relations, which a larger and more general experience in the market-place and elsewhere will give you.

And I say of this, as I said of the other, *it is impossible for you to accept too unreservedly and too confidently the assertion that temper, tact, and common sense, (business ability, in short,) are essential to professional success.* You will need them all in striking with the landowner the first bargain of the long series in which agriculture, like every other business, consists. You will need them all when taking your farm, when making your purchases and sales, and especially when dealing with your labourers.

It is, in fact, in this last relation, more than anywhere else, that your ability of this kind will show itself—in selecting your labourers—in getting the right man and putting him in the right place—and in your relations with them afterwards—so that

all the difference between the services of an ignorant, ill-conditioned body of men, and that of active, intelligent fellow labourers may be in your favour. Even men of undoubted practical skill are dependant upon the willing services of their men. This has been strikingly illustrated within the last few weeks, in instances where no one will deny that a high degree of professional judgment and ability existed.

You know the late Jonas Webb had a career of unparalleled success as a breeder of Southdown sheep. Next to him perhaps stood Mr. Rigden, of Sussex, and Lord Walsingham, of Norfolk. Mr. Webb was almost always first in any general competition among Southdown breeders. Mr. Rigden almost always beat Lord Walsingham in any competition between these two. Mr. Webb is no longer with us, and the competition now is between Mr. Rigden and Lord Walsingham alone. The latter has, I understand, secured, during the past year, the services of Mr. Webb's old shepherd. Mr. Rigden's shepherd, on the other hand, has been of late disabled by illness. Under these circumstances, these two breeders met at Worcester the other day, and Lord Walsingham took all the prizes! An incident of this kind shows how dependant even the practical man is on the skill and good will of his labourers—and

I relate it here as an illustration not only of the need of skill but of the necessity also of so conducting business as to be on good terms with your servants, and with every other class with whom you are in business relations.

For this second qualification, which you need in order to professional success, as well as for that of personal skill, the only school open to you is actual experience and observation. In this respect an Agricultural College does not differ from any other place of professional education. A resolute student can acquire here a great amount of skill in the art which he has come to learn. He can, of course, acquire the intelligence which is to direct him in his operations, but the responsible prosecution of his business can be learnt only in actual experience. It may, therefore, be your interest, in order to supplement what the Agricultural College can communicate, that you should seek elsewhere practice and experience in business arrangements, either on a farm, or with a salesman, or in an office, before taking a farm on your own account.

Be this however as it may, it is worth while to remember that while the skill which you may acquire, here or elsewhere, will confer on you only the rank of a good farm labourer, this business ability, in addition to it, will only raise you to the

rank of a good farm manager. A successful and influential, because intelligent agriculturist, needs something more than these. And this is the third point to which I have to direct your attention: he needs a LIBERAL AND SCIENTIFIC EDUCATION.

As I have mentioned this last of the three—and especially as I have referred to its resulting in an altogether different rank and style of man — it may occur to you that I am advocating scientific knowledge and a liberal education simply on the ground that it places you in a higher social rank. That, of course, is a result which no sensible man will undervalue, but it is not the ground on which I have any special right to recommend it. Unless it be professionally serviceable, I have no right to be its advocate from this place. But here again, gentlemen, I believe you may with the most unreserved confidence accept the assertion that *a knowledge of all the sciences of matter will be of direct advantage to you in your profession.*

How can it be otherwise? Your experience in the field is necessarily in accordance with all the great natural truths determined by the geologist, the chemist, and the natural philosopher. These have been observed under such a variety of circumstances, in such a multitude of instances, on every kind of scale, that those relations and properties of matter which they illustrate and teach

may be trusted to as existing everywhere, affecting therefore, or rather I may say *moulding* the practice, and *constituting* the experience of the farmer as they do that of every other art and manufacture.

One sometimes hears experienced farmers speak of the doctrines of the chemist or the botanist as if they were mere theory—that is, I suppose, mere speculation. But this is a great mistake. The doctrines of the chemist, the geologist, and botanist are based on facts much more numerous and more carefully determined than those on which many a practical agriculturist is content to build his confidence. And what is more, they are built, among others, on the very facts which agriculture itself presents.

Experience is of value just in proportion as the facts which it has witnessed have in this way taught their lesson perfectly — the longer the experience the greater is its value, because the more the facts of which it takes account, the less the chance of the peculiarities of any of them interfering with the lesson taught by all. Now science is the result of all experience—its doctrines are the truths which the observation of all time has taught. How can anyone despise or disregard its teaching, while an experience in the field, furnishing perhaps but two or three of the thousand

foundation stones on which it rests, is considered by him of such value! I must say that I greatly prefer to let the usefulness of a scientific education to the farmer rest in this way on the obvious nature of things, rather than pretend to prove it as an actual fact by reference to particular instances.

When you consider the great mass of truths determined by the chemist concerning the constitution of matter, and the relations of its constituents to one another, surely the pretence to prove by instances the usefulness of chemical science to one engaged in that perpetual reconstruction of matter, which goes on in every agricultural process, whether in the field or farmery—whether in the growth of plant or animal—must seem a mere gratuitous impertinence. One feels, in such a case, somewhat as if in the position—still possible in certain circles—of having to convince an agriculturist of the usefulness of statistical information on agricultural results—only the former case is even stronger. As if knowledge of the *facts* relating to our business, whether those which the chemist gives us illustrative of its processes, or those which the statist gives us indicative of its results, can fail of being beneficial. In either case, we may be sure that whether we may choose to shut our eyes to them or not, there these facts are; and there they are

at work, operating mischievously to us if in our ignorance we run counter to them, or beneficially if by our knowledge of them we are enabled to make use of them.

It is unnecessary, I feel, to refer at any greater length to the practical value of scientific knowledge in the prosecution of farming as a business. Unquestionably the labours, both of the student and of the teacher of farm practice, are, as I said, lightened, made easier and more efficient by the agricultural light which is thrown upon them by all the sciences represented at an Agricultural College. And I need not refer at any length to the ample scope, as students of the sciences of agriculture, which you have in the various professorships and schools collected here.

I shall now, therefore, confine myself exclusively to my own department of the agricultural education communicated here. You are aware that during the ensuing session, the lectureship on practical agriculture will be taken piecemeal by a number of lecturers. You will, no doubt, in this way, hear some variety of opinion expressed, and there may be some differences and even inconsistency in the advice given you; and this may perhaps be considered a defect or fault in the arrangement that has thus been made. I do not think it is. This variety and uncertainty will be found by you

hereafter more in accordance with your varying experience from year to year, from field to field, or it may be from farm to farm—than a more complete and uniform series of lessons, however logically consistent they might be, would prove. It must not be forgotten that there is still a great extent of variety, uncertainty, and inexactness in the experience of the farmer; and it would be no proof of the efficiency of the teacher, or of the excellence of a plan of teaching, that it pretended to uniformity, consistency, and precision. One does not need an exact knowledge of the sciences in their relationship to agriculture to know that many of the influences under which the soil, the plant, the animal is placed are still unreduced to rule. Our results in the field, the fold-yard, and the dairy are affected by the apparent caprice and irregularity of out-field causes as well as by the uniform and steady operation of those influences which can be regulated and foreseen. Agriculture in fact seems rather on the boundary line than within the field of many of the sciences—just where their rule is making rapid inroads on the vast territory by which each is surrounded. You cannot expect certainty and exactness here any more than you can look for the safety and decorum of civilization on a frontier that is being continually broken by the incursions

of savages. It is just there, however, that a community will most value the order and security existing at least on one side of them, and so agriculturists have reason to be thankful for what of certainty and confidence the researches of philosophers have given them. It is very true that this certainty has reference rather to principles than to details—that in order to the successful prosecution of the art every one of us must for himself and by experience strike the average of a large body of unforeseeable liabilities. Its rules, originally founded on these averages, are still to be defended chiefly on the ground of their results *upon the whole*. Still these principles and these rules together constitute a very fairly ordered system of skilfully applied knowledge, and they are certainly necessary to be understood by the agricultural student.

What I contend for is that these principles and these rules are best taught when, in addition to witnessing their actual development and prosecution in the field, they are also examined, illustrated, and described in the lecture-room, even with all their inconsistencies and inexactness. Of course one does not contend that an art can be taught by mere words—but there is much connected with it that can be learnt in this way: and a certain knowledge on the one hand of the

principles, and, on the other of the rules, of good agriculture can be thus communicated. Cannot the knowledge of these rules and principles be communicated orally? Cannot the student hear and read what there is to learn under either of these heads? Can he not, for instance, learn from books and lectures the fundamental principle that material atoms are immutable? And cannot he thus become acquainted with the nature of those atoms with which in air and soil the farmer has to deal? Can he not from books and lectures learn all the uses of these atoms as the building material of plants and animals? And, the rules which experience has taught, and which these principles confirm, by which these atoms are economised, and waste of agricultural building material is avoided—cannot he store his memory with them at his desk? Will not books or conversation describe to him the processes of tillage by which the soil is made a storeroom of these atoms? And the art of land drainage, by which rain-water, having gathered from the air and soil a quantity of this building material, is hindered from carrying it at once to waste into the neighbouring brook—is it not capable of description? Cannot the student learn from lectures, or from books, the methods of saving and economising those portions of this building material which in

farm manure are added to the land? Those methods, too, of arranging the succession of our crops by which the stores accumulated in the land are drawn upon in the order least likely to interfere with a continual supply;—all this certainly may be communicated orally. And so may every other principle and every other maxim, rule, injunction, which practice and experience have laid down, and which these principles either explain, correct, or justify. A man who knows all that books can tell him, or that can be poured into his ear on agriculture, can enumerate every detail in the whole range of farm practice, and every item in the chain on which its theory depends. He can tell you every process in the field, the farm-yard, and feeding-house proper to every month, connected with every plant and animal, characteristic of every district. He can describe the failures and successes of every kind of farming in every county in the kingdom. He can give you all the methods, all the rules, all the results of agriculture; and he can bring to bear all the light which all the sciences have given him in criticism, condemnation, justification, as the case may be, of every detail in all this mass of information. Of course such knowledge and ability is useful to the farmer. It includes indeed that which, acquired one way or another, is essential.

This then is the case for oral instruction in a scheme of agricultural education.

And now let us hear the case quite as strong upon the other side, if so it must be called, for the need of practical instruction. These *words*, it will be said, in which your well-read agricultural student expresses what he has thus acquired, may have been originally spoken by one in whom they indicated knowledge—but at second-hand they are but words. It is not in their power fully to convey the ideas which they may have been originally intended to express. Put this so-called knowledge to the test, and you will find that until it has been rectified or rather vivified by actual practice, it will prove insufficient. The student will find the means, which in practised hands suffice, altogether insufficient. He will be behindhand with his operations, and they will fail from faulty execution as well as from being out of season; for their proper execution depends not only on the knowledge of the master but on his ability to direct his men; and the labour of the farm cannot be expected, in unpractised hands, to be either economically or efficiently performed. Nor can the marketing, on which its profits so materially depend, be expected to succeed. It must be remembered agriculture is a business as well as an art; its proper end is a sufficient money return for the capital invested in

it. And so it is that the most accomplished student who ever left an agricultural lecture room or college has obviously that to learn which lectures cannot teach him before he can be called an accomplished agriculturist.

It is certainly of great importance that men who may come here for a short session or two, thinking that they are thereby fitted for immediate entry on a farm, should bear this seriously in mind.

You may be taught in class-rooms all the sciences which explain all agricultural results; you may learn the plan and even the full details of a well arranged agricultural year; but be assured that your annual result may be bad, notwithstanding a good plan and its details, and even good it may be, in spite of their defects, according to the tact and skill and business habits which you bring to bear on their superintendence; and these are what you cannot learn from lectures or from books. This it is well to bear in mind, else you will be disappointed when you leave your agricultural studies for the field on which you are to apply them; and instead of the noble scope for intellectual exercise and enjoyment which you had expected in the profession of agriculture, and which most truly may be found in it; instead of the scope for developing large plans and well-arranged series of operations which you had

expected in the art of agriculture, and which doubtless it provides, you find to your dissatisfaction that the real and principal truth of the matter is that you have entered on the business of farming—a retail business, too—depending no doubt in all its facts on those great natural laws expounded by the geologist, the botanist, and chemist; depending also for its results on the skilful arrangement and adaptation of your means to the end desired; but depending for its profits upon the personal superintendence by the master of the minutes and the pence expended, whether in labour or in stock, far more than on anything else whatever.

This, then, is the case for the practical part of an efficient agricultural education. It should not be stated as if antagonistic to the other. Neither is it antagonistic; each is the complement of the other. Both are needed. They are perfectly consistent—as consistent obviously as language is with the fuller meaning which experience gives it.

And there is opportunity given to you here of acquiring both. In the field, under Mr. Fletcher, and here, under a number of scientific lecturers, you will have the opportunity of making full use both of the practical and the descriptive parts of a good agricultural education. If I were you I would not make too much of any discrepancies or

inconsistencies between the two which you may detect. You will find puzzles and anomalies enough in farm practice to make inconsistencies and discrepancies in agricultural instruction not only pardonable but inevitable. And you may be assured that, whether consistent or not, both field experience and general intelligence will be of service to you every day of your actual professional life. Just run through the year's operations on the farm, and see:—

We will suppose that the first act of an agricultural twelvemonth consists in the entry on a farm. A farm is offered, and the terms of the lease having been discussed and acquiesced in it is taken. Such of the rights and property of the outgoing tenant as remain upon it are valued and paid for. Working cattle and implements are purchased, and labourers are hired. The crop for the ensuing year on each of the fields is fixed upon, and such cultivation as the season indicates for each is at once commenced. Perhaps more permanent improvements are contemplated, or, it may be, entered upon at once. Lime has to be applied on some of the fields. Draining (it may be the most convenient season) may be planned out, let, and executed. The more proper annual work upon the farm proceeds. Seed-time either is already, or will soon arrive. Seeds and seed corn in quantity

sufficient for the extent contemplated of every crop must be procured. The details of the previous cultivation must be directed and the seed put in in proper season and condition. The cultivation of the land and the cultivation of the crop go on together—hoeing, thinning, or perhaps top-dressing the young plant, and the tilling of the soil as its feeding ground. Meanwhile the consumption of some of the growing crops must be provided for. Young cattle for fatting during the ensuing winter, or perhaps sheep in a condition to sell before the winter, must be purchased for the pastures. Possibly dairying may be determined on, in which case special arrangements must be made. By and bye sheep-shearing, and all the details of shepherding, and of live stock management in general, will require attention. Haymaking time comes round, and harvest time for grain crops and for root crops: and the hazards of our island climate will try the intelligence, the temper, and the skill of the agriculturist. Sales of farm produce next put his judgment to the test. Purchases of stock, too, will do the same when he comes to arrange for the consumption of the crop provided by the summer's cultivation: and the management of his cattle and his sheep when on their winter's store of food, so as most economically to manufacture meat and provide manure, will give scope

enough for all his agricultural ability. The accounts of all his proceedings having been carefully recorded and arranged, the balance will at length appear as the unquestionable indication of the way in which that ability has made use of the circumstances on and under which it had to operate.

Now where in all these particulars is there an instance in which practical skill to be obtained only in the field, and professional intelligence such as may be gained from books and lectures, are not both required? The general relationship of landlord and tenant, and the expression given to it in the conditions of the lease, may be discussed intelligently and with good effect by one acquainted with only the literature of the subject: but that one condition which more than any other affects the character of the bargain—the amount of rent regarding which it covenants—must be left to experience alone. And even in the other particulars of the agreement there are peculiarities of circumstance to be accommodated which only a practised and accustomed hand can efficiently arrange. A book can no more give the details of the arrangement between landlord and tenant, or between the occupier of a farm and his successor, proper for every variety of circumstances, than can an Act of Parliament, and the inability of that

seems now very generally admitted. The principles of the arrangement best calculated to maintain fertility, while the interests of the landlord and his tenant are provided for, can be described, but the application of them under the peculiarities of every separate case must be left to local tact and skill, including much in addition to mere general intelligence. Obviously all valuations, whether between tenants, or in purchases of stock, come under the same class of particulars, needing experience and skill in addition to mere general intelligence.

Then take the details of cultivation. These, as every body knows, are especially under the guidance of local experience, determined by such local peculiarities as the average annual rainfall, the number of dry days in the summer months, the maximum and minimum of the thermometer, the quality of the soil, and the character of the labourer. A Scottish turnip seed time would produce a mildewed crop in Southern England—the seeding of the wheat and oat crop deemed enough on well-cultivated land in South and Midland England—5 pecks of the former and 3 bushels of the latter per imperial acre—would not, I believe, be generally approved of by Scottish farmers. And it is not always a question of mere climate. A friend of mine occupying a large

extent of land in Gloucestershire took a farm in Sussex, on the edge of the chalk downs there—the two districts not particularly differing in their climate. The labourers employed upon that farm had been resident 20 and 30 years upon it, and of course knew perfectly the character of the land and the agricultural customs to which it had given rise. On arriving there one April morning, the new tenant was frightened to find them at work trampling the young wheat in with long teams of oxen drawing heavy rollers twice to a place over the field, leaving the dry white chalky land behind them as hard as a road and with really little better promise of a wheat crop on it than the road itself presented. His opinion that local experience ought to override all other guides induced him to submit (for so he felt it at the time) and the result justified a practice against which all his previously acquired agricultural intelligence protested. The experience of the district had already proved its propriety—had proved the need of that induration of the soil, for the accomplishment of which however no doubt "intelligence" may find some more compendious and less laborious means than the driving of long teams of heavy cattle over it appears to be. Skill, the result of local practice, as well as intelligence to be acquired from books is needed for the efficient direction of the details of cultivation.

The same truth appears still later on the scene —and at haymaking and in harvest time, both of grain and green crops, local peculiarities of management, sometimes condemned by mere general intelligence, are justified in their several localities by those results *upon the whole* in which the lessons of agricultural experience consist. It appears too in the management of live stock—indeed it is more obvious here than in any previous department of the former operations, for here, in addition to the local influences which produce local peculiarities of practice, there are individual influences at work. Of course many rules affecting all animals alike have been determined—the influence of shelter, quiet, warmth, and the relative nutritive effects of different kinds of food and management, have been illustrated by science and confirmed by practice; but a good herdsman knows that these rules need to be applied with discriminating judgment, and varied according to the temperament and character of individual animals. A skill which cannot be acquired from books is needed here. The labourer in charge of them is the man who must exhibit it, but the master needs it too or he will not detect the failures of his servant. In dairying especially is there need of this detailed attention, of which experience only will sufficiently impress the importance. The best illus-

tration I can give of this is the answer of an old Gloucestershire dairyman to one who had been speaking of the way in which a knowledge of the chemistry of milk might influence dairy management. Says he, "nine-tenths of the profits of the dairy farmer depend simply on the master seeing for himself that his cows are always thoroughly and carefully milked." Such was the proportionate value which long experience had laid down as belonging to the influence of a common-place ordinary matter like attention to a point of mere routine.

I would place this, the practical aspect of the subject, thus strongly before agricultural students, because I may presume, if only from their appearance here, that they are already sufficiently impressed with the value of such general and professional intelligence as books and lectures can convey—so that if the need of either branch of an efficient agricultural education requires to be especially insisted on it is that in which practice and experience are the only efficient teachers.

[Mr. Morton concluded with an explanation of the arrangements which had been made for conducting the agricultural lectureship during the coming session.]

LECTURE III.

In the few words which I have to address to you to-day, I do not propose so much to describe the means of making chemistry practically useful to agriculture, as to discuss the advantage, I might say the necessity, of the study of scientific chemistry to all who wish thoroughly to master the principles of the agricultural art. Yet as I feel unwilling to attempt the severance, supposing it possible, of these two subjects, I shall illustrate my main point by citing, besides more general instances, a few of those special cases in which a knowledge of chemical compounds has suggested improvements or explained problems in agricultural practice.

There is one question which men of science are continually asked to answer. No sooner is a new fact discovered than the inquiry is made, "Of what use is this discovery?" The chemist is told "You have found out, I dare say, something that was not known before, and you have given it a long name, not easy to spell, and which I will not venture to pronounce; but of what use is this novelty of

yours? Is it good to eat or to drink? Has it any medicinal virtues? Can it dye wool, or silk, or cotton, crimson, or blue, or purple?" The chemist who is thus addressed does not feel aggrieved; for it is better to be asked any question, any how, than to be met with a silent and contemptuous indifference that is too conceited and too careless to inquire at all. And he has a ready answer. First of all he states that the man of science must examine every phenomenon; unveil every fact in a systematic, in an exhaustive manner, *that nothing may be missed*—that man's mastery over matter may be more complete—and that his knowledge may grow more perfect; and secondly, he affirms that his compounds, those precious drops of spirit, that treasured drachm of oil, or those rare and lustrous crystals, have over and over again been brought out of their mysterious seclusion in the laboratory, in spite of their names hard to pronounce, and their odours not generally appreciated by the uneducated nose. Then we hear these curious and long-neglected products talked of everywhere, — those rarities once weighed by the grain, now manufactured by the hundred weight—once named only to be despised, now causing vague amazement not unmixed with pleasure, (perhaps partly owing to their commercial aspects). Such has been the case with what chemists have

named the "terchloride of formyle," a liquid of purely scientific origin, and which, as chloroform, is now made on an enormous scale, and has proved, as I need not detail, a priceless boon. Such, again, has been the case with the liquid called originally "bicarburetted hydrogen," and now known as benzole, and which has not only been itself put to many uses, but has become the starting-point in manufactures of large and remarkable importance. Such, again, has been the case, and this third instance shall suffice, with a singular substance obtained by a scientific chemist, WM. PERKIN, in his attempts to prepare quinine artificially. I will not give you the proper name of the substance to which I refer, for you might think it rather too long, but you will recognize the product at once as Mauve, and will agree with me in thinking that it is a magnificent trophy of science; for while its splendid tints have delighted the eye, its manufacture has employed, in many ways, the talent and industry of thousands. I might add a hundred similar instances; let these suffice to illustrate the practical advantages of a science proper. I will now pass on to consider the points of contact between chemistry as a science, and the practical art with which we are here more immediately concerned. At the outset there is one prominent truth which cannot be too distinctly affirmed,

namely, that before we can apply a science successfully to any special art, whatever that art be, we must thoroughly master the elementary and essential principles of the science, securing a solid basis; digging, in fact, the foundations before building the house. Before a man can apply chemistry to any practical end, whether that end be brewing, dyeing, distilling, farming, he must know the simplest facts about the various kinds of matter with which he meets on all sides; something about the changes which they suffer and the forms they assume; something about what they are and what they seem to be. He must know not only how to separate one kind of matter from others but how to recognize it when separated. And besides all this knowledge, necessary before the conclusions of chemistry can be appreciated, he must, in order successfully to adapt and apply these conclusions in his own department and for his special ends, have become in some measure practically acquainted with the modes of chemical manipulation. That I might shew how intimately and how invariably chemical processes are involved in agricultural operations it would be necessary for me to trace the successive steps in plant-culture, in all of which this connection is more or less clearly displayed. A course of lectures would scarcely suffice for the due treatment of this sub-

ject, and even the few illustrations that I shall bring forward, that they may be understood, demand some preliminary knowledge of scientific chemistry, and thus afford excellent proof of the proposition laid down. To talk of carbonic acid, of nitric acid, of ammonia, of lime and potash, of silica and phosphates, and of their sources natural and artificial, their uses and their changes in the marvellously complex operations of vegetable growth, without knowing whether these chemical substances are simple or compound—solid, liquid or gaseous—soluble or insoluble—liable to be lost by evaporation, washed away by water, or locked up in some unavailable form,—is like looking for fruit on a tree which has not flowered—like pointing out the variations of a species before that species has been itself described.

It belongs to scientific chemistry, then, as distinguished from applied chemistry, to discuss the various properties, and changes, and combinations of those elements which are wrought into the structures of plants and animals by their vital powers. But as these elements do not directly enter as simple elements into the organic structures, but as compounds more or less complex, chemistry must teach the properties, the changes, and the combinations of these compounds as well as of their constituent elements. Then, again, there

are certain states and modes of combination, and certain compounds in which alone their necessary food can be administered to plants and animals. These scientific chemistry recognizes: it also directs us how to imitate, to aid, and even to exalt these natural conditions of sustenance, by shewing us how to prepare and introduce from other quarters the requisite plant-constituents in their most suitable form. By the ordinary process of analysis, as applicable to any other materials as to plants, the constituents of a plant may be ascertained. This done, according to the exact processes pointed out by pure scientific chemistry, the old opinions as to the ingredients necessary as plant-food are at once proved to be idle and groundless. Not from air alone, or water alone, or from minute particles of earth alone are the vegetable treasures of the earth elaborated; but to all three sources do they owe their nourishment. The first process performed upon a fresh plant is to dry it; it thus loses one of its chief constituents, water, a compound of the two colourless and elementary gases, oxygen and hydrogen. But water is not the only compound into which these two elements enter—for oxygen and hydrogen along with carbon and nitrogen, two other elementary bodies, make up the remainder of the volatile materials lost by a plant when it is submitted to a heat more than

sufficient to drive off its constituent water. A mixture of carbon with the so-called *mineral* ingredients of the plant remains. Further heating in contact with the oxygen of the air causes this carbon to combine with oxygen, and yields by its combustion carbonic acid. Besides the four above-named elements, carbon, hydrogen, oxygen, and nitrogen, there are about half-a-dozen metals and the same number of metalloids discoverable in the fixed residue or ash of plants. So that out of the 64 elements of which the whole bulk of the earth is made up, not more than 16 are the necessary and invariable constituents of plants. It is then with the chemical properties, relations, and changes of these 16 elements that the agriculturist is mainly concerned.

It has been usual of late years to arrange chemical substances in two sections, inorganic and organic. The organic element, *par excellence*, is carbon, for it is a necessary and invariable part of all exclusively organic compounds. Organic chemistry has indeed been defined to be "The History of the Wanderings of Carbon." But though this carbon in different forms makes up 50 per cent. on an average of the weight of a dried plant, yet it is absolutely and utterly useless to the plant as carbon. It is indeed almost certain that it is only when combined with two proportions of oxygen,

forming carbonic acid, that it is of any direct value to plant-life. It is here unnecessary further to allude to water, the main origin of the hydrogen and oxygen of plants; but it may be stated that chemistry can shew that carbonic acid exists in the air, that it is dissolved by the rain, and carried down into the soil. Chemistry can also shew that most organic substances, some slowly some quickly, suffer changes, yielding among other products of their decay this very gas carbonic acid. Chemistry points out, too, that carbon, if it lack a direct value, yet enjoys a singular property of absorbing other materials useful to the plant or improving to the soil. Among the materials thus absorbed notably by carbon in the form of charcoal or soot, and also by many kinds of soil, especially by the so-called humus bodies produced by the decay of vegetable structures in the soil, — ammonia, nitric acid, and oxygen are the most important. The average necessary supply of nitrogen is conveyed to the plant, not directly from the vast storehouse of uncombined nitrogen, the air, but from the minute proportion of the compound of nitrogen with hydrogen, and of nitrogen with oxygen, occurring in the atmosphere. Since chemical science identifies the carbon of plants, and likewise shews where and how it may be best introduced into soils lacking this chief organic

element, so it identifies the nitrogen of the plant, points out the compounds in which it may be introduced so as to be useful, and finds in nitre and in sulphate of ammonia the very materials which are required to supplement any lack of naturally-supplied nitrogen compounds. Descriptive chemistry tells the agriculturist of the properties of these salts—while the methods of chemical analysis enable him directly to test the purity of the samples he examines, pointing out the pure salt, sulphate of ammonia, from the adulterated mixture with water, sulphate of soda, and other useless fixed salts, or the pure saltpetre from the corresponding soda salt. But chemistry points out that this latter salt, Peruvian or cubic nitre, contains in an equal weight of material a larger quantity of nitrogen; and as it is far cheaper than nitrate of potash, is more generally useful where it is desirable to supply nitrogenous compounds not potash. One other point in which advantage is taken of the properties of substances as learnt by chemical inquiries may be here mentioned. Farmyard or other to some extent nitrogenous manures, either containing or developing ammonia, may not always be required for immediate use. How then is the volatile ammonia to be retained? A knowledge of the properties of ammonia will enable you to answer this question in several ways.

Ammonia, along with humus or other vegetable matters and lime, yields, when exposed to the oxygen of the air, nitrate of lime, a permanent and valuable salt. Indeed there are some reasons for thinking that ammonia and ammoniacal salts always suffer this oxidation into a nitrate before they are assimilated by the plant. The ease with which ammonia may be thus oxidized may be seen by pouring a few drops of ammonia into a flask; the gaseous ammonia will mingle with the air of the flask, and if a heated wire, or a little rust of iron be introduced into the flask we shall get dense white clouds of nitrite and nitrate of ammonia. The change is an interesting one, and throws some light on the atmospheric oxidation of ammonia. It is a most instructive fact that the five final products of the complete oxidation of waste animal matter, viz.—

CO_2 carbonic acid gas.
HO water.
NO_5, HO nitric acid.
SO_3, HO sulphuric acid.
PO_5, 3 HO phosphoric acid.

appear by the latest researches to be the only combinations of these five elements from which a plant can directly derive its supply of carbon, hydrogen, nitrogen, sulphur, and phosphorus respectively.

The mention made of nitrate of lime and of nitrate of potash leads me to the consideration of what are commonly called the mineral or fixed constituents of plants. It has indeed been impossible to do more than allude to a few of the more conspicuous points in which a knowledge of the chemical and physical properties of water, of carbonic acid, and of nitric acid and ammonia explains the functions of these gaseous and liquid plant-constituents, and indicates fresh sources of supply. Nor have I been able to speak at all of another most important office fulfilled by water, as the universal solvent and carrier of the food of plants, an office the magnitude of whose duties may be judged of from the observation, that about two imperial gallons of water are exhaled from a single plant of barley during its existence. Leaving out all details concerning these most interesting subjects, I would next briefly advert to the advantages which may accrue to the agriculturist from a knowledge of the chemical compounds commonly spoken of as the mineral food of plants.

The plant as we have seen has two sources of food —the air which surrounds its stem and leaves, and the soil in which its roots are fixed. We are not now concerned with climate and weather, the conditions of moisture, temperature, &c., of a district and season, which certain agricultural operations,

as draining, planting, &c., may indeed beneficially effect. Chemistry cannot be so applied on the large scale as to influence and alter the composition of the atmosphere, the aerial food of plants, its duty lies in the *economical perfecting* of the soil. The grand aim of the agriculturist is to form the largest quantity and the best quality of food, vegetable and animal, at the least cost consistent with the permanent good condition of the land. As the animals which he rears subsist on vegetable food, his first aim is to secure the healthy growth and perfect maturity of the plant which he cultivates. The aid which chemistry can here render the agriculturist is evident. What mineral elements, we ask, do the wheat, the clover, and the turnips contain? If the supply of these elements be deficient, how can they best be given? The soil may be barren, and yet contain stores of all the materials requisite for plant-food, but so securely locked up in insoluble forms as to defy even the wonderful powers of the plant to use them. It is requisite to do something more than merely add the special material which the soil needs, it must be added in an available form. And in some cases it need not be added at all; it will suffice to develope the hidden resources of the soil by some chemical or mechanical process. If a soil, for instance, lacks available potash, but contains insoluble silicates of

that alkali, liming will slowly release the potash. Chemistry will shew where this process may be usefully performed, and predict and explain in other instances where failure would ensue. Chemistry will point out the time for applying lime, the mode of applying it, the quantity required, and even indicate remedies if the land has been overlimed. And so in other cases.

Again,—the soil may have been once fertile and have become barren after years of continuous cropping of the same plant. The continuous drain upon the supplies of some substance necessary for that crop may have impoverished the soil. Then chemistry will suggest and explain the process of subsoil ploughing, which exposes fresh earth to the action of the air; of mixing soils; of manuring. And besides all this, it assists in arranging, by a comparison of soil analysis with the composition of various kinds of plant-ashes, the most suitable rotation of crops.

Again,—is waste land to be brought under cultivation? Chemistry points out the reclaiming plans which will prove most effectual, explains their chemical results, and helps to indicate the most suitable crops for the newly-reclaimed land. Upon a sandy soil the process of warping is, if possible, followed, whereby the rich alluvial deposit of a river adds the required organic matter, alkaline

salts and phosphates to the barren sand. Upon a peat bog, on the other hand, the quantity of available mineral matter, for mechanical as well as chemical reasons, has to be increased, so that the rationale of paring and burning becomes apparent. Chemistry throws indeed much light upon the process of burning. In burning clay and subsoils, for instance, it has been found that their stores of valuable material are more freely liberated when a moderate heat only is employed, a higher temperature causing the potash, &c., to enter again, according to well known chemical facts, into unavailable insoluble compounds. Chemistry thus alone can offer adequate explanations of operations which seem at the first glance simply mechanical. To some of these we have just referred; others may be noted in the various phenomena of the origin of soils, the weathering of rocks, &c. Here the mighty agencies of water and carbonic acid are at work. Not to the wearing and tearing action of the mountain torrent only, or the storm of waters or of wind is the disintegration of rocks to be assigned; but by mist, and dew, and shower, with all the sureness if with some of the slowness of nature's methods, by means of dissolved oxygen and carbonic acid, are the hard, and solid, and crystalline masses worn away.

Another point, often overlooked, may be noted

here. A knowledge of the chemical composition and properties of the various minerals found in a given county may perchance prevent the agriculturist from passing by unheeded some of the best treasures of the earth. Guided by science he may find valuable deposits of china clay, or of rich ironstone, or of bituminous shale for making gas or illuminating oil, or of coal, of brick-earth, of slate, and of building stone. And the advantages of some elementary knowledge of chemical science to the agriculturist settling in a distant land, it would be difficult properly to estimate. He has singular opportunities, too often missed, of discovering the mineral treasures of unexplored districts, and of indicating the path, as an early pioneer, to be taken by the more experienced mineralogist.* Let us now resume the discussion

* Take as an example a series of combustible minerals. Beginning with the pure bitumen known as Albertite, a coal which contains no more than 1 part of ash in 1000, we come next to the various kinds of ordinary coal with from 3 to 20 per cent. of inorganic matter in them, and then to the bituminous shales containing a still larger proportion of ash. Finally we arrive at a class of slates and shales which present none of the appearances of combustible minerals. Yet one of these minerals from Tasmania, called erroneously Dysodile, is used as fuel, though apparently an incombustible rock, and contains about 35 per cent. of organic matter. It might be easily passed by, as a worthless and common stone, by the careless observer.

of those mineral bodies which constitute the ash of plants.

Differing, as plants do, in the relative proportion as well as in the absolute amount of their mineral constituents, chemistry aids in pointing out (supposing other conditions of aspect, climate, &c., to be suitable) the crops and rotation of crops that may be best grown on any given tract. And these indications are not all. The discrimination of various fertilizing agents is a most important matter almost wholly dependant upon chemical knowledge. In the disintegrated rocks we find indeed all the forms of the mineral food of plants, but not always in due and sufficient proportion. By those mechanical and common operations to which I have already referred, we can in many cases improve the land and qualify it for its destined use; but in others we must add from extraneous sources the potash or the soda, the lime, the magnesia or the iron, the chlorine, the sulphuric, the phosphoric, or the silicic acid. Or we may find a general enrichment of the soil necessary, in which case a comprehensive fertilizer like farm-yard manure is most usefully employed—supplying as it does the so-called organic as well as the mineral elements of the crop.

Do we need soda? Common salt, the chloride of sodium may sometimes prove a serviceable

source of this ingredient. Potash? Then pearl-ashes, which mainly consist of carbonate of potash, and saltpetre, the nitrate of potash, are suggested by chemistry. Here a curious and recent discovery may be noted. Woollen rags and woollen waste have, as is generally known, been largely used as a manure, especially for hops. The general good effect of these materials has been (with justice) attributed to the large proportion of nitrogen, amounting in clean wool to nearly 18 per cent., which they contain, and which is slowly liberated; but it has been lately found that a marked and immediate beneficial result is obtained where the waste of unwashed wool has been used. This waste contains nearly all the *suint* of the original unwashed fleece. This suint, which forms a large proportion of the waste, is a kind of soap—a soap not only rich in potash, but containing a mere trace of soda if any. In fact a manufacture of potash and potash-salts obtained by washing sheep's-wool in cold soft water, and evaporating and igniting the alkaline soap thus extracted, has been successfully established in France. Specimens of the products were shewn in last year's International Exhibition. It may easily be perceived that shoddy, which has suffered operations and vicissitudes too numerous to recount, does not contain much of this valuable potash compound,

nor indeed do the cuttings of woollen cloth nor woollen rags, although these materials abound in nitrogen.

Passing from potash and soda, we next inquire what sources of lime and magnesia can chemistry suggest. Of lime, chiefly as carbonate, most soils have no lack, while abundant and well-known supplies are generally at hand. Of the use of lime for other purposes than supplying that ingredient to the soil I have already spoken; while of the beneficial action of sulphate of lime (which occurs as gypsum, alabaster, selenite, &c.) chemistry has hitherto failed to offer an adequate explanation. If magnesia be needed an abundant source offers itself in the cheap salt, sulphate of magnesia, or Epsom salts, a common ingredient of many mineral waters. The successful results obtained by the agricultural use of this salt suggest a more extended employment of it in conjunction, perhaps, with other manures. Magnesian limestone or dolomite, which contains much magnesia, suggests itself as another and in many places a more readily accessible source of this earth.

Of the remaining mineral plant-constituents the chief are the phosphoric and silicic acids. Chemical analysis has shewn that the available, because soluble, silica of a soil is increased by its exposure to atmospheric influences. Attempts to add solu-

ble silica in the form of an alkaline silicate, as silicate of soda, can hardly be pronounced successful, but better results have attended experiments in which certain natural varieties of sand containing much soluble silica have been employed. But perhaps the greatest amount of information given by the chemist to the agriculturist relates to the necessity for and the sources of phosphoric acid. The bones of the higher animals reveal to chemical analysis a large proportion of phosphates, as well as of nitrogenous animal matter. Burnt, the phosphates remain in the ash or residue, and amount in some cases to 88 per cent. Spent animal charcoal, bones and blood burnt in partially closed vessels, are also rich in phosphates. The various phosphatic concretions known as coprolites, mostly fossil bones, from which much of the carbonate of lime has been removed by the solvent action of water containing carbonic acid, often afford no less than 60 per cent. of phosphates; while the mineral known as apatite, found in abundance in Spain, Iceland, and Norway, sometimes consists almost entirely of phosphate of lime. Sombrerite also, sometimes called Sombrero Island Guano, is another mineral remarkably rich in phosphate of lime, some specimens containing as much as 85 per cent. All these materials demand the aid of the chemist, not only to recognize

them as sources of phosphoric acid, but so to work them up as to present them to the plant in a suitable form. Phosphatic guanos, on the other hand, present the greater part of their phosphoric acid in an immediately available form. Some kinds of sea-sand, rich in remains of shells, contain a small quantity of phosphate of lime and a little nitrogenous matter, and have been largely and successfully employed as manure in certain parts of Cornwall, as at Bude, where a canal, the Bude canal, is scarcely used for any purpose but the conveyance of the sand from the haven into the interior. Let it not be forgotten, however, that in order that phosphatic and other mineral manurial agents may be of avail, it is absolutely necessary, in nine cases out of ten, and except where particular exhaustion of the soil has occurred, to supply a proportionately increased amount of nitrogenous plant-food. To neglect or ignore this is as if an artist, desirous of restoring the colours of a faded picture, were to supply every other tint where needed yet to omit the red. The atmosphere has indeed been computed to contain 60 millions of tons of ammonia, but experiment has proved that the available proportion of this quantity is no more than sufficient for the normal amount of plant-produce; so that if we would push the productive powers of the soil to the uttermost we

must increase the quantity of nitrogen naturally supplied.

It would be beside my present purpose were I further to enlarge on these points; I will only add here one observation—chemical analysis not only finds out what special material is needed in each case, and points to available sources of it, but enables the agriculturist to see that the material offered to him is really what he requires and what it is said to be. It does not indeed require chemical analysis to detect the coarse pebbles and sand added to guano to give it weight, but the more crafty adulterations of yellow loam and salt, and ground coprolites, and plaster of Paris, are not so conspicuous or so readily exposed.

I will detain you but a minute or so longer, while I catalogue a few other points in which a knowledge of chemical facts and principles is of direct value to the agriculturist. Having referred to the processes of the farm, let me now allude to its products.

Chemistry and Vegetable Physiology, going hand in hand, point out to the agriculturist the period in the development of the plant when the fruit—the root—the blossom—the leaves, as the case may be, have attained their complete perfection, and are richest in their essential constituents. They point out the time and the mode of gathering

and of storing these products. Is a new plant or a new variety of some well-known species introduced? Chemistry asks and answers the questions that may be put regarding the relative proportions in the new food of water, of gluten, of starch, &c. A knowledge of these and the other proximate principles of plants enables the agriculturist to mix and suitably apportion the food of his stock, as illustrated for instance in turnips as food for sheep, where the disadvantages of the large proportion of water they contain, 91.5 per cent., may to a certain extent be obviated by the admixture of oat-straw which contains scarcely over 12 per cent., the good effects extending to the land as well as to the animal. In the case of other kinds of vegetable food, chemistry points out the peculiarities which shew the importance of a mixed food. Let me here adduce a curious observation which I confess caused me at first some surprise. Several varieties of beans and peas removed from the pod when quite ripe, lost at the ordinary summer temperature no less than 50 to 53 per cent. of their weight in eight days, and 43 per cent. have been lost in two days. No more loss occurred after eight days, at which period the maximum loss had been suffered. The average per centage of water in dry pulse being 13 per cent., we find that the total per centage of water in fresh mature

pulse is 66: a figure not so far removed from that of some root-crops, from which, owing to the corky layer of their exposed epidermis, the transpiration of water is very slow. I need not point out to you the important bearing which this experiment has upon the storing of pulse; nor that half the money spent in the purchase of beans which have been gathered immediately before their sale is spent in nothing but water.* Nor is the light obscure which is thrown by chemical experiment upon the various after processes to which vegetable products are subjected. For example, chemistry reveals the fact that the inner or second layer of the grain of wheat is richer in nutritious gluten than fine flour, while the thin outer covering may be removed without detriment. To throw away or turn to commoner uses the whole bran, one fourth of the total weight of the grain, is thus seen to be a terrible waste of wholesome food. To understand the important process of breadmaking, an acquaintance with the chemical nature and changes of the various substances involved is absolutely necessary. Such knowledge, it may be said, is useless—but it in fact enables us to explain and correct occasional failures; and it is surely better

* But soon after the seed is ripe it begins to lose water even in the pod, for a small oval opening near the base of the pod (at the proximal extremity of the ventral suture) occurs, and through this the air circulates and dries the seed.

that whatever we do, we should do not by rote, but as reasoning beings.

The analysis of various water-supplies is another important point. It is an easy task for chemistry to determine the water best suited for the various uses of the farm, and to suggest, where necessary, effective modes of purification.

Of the medicinal virtues of certain plants a chemical knowledge of their active principles will enable you to take advantage. In like manner it will detect injurious substances and suggest antidotes. Its importance to a right use of the materia medica can scarcely be exaggerated.

Again, the chemistry of animal products deserves careful study. The constituents of milk as a model food, and the principles concerned in the preparation of dairy produce, of butter and of cheese; the process of curing bacon and of salting and of cooking meat; on all these subjects chemistry throws light. What, for instance, can be more interesting than the following application lately made of Mr. Graham's discovery of "dialysis?" The brine in which salted meat has been steeped contains, as is well known, much of the albuminous and other nutritive constituents of the meat, but mingled with so much salt as to be useless: place the liquid however on the dialyser—float this in a vessel of water—in obedience to their properties

the salt will diffuse away into the outer vessel of water—the albuminous substances remaining in the dialyser, unable to permeate it.

I trust I have said enough of the connection of chemistry with agriculture to shew how necessary is a knowledge of the science before we can safely and surely apply it to our art: that we must know what it is which we are about to apply, before we can apply it: that we must not, in fact, work in the dark. Yet I do not deny that many points are still obscure: that chemistry, because we do not know enough of it, seems sometimes at fault.

Do not think your chemical work dull or dreary: remember that your experiments are in fact questions which you ask of Nature, and be sure that if you are careful to ask the question aright you are certain to get the true answer. The colour will change, the precipitate will form, the gas will be evolved, as the case may be, without fail. Thus you will get some glimpses by small experiments in the laboratory, of Nature's secrets—of the great marvels of the forest and the field.

LECTURE IV.

Gentlemen,

We cannot, perhaps, find a better use for the first lecture of the new session than to look for a time at the general aspect of the work which occupies us in this class. It does not now come before you with the freshness of an entirely new pursuit. Your introduction to the science has already been made, and partially ripened into familiarity, by your attendance on the botanical class last session. Our further labours will be in the same field; we merely pass forward to a different department of it. There would not be space to sketch a satisfactory outline of the main features of the subject, much less to fill in those details which are, for us, its necessary complement, within the compass of a single session. Accordingly, it was arranged that the course should commence in April and terminate shortly before the close of the year. In this we follow the cycle of vegetable growth. The swelling buds and delicate leaflets of early spring are among the first objects which lend themselves to our curiosity: the seasons of flower and fruit

yield abundance of material: and we are carried on by the last stage of the course to a time when the leaves hang crisp and shrivelled in our Beech-woods. But the course is interrupted in its progress by the seven weeks of the summer vacation; and this break in the continuity of the lectures corresponds to a transition in their subject matter. The last lecture before our separation closed a review of the Anatomy and Physiology of plants: the present one opens an examination of Systematic and Applied Botany. The order in which these divisions have come under our notice is not an arbitrary one, capable of being reversed at pleasure. A necessary foundation for the second is laid by the first. No significance can be given to written words before the letters which compose them are recognised, and its due value assigned to each letter. Equally impossible is it to classify plants, or intelligently to examine any plant or vegetable product which may especially interest us, in the absence of an appreciation of the structure and use of their component parts. Whatever may be the special path we intend subsequently to take, through this gateway must our entrance be made.

The first thing that engaged our attention was the microscopical structure of the tissues, and those great facts of cell formation and growth without which Vegetable Physiology would be a

confused and irreducible puzzle. Then, a successive examination of root, stem, buds, leaves, flowers, was the chief business of the course. We saw how each of them was built up; the diverse fashions they assumed; the tasks for which they were fitted; and the various ways in which they performed them. To say that we composed the biography of a plant would be another mode of summing up our studies, in a single expression. The embryo, with its tiny radicle, plumule, and cotyledons, was the starting point. Launched into the world it gradually shapes and uses the instruments by which it wins, from earth, air, and water, materials to be worked up after the pattern of its parent. To the organs on which its tenure of life depends, it adds the crown and completion of its work, the flower; and finally completes the circle by wrapping up in the seed a transcript of its own earliest form. Not that we followed the life and fortunes of one particular species. The subject of the biography was rather an ideal plant, a type to serve as a standard round which might be grouped the varying forms actually found in nature.

Equipped with this knowledge we now advance to the study of Systematic Botany, whose business, in its largest sense, is to describe and arrange all the kinds of plants to be found on the earth. "Divide and conquer" is its maxim; for it is only

by methodical arrangement that our limited capacity of simultaneous perception can grapple with the teeming multiplicity of the vegetable world. Our political geography furnishes a somewhat rough analogy. One or more townships form a parish; an assemblage of parishes constitutes a county; the counties by their aggregation make up the kingdom, whose area is completely covered and mapped out by all these divisions taken together. In like manner, the ascending series species, genus, order, class, sub-kingdom, forms an exhaustive classification of the entire vegetable kingdom. Nor will Systematic Botany become a closed science until the species of all climes have been thoroughly described, and the scheme in which they are enrolled be marshalled in so perfect a manner that the position of its members, in regard to nearness or remoteness, shall be precisely measured by the intensity of their likeness or unlikeness. A glimpse of the extent and population of this region may be caught in the fact that there are about 150,000 known species of flowering plants; a number which at once suggests the thought that no one can attain to more than a very limited acquaintance with so vast a territory. But it is plain that the two departments of Systematic Botany—the description of particular species, and the method of their arrangement—may

be made distinct and separate objects of study: and while it would be in vain to set about the task of a complete knowledge of the first, the general principles of naming and classification, and the characters of the chief groups resulting from their application, may be mastered with comparative ease. In truth they must be so mastered before the student ventures further. They form the outline map of the country, on which are laid down the great natural divisions and landmarks. It is in Special Descriptive Botany that a selection must be made. When we are in possession of the preliminary chart we need only to fill in minutely those portions of the domain in which our business or pleasure may give us a special interest. At this point therefore the various lines of special study and research diverge. Some men will concentrate themselves on the investigation of a particular group of plants, while others aim at a thorough knowledge of the Flora of our own country; some will examine medicinal plants, and others busy themselves about those whose products are of economic value. To us a different sphere is allotted; by us the greatest stress must be laid on the plants and vegetable structures which concern the art of agriculture.

These considerations give shape to the following part of the course and point out its plan. Our

attention will be first directed to the general principles of Nomenclature and Classification. Giving a passing notice to the Linnæan or Artificial System formerly in vogue, we shall take as the basis of our arrangement the Natural System, and travel through its classes and most important orders, successively examining their characteristics. A framework will thus be constructed on which to hang our knowledge of details. Under each order we shall examine the Species and chief varieties which are the subjects of field cultivation in any part of the kingdom; the trees (noting also the peculiarities in the structure of their wood) and shrubs which form our woods and hedges; the wild plants which, taking up their residence in fields and meadows, specially interfere with their cultivation.

In seeking to determine the bearing of Botany, studied in the way just indicated, on agriculture, we must avoid the confusion of speaking as if all the branches of the science bore, indiscriminately, the same relation to the art. The difference in method and matter between the Anatomy and Physiology of plants on the one hand, and Classification and Description on the other, yields a corresponding diversity in their application to agriculture.

To most questions relating to the vegetable

world, which commence with "How?" or "Why?" it is the province of Structural and Physiological Botany to respond. Within its sphere come all inquiries which have to do with the laws governing plant-life; the processes in which that life is occupied; the varieties in growth and action which follow from peculiarities of structure or changes in external conditions. Its function is to sum up and criticise the results of observation, to eliminate extraneous elements, and to recover the true line of cause and effect. That such a science stands in the most intimate relationship to the theory of agriculture is implied in its very name. The land under cultivation in this country is, in truth, a gigantic experimental garden, and the rational interpretation of the results it presents belongs in great part to vegetable physiology. Thus the recent generalization of the great process of natural selection—the battle of life among plants or animals—finds a most apt illustration in the altered distribution of grasses which may be induced by varying the conditions of cultivation. And in the solution of many problems of the greatest interest this science must largely share. Such are the phenomena of clover-sickness, the finger-and-toe disease, hybridisation, the influence of pedigree in cereals, the wider question of the exact kind and degree of qualities transmissible through seed.

In many such fields of research neighbouring sciences as it were overlap each other. It is true that rigid definitions may be framed of the respective stations of Chemistry and Botany; but the world of nature shews us a large tract of borderland over which they both range, though entering it from different sides. Take as an instance a chemical fact incidentally mentioned to you by my colleague the Professor of Chemistry. It is well known that flour made from the entire grain yields, on analysis, a larger proportion of nitrogenous material than when the external portion of the grain has been previously removed. Now a botanical examination of the microscopic structure of a cereal grain shews that its internal portion consists entirely of cells filled with starch granules; while, just under the integument, there is a minature wall of dark-coloured brick-shaped cells containing gluten. Thus the two investigations, independent in method, are identical in their conclusions; either result might have suggested the other. The sister sciences should accordingly address themselves to their common problems hand in hand, aided by the great storehouse of facts accumulated by agricultural experience. Liebig's latest work, "The Natural Laws of Husbandry," in spite of its blemishes, has at least this positive value; it is an earnest and emphatic inculcation of the truth

that it is on a combined study of Chemistry and Botany that theoretical agriculture must rest.

But the relation of science to practice is only half expressed by saying that it systematizes and explains the results of observation and experiment. Not only is it an interpreter, it is also a guide. Under its teaching older operations are rejected, or confirmed and simplified, or entirely new modes of procedure devised. There is no rivalry in the swift progress of Science and Art; their movement is one of reciprocation. They play, as has been well said, at leap-frog. Now one is in advance, now the other; alternately giving and receiving aid.

Vegetable Physiology has not perhaps, in later days, gained any conquest in the domain of agriculture so direct and brilliant as that won by Chemistry in the introduction of super-phosphates. In truth the share that she has had in improving the art is more adequately represented in the investigations of scientific agriculturists than in the writings of professed botanists. Many of these researches are in substance, though not in form, applications of Vegetable Physiology. Observant men have built up for themselves, often unaided by technical apparatus, fragmentary inductions which, when reclaimed and harmonized, are seen to be integral

parts of the science; and have drawn happy suggestions and fruitful inferences from their study. It was by speculations and experiments in Vegetable Physiology that Jethro Tull was led to the invention of Drilling. No man in our own country ever did more, single-handed, for the practice of agriculture than that solitary thinker, isolated by "long confinement within the limits of a lonely farm," and battling with the infirmities of "a life that has been a continued sickness." And assuredly no man ever strove more eagerly than he did to give a life and meaning to every detail, by tracing the phenomena of growth and cultivation up to "the principles which," in his own words, "by arguing from effects to their causes, I had formed to myself." Many of his conclusions are but partially true; a few, positively erroneous. Nevertheless, by sheer force of mental grasp and insight he clutched, as it were, in the early dawn of the science, at fragments of truth which increasing light has shewn to be key-stones in the fabric.*

* *Tull's Husbandry, Appendix of Notes to the Preface.* —If care be taken to give that larger signification to various words, such as "particles of earth," which he evidently assigns to them, many of his views will come much closer than is sometimes thought to those of more recent times. This excess of meaning, so to speak, has long since deserted these words, and found a more appropriate home in special technical terms. The quaint doctrines regarding the food

What, then, follows from these considerations? Clearly, that science is of direct and large importance to agriculture; but not necessarily that it is of direct advantage in the education of the individual student of agriculture. Largely indebted as the art is to the relative sciences, it still ranks as one which, in much of its growth, has anticipated them, and whose daily routine is in least immediate kinship to them. Even when an art owes its very existence to previous scientific discoveries, it does not follow that its skilful practice is dependent on a corresponding knowledge. The sciences of electricity and magnetism created the art of telegraphy; but the telegraph clerk may signal with the utmost nimbleness and precision without the slightest acquaintance with these sciences. The few comparatively elementary observations and calculations by which the navigator guides his course are based on astronomical tables constructed for him. He does not need, in order to be expert in his craft, to know the depth and extent of the scientific foundations on which his data rest. May not a student of agriculture, in like manner,

and growth of plants and their ultimate dependance on Comets, of "that miracle of a man, Sir Isaac Newton," with Tull's equally quaint, yet destructive criticism of them, shew very strikingly the infancy of the younger sciences when the elder sisters—Mechanics and Astronomy—had almost reached their full stature.

waiving all ambition of ranking among the pioneers of improvement, but accepting the results furnished from time to time by scientific men, content himself with the acquisition of the knowledge and skill absolutely demanded by the art?

The very possibility to any one of such a course, may be taken as a sign that for him it is the best. Our business, however, in this place is not with such men. Many of you have been drawn hither solely by the scientific training which this College affords; and it may be safely assumed that for any man of liberal culture and animated by the higher mental instincts, to travel blindly along his path in life is an intellectual impossibility. He cannot remain indifferent to the deeper working of the machinery which environs his daily occupations. Moreover, a very weighty qualification has to be appended to what has just been said. Among the useful arts, that of agriculture is one furthest removed from the possibility of a reduction to a simple code of rules applicable to all exigencies. The endless varieties of material, changes of condition, diversities of operations or of opinions, leave a very wide margin where keenness of observation and accuracy of judgment will find abundant scope. And it is certain that the vanguard, in point of skill and success, of British agriculturists, is formed and always will be formed of those

who, in addition to the habits which constitute the indispensable elements of success, are gifted with the most open eyes and the most active and enquiring minds. A scientific training initiates and fosters this spirit. It furnishes, in a short space of time, a store of knowledge, accurate and in orderly arrangement, which will be helpful in a thousand ways, directly and indirectly, in years to come.

Let us now continue our enquiry by turning to the second great division of Botanical science. The aim of Descriptive Botany, and consequently the relation in which it stands to an art such as Medicine or Agriculture, is of a different character from that assumed by the former branch. It has nothing to do with reasons, with laws, with processes. Its office is a less pretentious one. It lends itself as a handmaid willing to describe and define any vegetable structure which may be placed before it. Now there are a number of plants and botanical products which it is necessary that a student of agriculture should learn, as quickly as possible, to recognise and distinguish; and hence the help which this branch of the science gives is direct and immediate. A knowledge of Grasses, or of the structure, habits, and uses of Timber-trees may be cited as instances. But the subject of Seeds may be taken for more particular mention.

It is clear, at the outset, that an accurate acquaintance with the seeds he sows, ability to distinguish them and to detect substitution or adulteration, has a very palpable bearing on the interests of the sower. This ability is usually left to be acquired empirically in the course of time. By constant practice the eye becomes habituated to the colour and general appearance of a particular kind of seed; and gradually the power is gained of distinguishing it from others which it may resemble. But such knowledge is always partial and usually open to fallacy from accidental differences in size or colour; nor can it be taught. At best it has been learned in a roundabout and tedious manner. Its uncertainty is illustrated by the lawsuits which have occurred regarding Sainfoin mixed with Burnet; and the instances, not infrequent in this neighbourhood, where Lolium perenne, or Italicum (Common and Italian Rye Grass) has been sown largely mixed with Bromus mollis (Lop) to the great loss of the sower. Indeed in the case of many grass seeds it is quite impossible to gain the power of discrimination in the ordinary way. The rational method is evidently that which is adopted by the botanist. He examines carefully and fully the individual seed. To size, colour, or any prominent peculiarities he gives their due value. In fact a

knowledge of seeds acquired empirically is merely the apprehension, consciously or unconsciously, of a few characters of this kind belonging in reality to Descriptive Botany, but which the needs of their position have forced men to acquire. The variations of these characters in different samples are then determined. But, in addition, the educated eye finds indications of structure and significant markings which escape the notice of the unscientific observer, but may serve to distinguish the seed in the most certain manner. In this way seeds of Medicago lupulina (Nonsuch; the "Hop Trefoil" of the South of England) may be readily picked out from seeds of Medicago sativa (Lucerne) of equal size. In short such a knowledge, just because it is clear, methodical, and complete, is acquired more quickly and more easily retained. It is singular that while full descriptions, in other respects, of cultivated plants are extant, many Seeds of great interest in agriculture have been left undescribed or insufficiently described in botanical literature. For this reason, as well as on account of its intrinsic importance, your attention will be specially directed to this department.

Besides supplying, in this way, information of immediate value, Descriptive Botany has the further merit of rendering good service, when studied aright, as a mental training. It demands the active

exercise of the faculties of observation and discrimination; for, on the one hand, minute differences have to be accurately noted, and, on the other hand, points of essential analogy to be seized, amid variety of form. And in embodying its results in language, precision and neatness of expression are essential requisites, as well as that ready and familiar application of technical terms which can only come from a full appreciation of their force and appropriateness. The development of intellectual habits such as these, is of itself a result not unworthy of much labour. Moreover they have a peculiarly utilitarian value in a profession where much of the difference in individual skill depends on the capability of discerning minute shades of difference imperceptible to the less sensitive or less completely educated eye.

Two observations regarding the right mode of studying our subject here suggest themselves; both of them very obvious, but not the less needing our attention.

The first is that we should learn Botany as far as we can by direct personal observation. In all places where there is much reading, lecturing, and examination going on, the memory for thoughts and words is greatly stretched. A passive acquisition of knowledge by reading or listening is indeed, in some studies, the only available

method. But it is far otherwise with the Natural Sciences. As their materials were originally collected by the senses, so it is on the evidence of his own senses that every student, repeating the process, should base his knowledge of them. To Botany this latter character belongs in an eminent degree. It appeals most strongly to the eye. Much of what meets us in its study must, it is true, be mastered by verbal memory; and the laws of nature are only visible to the eye of reason. But the broad groundworks of the science, the facts of which these words are only the expression and these laws the generalization, ask from us our individual confirmation of their truth. Hence the advantage of a garden, museum, diagrams, and supply of specimens for lecture, which, however, can only serve as a stimulus and guide to personal work. We should accordingly make the memory of the eye a substitute for, or supplemental to, the already overtasked verbal memory. It may perhaps seem easier at the time to read a few sentences than carefully to verify the description they contain. But the economy is an unwise one. Of all those memories which, like garners, lie behind the outer senses, that of the eye is the most distinct and permanent. Largely, too, is its power multiplied by association. The triple chain of Hand, Eye, and Mind is the strongest. Handle, scrutinise, and think over any

object, and you will unconsciously shape for yourself a picture of it which will keep its place without effort among the mind's furniture, and may swiftly be revived with its outline undimmed and colours unfaded, when your remembrance of the contents of some paragraph or page has become blurred and hazy.

The other remark has a somewhat wider application. If our knowledge of Botany is to be any other than a wavering and uncertain instrument to whatever use we may wish to put it, it must be marked with thoroughness and accuracy. Not that it is needful to master a science in its integrity if we wish to avail ourselves of any part of it. We are not only at liberty, as we have seen, to make a selection, but the wide range of Botany even compels us to do so. Still the essential preliminaries, the chief facts and terminology, must always be carefully examined and appropriated. It is in vain to overleap them; to proceed to applications with a vacillating elementary knowledge; to seek, by a sort of misplaced intellectual parsimony, to pluck the most attractive fruit, unpurchased by any antecedent toil. The result is invariably a crude and misty style of thought, speech, and writing. For we cannot sever with impunity particles of knowledge from their natural connexion: the crystal itself is broken in the

endeavour to dislodge it from its matrix. The mirror that we hold up to nature must have the clear and uniform surface that gives a truthful reflection; if eked out by fragments of broken glass, the image will be distorted and discontinuous at every joining. Nor is it always true that the more we learn the more we have to remember. A deeper knowledge often renders that which lies nearer the surface more compact and portable. We do not add to the weight of a load of tools by having a wheelbarrow to carry them.

We have now completed a survey of the position occupied by Botany in the higher agricultural education; and have seen the modes in which the science is helpful to us. It teaches much that is directly useful; and from its study there must accrue to every one some benefit in the way of sharpening the senses and enlarging the mind.

The communication of a sound knowledge of the principles and method of Botany, and the details of its application to some special department, is all that can be attempted in a course of lectures. But I cannot allow this opportunity to pass without endeavouring to point out the dignity and value of the science in and for itself. Permit me, accordingly, a reference to some considerations based on a retrospect of the work of last session, which may serve as inducements to a wider study.

Consider first of all the great spectacle of adaptation of means to ends unfolded by the science, and the enjoyment to be reaped from its contemplation. So apparent, in truth, are many instances which suggest it, that to speak of the marvellous display of contrivance, adaptation, arrangement, harmony, design, spread before us in the vegetable world, is a well-worn commonplace. But the more we widen our horizon and the more dextrously we uncover the less obvious portions of Nature's mechanism, the keener and fresher does the pleasure become. It is at once a stimulus and a reward of the purest kind. We are finally led to sum up what is indicated by the more vague and metaphorical terms just used, in some generalized expression, such as the law of Teleology. But it is in vain to try to exclude all words which seem to imply too much the ingenuity of a finite artist working up to a foreseen end. The analogy with our own mode of planning and accomplishing is so instantaneously recalled, that there is no form of words into which we can put the general fact demanding expression, which will not wear the colour more of an inference than a simple statement.

Various ranges of correspondence are seen rising as it were above each other, tier after tier. Thus the physiological unit, the vegetable cell, stands

in the first stage, when viewed as an end to itself, as living for itself. Here too come those cases of direct relation, whether of a cell or of a higher organ, to the influences acting on it; the root finding its way through the soil, the tendril clinging to its support. The correspondence is a product of external conditions on the one side, and the capacity of being moulded by them, the innate pliability of the living structure, on the other.

But the cell is a member of a community and lives for others as well as itself. Each cell is the centre of a series of ever widening circles; and the production of a harmonious result depends on the precision with which the circles vibrating from different centres intersect each other. An organ often has functions which have no meaning except as referring to something distant in space or remote in time. The Medullary Rays, after their own growth is perfected, serve as channels of communication between the pith, annual rings, and bark; and also perhaps act mechanically in binding the rings together, forming, so to speak, the woof of the stem. But, in addition, it has been more recently shewn that the cells of which they are constructed, elaborate and store up in their interior, during the autumn, a reserve of starch or similar material, which is yielded to the rising current in spring, and devoted to the evolution of

the buds.* Hence the prospective arrangements in deciduous trees during the decline of the year are twofold. Not only are the rudimentary leaves and undeveloped shoots laid down and clothed with protecting scales, but a supply of food is elsewhere accumulated sufficient to carry them forward, on the return of spring, from the condition of consumers to that of producers. This last correspondence is of a more subtle character than those of the first grade.

In like manner two organs, such as stamen and pistil, nourished by the same liquid and incapable of influencing each other, have their growth graduated as it were in view of a future action; when the maturity of the pollen globule will synchronize with the readiness of the ovule. So also in more special adjustments of the same kind. The brush-like style of the Hare-bell stands in the unopened flower on a level with the surrounding anthers; and its rushing growth upward, as the flower expands, comes not a moment earlier than the dehiscence of the anthers; else the stigmata would not be pollenized.

Still higher are those instances where, from

* These results are due chiefly to Hartig, Schacht, and Hanstein; whose researches promise to solve at last the problem of the Circulation of the Sap, and to explain the apparent anomalies of previous observations and experiments.

peculiarities of position or structure, pollenization* could not be effected without the intervention of insects. We watch with corresponding interest the gradual convergence at the right time and place of agencies so different and remote.

Sometimes we come across more isolated instances of a relationship between plants and animals, in the shape of structures which, Janus-like, seem to look two ways. A curious case of this kind came under the notice of Mr. Darwin,† in regard to a species of crab which lives on some islands where the Cocoa-nut palm flourishes, and is provided with a front pair of strong and heavy claws and a hinder pair of narrower and weaker ones. On the one side is the Cocoa-nut, with its bony endocarp covered by the husk and marked at one extremity by three circular spots, dark-coloured and soft, which are placed opposite the position of the embryo plant, and serve for the exit of its rootlet in germination. On the other side

* The terms "Pollenize" and "Pollenization" embody, I think, with brevity and precision, an important act or state which we are at present compelled to express by a periphrasis such as "the application of pollen to the stigma." The word Fertilization is already sufficiently ambiguous; since it is employed, in a stricter sense, to indicate the action of the pollen-tube on the germinal corpuscle; and, in a more general sense, includes Pollenization, Fertilization proper, and all the intermediate stages.

† *Journal of a Naturalist.*

is the Crab, commencing at the right end of the nut, picking away the fibrous husk, and hammering with its front pair of claws through the dark spots which now serve for the entrance of the narrower pair, and the withdrawal piece by piece of the albumen.

Correspondences such as these which run obliquely between the animal and vegetable kingdoms, are perhaps more unexpected than any degree of co-ordination between the elements which compose either group. We are startled by the sight of these outriders shooting across from one of the two great processions of life to the other, and falling appositely into places left vacant for them.

Another set of arrangements is disclosed by the general history of a race of plants, which is missed when we consider only the placid course of an individual towards maturity. All that set out on the journey are, it is true, fully equipped for reaching, under favourable conditions, the goal. But the domain through which they travel is occupied by forces which at one time support, but at another time may destroy them. The plant population of the world has its Vital Statistics; and the provisions made for ensuring the preservation of the race, almost foreshadow the labours of the actuary. This end is secured by a wise prodigality of individual life. Glance for a moment at the history

of a flowering plant, commencing with the pollen globule. These globules are produced in enormous numbers, but only a very small fraction of them successfully bridges over the gap which separates them from the stigma; the rest are lost. Not every globule that reaches a stigma sends out a pollen-tube which arrives at the germinal corpuscle. Half only of the germinal cells (assuming two as the usual number in each embryo-sac) develope into embryos. Nor do all fertilised ovules grow into perfect seed; for, as in the acorn, one may outstrip its fellows in growth and render them abortive. Then come the fatalities attendant on the early life of the young plant after it has left its parent; the casualties from atmospheric influences, unsuitable soil, or the appetite of animals. The seed may never germinate; or the plant may be destroyed before reaching maturity. And thus each generation which arrives at the point whence it started is the scanty residue of a vast host which has been decimated at every step in the advance; and if we could measure the adverse influences meeting them at these stages, we could calculate the Chances of Survivorship. Note also that the number of ovules is not apportioned to the pollen-globules produced in the anther, but is always very much less. "Nature is a careful steward."

But the aspect at which we have hitherto been looking is not the only one. The law of Use is neither wide enough nor deep enough to embrace all that we can learn. The notion that a plant is a machine, all whose parts work with nicety and harmony towards such ends as the well-being of the individual, and the continuance of the race, is not an exhaustive one. There are structures which are of no use in the ordinary sense of the term; organs which have no function. The fifth stamen in Pentstemon, for example, is in one sense a failure. A filament with a tuft of hairs on its thickened summit; it is not only meaningless but a positive waste of material. And what can we make of those curious structures, half stamen half petal, which are so often formed in cultivated Tulips? They are unintelligible distortions.

The fault, however, lies in our own point of view; the design seems imperfect because we have only watched the coming to the surface, in one direction, of a deeper law. This second generalization does not abolish the first, but absorbs and includes it. So soon as we take our stand on the law of Homology (using that word in its widest sense) harmony is restored. Everything now has a significance; even little shreds of structure which before were quite unintelligible. The rudimentary stamen of Pentstemon becomes

a beautiful illustration of floral symmetry; the abnormalities of the Tulip a proof of the formation of the flower on the type of the leaf. Nor need we resort to aberrant forms only for an example of this latter doctrine, for the fringed sepals of a Rose-bud will teach the same lesson. Of the five calycine segments, the two outermost bear the processes on both edges; the next one, half exposed and half concealed in the bud, has them on one side only; while the margins of the two inner ones are entire. This arrangement has been expressed with more vivacity in a somewhat doggrel couplet, written I know not by whom or how long ago. The third segment speaks:—

> Quinque sumus fratres, unus barbatus et alter,
> Imberbesque duo; sum semiberbis ego.

Now it is easily seen that the series constitutes a transition from the ordinary pinnate leaf of the Rose to a sepal of the usual form, though the extremes have so little superficial likeness. The appendages on the two outer segments represent leaflets; in the next one they are partially retained, while the two inner ones correspond to flattened petioles only.

Again—not only are there structures which we can only represent to ourselves as reminiscences, or prophecies of a Pattern or Ideal Type, but modifications for more obviously utilitarian pur-

poses, or adaptations to external conditions, instead of annulling the Type are superinduced on it. Allow me to point out a very simple example occurring in the raceme of the Laburnum. In the general Plan of a Leguminous flower, the odd sepal is inferior; and the odd petal, in accordance with the law of alternation, is superior, or nearest the extremity of the axis from which the flower grows. And this arrangement seems also to agree with the position which would naturally be assumed by the parts of a Papilionaceous corolla when floating in the breeze; for the Standard is uppermost, the Wings lateral, and the boat-shaped Keel lowest. Now the keels in the raceme of the Laburnum ride on the air as usual; and yet, since the raceme is pendent, it is clear that the typical position of the parts must be reversed. But if we examine the flowers in the condition of bud, we shall find that they are still faithful to the original type. Subsequently they are turned round by the stalks becoming gradually twisted; and it seems to me that the torsion commences earlier than can be explained by the action of the wind.

There is but little in the workings of Vegetable Life likely to suggest the use of mathematical symbols for its expression. The rigidity of a mathematical formula seems very alien to the characteristic plasticity of a living being; and yet it

is found that such a mode of expression is very applicable to at least one set of appearances in this field. In regard to very many plants it has been satisfactorily determined that their leaves are arranged in a spiral which can be expressed by a fraction, the denominator of which indicates the number of leaves contained in each cycle, and the numerator the number of turns round the stem the spiral has to take in order to include all the leaves of the cycle; while the entire fraction signifies the distance in parts of a circle at which each leaf is set from its predecessor and successor. But further, when the different fractions obtained in this way are compared, they are seen to form a regular series with definite properties. The numerator of each fraction is equal to the sum of the two preceding numerators; the denominator, to the sum of the two preceding denominators; and there are no intermediate members. Since each fraction represents the leaf-arrangement of a certain number of plants, the Vegetable Kingdom might conceivably be thrown into a set of classes corresponding to the members of the series. But while the typical leaf-arrangement seems to be constant in the same species, it does not conform to and accompany any of the general characters on which higher groups are founded; and thus each of the supposed classes would contain plants

differing in every respect but one. So that in spite of the symmetry and completeness of the series, it is still a fragment incapable of being brought into relation with any known line of cause and effect, or of being used for purposes of classification.

The singularity of this appearance of mathematical relations in a region so unlike that over which they usually reign is heightened by a coincidence which has lately been noticed. "Upon comparing this arrangement of the leaves in plants with the revolutions of the members of our solar system, Pierce has discovered the most perfect identity between the fundamental laws which regulate both;" by which is meant that the series of fractions which indicate the ratios of the times of revolution of the planets taken in order is identical with that which has just been described.*

Truly, if this be so, we may perhaps be pardoned for asking the prosaic methods of ordinary science to stand aside for a moment, since they are entirely silent in the presence of this strange resemblance and can only register it among outstanding and unexplained coincidences. Does it not almost seem as if they had unconsciously constructed a

* Agassiz, Essay on Classification, p. 193; where tables are given and some remarks made in reference to the apparent discrepancy in the case of the Earth.

new Astrology, and vivified the traces of her ancient lords which still linger on the carpet of the earth? For Mercury when departing left an image of his familiar cap in the thatched capsule which gives its very name to Polytrichum formosum ($\frac{1}{3}\frac{3}{4}$); the fragrant Orchid, Gymnadenia conopsæa is no unfit emblem of Venus ($\frac{8}{2}\frac{}{1}$); the dusty livery of the Earth is still worn by the lowly road-side Plantain; Convolvulus tricolor carries the standard of Mars ($\frac{5}{1}\frac{}{3}$); White Lily shoots prefigure the Asteroids ($\frac{3}{8}$); King Jupiter has put his own mark on his vicegerent in the forest, the Oak ($\frac{2}{5}$); "grey-haired Saturn" broods over the gloomy Alder ($\frac{1}{3}$); the Iris is assuredly the messenger of Uranus ($\frac{1}{2}$); and remote Neptune, long unseen, perchance is symbolised in that strangest of plants, the newly-found Welwitschia. Could the chain be more complete or the links between the respective Plants and Planets be more evident?

After thus indicating one of the chief lines of thought along which a student of Botany will naturally be carried, any further criticism of the genesis and exact scientific value of the two general conceptions illustrated, would be beyond my present purpose; since they have been used simply as frames for holding up the science to view and shewing that it contains much that is fitted to engage our highest thoughts.

Enough has also been said to suggest that a characteristic value attaches to Botany in common with the entire group of sciences which are concerned with the past and present manifestations of life in both its forms on the surface of the globe. Standing at the opposite pole to Mechanics and Physics, Biology introduces us to phenomena of so different a character as to call up an entirely new set of conceptions. Hence it forms an indispensable element in the higher education; for without some knowledge of its results, and insight into its method, our thoughts concerning the great world around us must be narrow and one-sided. Aristotle, the founder of Zoology, urges this view with remarkable earnestness and force in a comparison which he draws between the Abstract Sciences on the one hand and the Sciences of Life on the other. He speaks of the "inconceivable delights" which the contemplation of living nature offers to all thoughtful men; rebukes a "childish aversion" to minute anatomical research; and vindicates for such studies a high position as revealing in their objects, in place of a superficial attractiveness, an interior beauty seen by the reason.*

We are thus led in conclusion to give a passing notice to one of the indirect advantages of botanical study.

* Aristotle, De Part. An. I. 5.

It is true that a more intense and personal interest is felt, the nearer our enquiries approach the position occupied by Man himself; and for this reason a wider interest will always centre on the higher walks of Zoology than will be accorded to the more tranquil paths of botanical research. But, in return, a greater external charm belongs to the latter. They lead us among objects which not only present nothing repulsive to the senses, but are directly fitted to sustain and increase the higher Sense of Beauty. In all times men have lingered over the graces in form and colour of stems, leaves, flowers, and fruit. The reality and width of this appreciation will be evident to any one who will consider how great a blank would be made if the charm of all Plant-life and of its manifold reflections in Art were suddenly to vanish; and illustrations of the force with which vegetable forms impress themselves on the imagination might be endlessly multiplied from the nobler creations of Sculptors, Painters, or Poets, or from the ruder transcripts of nature on almost every work of man's hands which is susceptible of ornament.

But a specific set of instances taken from the decorations with which the builders of Palestine, Egypt, Greece, and Britain crowned the columns they set up, will shew more pointedly how naturally the vegetation of a country lends a physiognomy to its art.

When Hiram of Tyre, the cunning workman "skilful to find out every device," came up to Jerusalem at the bidding of Solomon, he made "nets of checker work and wreaths of chain work" to hang on the two pillars, Jachim and Boaz, that were to stand in the porch of the Temple; with "a hundred pomegranates to put upon the chains." "And the chapiters that were upon the top of the pillars were of lily-work." In like manner the granite columns reared by the ancient Egyptians are often surmounted each by a group of nine pinnatisect leaves of stone, the very counterpart of the feathery coronet on the summit of the Date-Palm; or it may be by flowers of Nymphæa Lotus, or heads of Papyrus: and in addition, Dr. Seemann has surmised that the swollen stem of the Deleb-Palm of Nubia is the prototype of the bulb-like shafts so characteristic of the valley of the Nile.* Again, one of the most elegant creations of Grecian art, the Corinthian capital is an imitation of the foliage of the Acanthus, and was suggested to Callimachus, as the story goes, by the sight of a neglected basket round which the plant had clustered, its leaves curling back against a tile which happened to cover the basket. And finally, in our own island, carvings like those in the cloisters of Melrose Abbey, which have perpetu-

* Journal of Botany, April, 1863, p. 104.

ated, and by their sturdy adherence to literal truth have even ennobled, the cabbage leaves that grew in the monastic garden,* bear independent testimony to the same impulse.

Accordingly, so deeply rooted a feeling ought not to be left entirely out of account among the accompaniments of botanical work; for although not directly concerned in the study it will be fostered by it, and may become both a pleasant and helpful auxiliary and a source of quiet and healthy enjoyment. Scientific knowledge will not mar it;

"That which we call a rose,
By any other name would smell as sweet."

On the contrary, the field for its exercise will be indefinitely enlarged by increase of knowledge. And assuredly the beauty of an organ is not dimmed but rather illumined and spiritualized when we see in it an adaptation, a correspondence, an analogy, an ideal type. The touch of something beyond merely material grace lifts it into a higher region of thought and feeling.

I must now leave the further prosecution of the higher departments of Structural and Physiological Botany to the individual study of those whose tastes may lie in this direction; heartily commending it to your earnest attention.

* The Oxford Museum (Acland and Ruskin), p. 83

LECTURE V.

Gentlemen,

I have to make a few observations to-day on the advantages to an agriculturist of a knowledge of Veterinary Science. The introduction of Lectures on Veterinary Surgery into the College course is a primâ facie evidence that, in the judgment of the Council, a sound acquaintance with the principles on which the growth and maintenance of the bodies of animals depend is a desideratum in the acquirements of those whose future profession will be the cultivation of the soil. Of course it will be readily granted that all scientific knowledge, if of a sound character, is not only instrumental in forming the intellect of youth but also worthy of attainment for its own sake; and what is generally true of all science is particularly so of that one on which I shall have the honour of lecturing to you. It has a special place in the education of the agriculturist; tending to form in him habits of observation and attention to circumstances often of the most trifling kind; fostering a taste for direct contact with stock and careful

observation of their various peculiarities; pointing out the necessity not only of a general acquaintance with domestic animals but of such an attention as is only to be acquired by handling them, watching their movements, comparing one with another, in fact becoming thoroughly acquainted with them as almost members of his family.

And let me observe that this is not merely one of the *results* which a study of Veterinary Science secures; you cannot *commence* the study without also commencing these most beneficial habits; at the very threshold this kind of attention will be demanded of you. And to shew that I am making no extravagant pretensions for Veterinary Science I would ask you to follow me whilst I state in order the several branches into which the science is divided, and endeavour as I go along to point out the direct and indirect benefit to be derived from a study of each.

The College course wisely prescribes Anatomy as the subject for your introduction to the science, and this comprises a study of the frames of all the domestic animals, of their organs and their actions. You will have fully explained the several parts of the skeleton; the arrangement of the muscles, veins, arteries, and nerves; the situation as well as the anatomy of all the organs, such as the eye, teeth, stomach, lungs; all being illustrated

by a beautiful collection of anatomical preparations now in the College Museum, purchased at a considerable expense by the Council for your benefit.

And to a reflective mind do not my introductory remarks seem in a measure borne out? How full of direct interest and use to the agriculturist must be the formation of the skeleton, the relative sizes and positions of that framework on which the flesh of the animal is suspended, and on the judicious covering of which much of the success of the fattener of cattle must greatly depend.

Is it not an advantage to one whose eye will be called upon to detect faulty forms, deficiencies as well as perfections, to know the exact position of every bone, the direction of every muscle, and the normal size of each? Is not your judgment of the various parts of the horse, ox, and sheep, and indeed of every domestic animal, likely to be materially affected by having your attention directed to these studies from the commencement to the end of your educational course here? I know no better training for him whose aim in after life may be either to improve his stock or keep his stock up to a certain standard, a thing only to be done by painstaking and minute comparison of all the points of stock, than an early study of Anatomy.

And, again, it is not easy to over-estimate the importance of the knowledge which many of you may acquire, if by an earnest study of the beautiful collection of teeth in the College Museum, you are enabled to tell the ages of various stock, especially when, as at present, early maturity of frame causes, as we should naturally suppose it would, a premature development of teeth. Nor does it need much reflection to see the importance of knowing the age of the horse by an examination of his teeth: except in a few rare instances, the several stages of growth have such marked peculiarities that there is little difficulty in recognising the appearances of the mouth indicative of certain ages; and therefore you may consider that in the ample collection of horses' mouths in the Museum you have the normal type of each period, from the earliest youth to mature age, and thus have brought under your notice an amount of knowledge with regard to the dentition of the horse which it would take any man years of observation to accumulate for himself.

And if it be true that a knowledge of Anatomy is so valuable to an agriculturist; scarcely less so is a certain acquaintance with Pathology and Therapeutics. What more serviceable to any one whose prosperity in a great measure hinges upon the healthy development of stock, than to have

some acquaintance with the origin of disease, its course and its termination, and to have sound views as to the principles upon which the health of stock depends?

It is quite true that no knowledge of Pathology will give a man power to secure an immunity from disease, any more than it will enable a skilful practitioner always to cope with it; but it can furnish him with the principles of health, from a careful attention to which great benefit must arise. Take, for example, several of the complaints of the foot—a sound knowledge as to the normal condition of health in this part will enable any intelligent man to do much in the way of preventing lameness. It is no exaggeration to say that many a horse is lamed by bad shoeing. During that necessary operation the ignorant blacksmith not unfrequently carves away the horny sole to such an extent that the sensitive parts of the foot are left unprotected; the horn thus removed will not be reproduced for several weeks, and during this interval bruises and other injuries may occur to a serious extent. Now you will be taught that the part of the foot which has thus engaged the sedulous attention of the blacksmith, even to its destruction, is necessary to the foot in its normal state of health and usefulness; and that good shoeing should remove no more of

the horn than is essential to preserve the natural bearing of the foot on the ground.

Again, from an acceptance of the principle that the normal condition of this horn is hard and such as to minister to the support of the horse's body, a natural inference follows, that all those circumstances which produce softness and sponginess are to be guarded against; and so thrush, which generally arises from the horse standing continually on dirty wet litter, weakening its foot, and causing the frog to become soft and spongy, is obviated. Grease, again, being the effect of the continued application of moisture to the skin succeeded by evaporation will be guarded against by careful stable management. Many of the diseases of the eye, resulting as they do from improperly ventilated and badly cleaned stables, in which the dung being allowed to accumulate gives off ammonia to the serious discomfort and injury of the horse, can in a great measure be prevented.

And then, again, an acquaintance with the origin of foot-rot will often be the means of enabling a man to guard against its outbreak, or certainly against its spreading.

How valuable, also, in the way of prevention of evil, may not a knowledge of Veterinary Science prove in the sheep-fold—teaching a student, as it will, that patience and a dependence on the powers

of nature are the most valuable qualifications for any one who has the charge of ewes. And surely the opportunity which the Hospital attached to the College gives you of observing the progress of disease in the cases which may be therein from time to time treated, is not to be disregarded. I hope that, as the course progresses, subjects for post mortem examination will not be unfrequent; and that you will have examples under your own observation of most of the commonest complaints to which horses and beasts are subject, so that the points of unsoundness especially may be practically, i.e. by living examples, impressed upon your minds:

Not that we would have you gather from these remarks that it is our aim here to make the students veterinary surgeons, or even capable of prescribing for their sick animals. It is one of the sure evidences of a well-instructed and well-balanced mind to be cautious of acting in matters where it feels its ignorance, and to be reliant on the help of better informed men; and therefore we should regard our system to have failed, if it did not produce in you a proper respect for the skill and services of well-qualified practitioners. It is the ignorant untutored mind which is rash and easily led into experiments; the well-educated,

conscious of its deficiencies, is cautious and reliant on the help of superiors.

And therefore, with the exception of the few whose lot may be cast "far from the busy haunts of man," in the wilds of New Zealand or Australia, and on whose own skill and knowledge their flocks may be dependent for medical treatment, you will find that the chief value of the course of study in Veterinary Science will be what I have endeavoured to point out; namely, an acquaintance with the frames, forms, and habits of our domestic animals; a knowledge of the principles of health and therefore of disease, which are only modifications of these; a respect for the skill of the practitioner and therefore an appreciation of the necessity of an early application for his help, and not, as is too often the case, a recourse to him when the disease is beyond treatment.

I might extend these remarks to a much greater length, for I believe that Veterinary Science has a very direct bearing on the daily business of the agriculturist; but I trust enough has been said to convince you that the study is not only interesting and well adapted for a place in an educational course, but one of which the knowledge will be remunerative to the agriculturist. Any study which, besides developing the faculties, furnishes a student with much practical knowledge

in the profession he is to be engaged in in after life has a prominent claim on his early attention and industry.

DESCRIPTION OF THE COLLEGE FARM.

The Farm, attached to the College contains 500 acres of land, of which there are 40 acres in pasture, the remainder arable. The soil is very variable and belongs to the Oolitic series, known as the "Bath oolitic formation," being composed of clays, marls, limestones, and inferior brash: by far the largest portion of the Farm is of the latter kind, and consequently, in an agricultural point of view, is of an inferior value. The character of the land differs so greatly that in some fields no less than three or four varieties of soil may be found within an area of 80 or 100 square yards. In a furrow of ten chains in length the plough not unfrequently passes through soil alternating from brash to rich loam, or it may be to a cold tenacious clay. As the surface rests almost entirely upon the limestone rock, but few drains occur on the Farm; these are found necessary only in certain portions of a field where a vein of clay is met with, or the downward passage of surface water is impeded by the heavy character of the subsoil.

The Farm lies within an irregular boundary, and is divided into 20 fields varying in size from 10 to 50 acres: about two-thirds of the land is conveniently situated as regards the Farm Buildings, the remainder is scattered, difficult of access, and costly to cultivate by reason of its irregular surface.

The system of management pursued partakes of that commonly adopted upon similar Farms, the greatest vigilance and care being used in carrying out the details of each day's practice.

On the better portion of the land the Norfolk or four-course system is followed as far as may be practicable. Beans or pulse follow a wheat crop, whilst on the lighter land pease take the place of a root crop; by pursuing this course of cropping an interval of six years occurs between the clover crop, and in these days of clover sickness this is desirable. In the management of the brashy poorer soils the prevailing custom of the Cotswold farmers is not ignored: it has long been their habit to suffer the clover plant to remain a second year, thereby affording a large breadth of valuable sheep food, and causing a saving of labour. The high price of wool and demand for mutton offering the greatest encouragement to Flock Masters, the attention of those in charge of the College Farm is directed towards an increased breadth

and growth of all descriptions of green crops for feeding off upon the land by sheep.

The variety of soil, if it entails greater risk and anxiety upon the cultivator, affords the looker-on an opportunity of acquainting himself with the several systems of management which are being pursued, and this is desirable at an Agricultural Educational Establishment. The cultivation of the land is regularly and systematically carried out. No sooner is the corn removed from the stubble than the steam plough is set to work towing either the Cultivator at a shallow depth or the powerful Digging Breast at a depth of 12 or 14 inches.

The following may be taken as a fair statement of the proportions and description of Crop grown annually upon this Farm :—

Wheat, after Clover, 80 to 120 Acres.
Manured before Spring, 8 Tons.

Wheat, after Turnips, 20 Acres,
Corn spent on Lands.

Barley, after Turnips, 80 to 100 Acres,
Corn spent on Lands.

Oats, after Turnips, 15 to 20 Acres,
Corn spent on Lands.

Beans, after Wheat, 10 to 20 Acres,
Manured in Winter, 12 Tons.

Pease, after Wheat, 10 to 15 Acres,
Manured sometimes, 10 Tons.

Early Turnips or Rape, 15 to 20 Acres,
Artificial Manure, 3 Cwt.

Grey-top Turnips, 10 Acres,
Artificial Manure, 3 Cwt.

Mangold, 15 Acres,
Manured with Dung, 14 Tons, and Artificial, 3 Cwt.

Swedes, 50 to 60 Acres,
Part Manured, Dung 10 Tons; remainder, Artificial Manure, 3 Cwt.

Vetches and Rye, 15 Acres,
Manured, 10 Tons.

From 80 to 100 acres of the spring corn is sown with a mixture of grass seeds varying in quantity and sorts according to the nature of the soil; a small proportion of rye grass is always sown with the clovers, the latter being too uncertain solely to depend upon.

The custom has been to top dress the wheat in early spring with 1¼ cwt. or more of nitrate of soda, a treatment which has considerably increased the yield.

The cleansing of both cereals and roots is vigorously persevered in whenever it is possible to hoe them.

The Corn is cut with McCormick's and Samuelson's Reaping Machines.

The Farm Buildings are massive and roomy, and contain all the requisites for a Farm of this size. There is a fixed Engine of ten horse power, giving motion to a threshing mill in an adjoining

barn, to a pair of stones for grinding and bruising corn, to chaff and root-cutters, and to the pumps. The centre of the Farm is occupied by the feeding boxes and cowhouse; at one end of this building is the chaff and root-house, where all material is prepared for the stock; the latter are conveniently located on either side of this building, in yards, sheds, and styes. Another row of buildings forms the cart stable, the interior of which is so divided that each animal can move about at leisure, and be fed at the head; two harness rooms lead out of this building to the yard; and facing them is a line of buildings comprising a slaughter-house, tool and artificial manure house, blacksmith's and carpenter's shops, and office. The shed room, straw and hay lofts, and granary, are under the roofs of the buildings just described. On the south-west the Farm Manager's and Bailiff's residences are connected with the buildings; on the north side is a neat and roomy rick yard.

The Flock comprises 250 breeding ewes of the pure Cotswold type; the flock is being rapidly improved by the introduction of rams from some of the celebrated breeders in the neighbourhood. The management hitherto adopted with the flock has been to fatten off all the wether and some few of the ewe lambs, also the cull ewes, the

latter representing about one-fifth of the flock of ewes.

The Horned Cattle include 12 milch cows, many of high pedigree: the produce is, with scarcely an exception, reared, and either sold off as beef or the heifers taken into the dairy; as the College is a good customer for milk, cows yielding it liberally are more sought after than those possessing only the merits of high breeding. During the winter months large quantities of grains, mixed with straw chaff, are consumed by this stock, the younger animals receiving in addition a small amount of meal or cake daily.

The Horses, nine in number, are selected from the Clydesdale, Suffolk, and West-country breeds, many of them possess excellent points.

The Pigs, of the pure Berkshire breed, are noted for their superior quality, and have already appeared as prize takers at the Royal Agricultural Society's and other meetings.

The Labourers are selected with due regard to their qualifications and respectability. The horse-keeper is solely responsible for the feeding of the horses, as no carter has access to the food; he is likewise pig-man. The carters have each the charge of one pair of horses, two carts, and one plough; these they are required to keep in good order.

An apartment is provided for the accommodation of all the labourers during the hours allotted for meals. Connected with this are sleeping apartments for those in charge of stock and the men attached to the stable.

EXAMINATION PAPERS,

CHRISTMAS, 1863.

AGRICULTURE.

Mr. JOHN CHALMERS MORTON.

CLASSES III. & II.

In answering the following questions on the management of a farm, you will make your replies throughout consistent with the scheme of cultivation which you lay down for yourself in the first of them. The farm in question is 500 acres in extent, 100 acres being in permanent pasture; the soil, well drained and fertile, is a somewhat adhesive loam; and its quality may be indicated by its rent and rates, which amount to £2. 5*s.* per acre. Answer as concisely as possible. The examiner does not ask for essays on the several subjects, but merely for evidence that you understand them.

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1. State the mode in which you will crop this farm, supposing it situated in midland or southern England; giving the acreage under the several crops you name.

2. State the quantity of seed per acre you will

require for each of the crops you grow; and state the quantity of bushels and tons of the grain and green crops respectively per acre which you expect to obtain. (Remember the quality of the soil, and the purchases of manure and cattle food to which your following answers will commit you.)

3. State the total quantities of the several grain and other crops you will have for sale and calculate their value according to existing prices. Estimate the quantities (in tons) of green crops and hay that will be available as food for stock, specifying separately the quantity to be consumed upon the land by sheep, and the quantity to be carried home for consumption in the yards and stalls. And state the quantity of straw you will have for litter.

4. What quantity (in tons) of manure shall you be able to make during the year; and how, when, and where shall you apply it in the course of the year? What quantities and kinds of other manures shall you purchase annually; and how, when, and where shall you apply them?

5. Supposing that all your food for stock is consumed by fatting sheep and beasts, which you purchase as you require them and sell as they are fit, what quantities of oil-cake or other food do you purpose to buy to use with your green food and fodder? Estimate the number of cattle and sheep you shall keep and the time during which

you shall keep them. In order to this, state (1) the average weekly consumption of green food and of cake or corn by a full grown sheep and beast fatting to 28lb. and 2 cwt. a quarter respectively; and (2) the number of weeks which your quantities of food allotted for each class of stock will last a sheep and a beast respectively; and (3) deduce thence how many of each kind you must buy, and when you must purchase and sell. State also the price per head you will likely give for what you buy, and the price per head you hope to get for them on sale; and so deduce the money produce of your green crop.

6. How many horses shall you need to work your farm? State the weekly feeding in Spring, Summer, Autumn, and Winter respectively.

7. Give the number and kinds of the several agricultural implements you will need upon the farm, and state the cost of each.

8. What will be your probable expenditure in wages per acre per annum; and name the ordinary prices per acre of the following operations—(1) hoeing wheat; (2) thinning turnips; (3) digging potatoes; (4) mowing clover; (5) reaping wheat.

9. What are the principal means at our command for the improvement of grass land?

10. Describe the operation of cheese-making, and say what quantity should be made from good

pasture land in a dairy of 50 good cows during the month of June.

11. What are the principal means at our command for the improvement of light soils?

12. What are the principal means at our command for the improvement of heavy soils?

In addition to the above questions the candidates for the Diploma were subjected on the Farm to a vivâ voce examination of six hours, conducted by Mr. Fletcher and Mr. Baldwin.

Mr. J. LYNCH FLETCHER.

Class I.

1. What work usually and properly takes place on an arable farm in the month of October?

2. Write the particulars of the management of the sheep on the R. A. C. farm during the past Session.

3. Give a short description of the Devon breed of cattle.

4. What are the chief benefits arising to land from perfect drainage?

5. Name the different methods of sowing wheat, and the advantages or disadvantages of each.

6. Describe the preparation of land for the mangold crop, and give an account of every expenditure upon the same up to the time of harvesting the tubers.

7. What is the difference in the preparation of lea ground for wheat and that on which roots have been fed off?

8. Fully describe Fowler's system of steam ploughing.

9. And state the average consumption of water, oil, and coals per diem.

10. Mention any circumstances which would influence you in the arrangement of your Farm Buildings.

11. Supposing the Norfolk four-course system carried out on the R. A. C. Farm, state in order the various crops which would be found on fields No. 1 to No. 10 in 1865.

In addition to the above questions the candidates were subjected to a vivâ voce examination on parts of implements, roots, feeding materials, and on such practical matters as suggested themselves to the Farm Manager.

AGRICULTURAL CHEMISTRY,

Dr. THOMAS ANDERSON, Professor of Chemistry in the University of Glasgow.

Class III.

1. Describe in general terms the composition and chemical relations of the albuminous constituents of plants.

2. What is the nature of the chemical changes occurring in the seed during the process of germination?

3. Which of the saccharine or starchy constituents of plants is insoluble in dilute acids and alkalies?

4. In what plants does silica abound, and in which of their parts is it most and in which least abundant?

5. Explain the chemical constitution of felspar, and describe the mode in which it is decomposed and disintegrated by air and moisture.

6. What agent causes the disintegration of limestone rocks, and how does it act?

7. What proportion of an ordinary fertile soil is soluble in water, and what substances are most abundant in the solution?

8. What is meant by the absorbent power of soils: how and in what substances is it chiefly exerted?

9. Describe the changes which farm-yard manure undergoes in keeping under cover and exposed to the air.

10. Explain the difference between a general and a special manure, and state what substances it is most important for the latter to contain.

11. What are the most important points of

difference in the action of salts of ammonia and of nitric acid when used as manures ?

12. What are the relative values of fatty and saccharine matters in the feeding of stock ?

ORGANIC & ANALYTICAL CHEMISTRY.

PROFESSOR CHURCH.

CLASS II.

1. Give some account of the manufacture and uses of Paraffine and Paraffine Oils.

2. Write the formulæ of Dextrine, Cellulose, Grape-sugar, Fruit-sugar, Cane-sugar, and Asparagine.

3. Compare the properties and feeding value of Gluten and Gelatine.

4. What are the chief sources of Citric and Tartaric Acids ?

5. Describe the characteristic properties of Albumen, Fibrine, and Legumine.

6. State the average percentage of Caseine in the milk of the cow, ewe, and sow. Detail the preparation of pure Caseine from milk.

7. Give an approximative idea of the composition of the Seed of Maize, Flax, and field Beans.

8. Illustrate the meaning of the term "Isomerism."

9. What change has the following equation been supposed to illustrate :—

$C_{12} H_{10} O_{10} + 2 NH_3 = C_{12} H_{10} N_2 O_4 + 6 HO$?

10 Give the tests for Phosphoric Acid with which you may be acquainted.

11. A solution contains Salts of Mercury, Arsenic, and Potassium; how do you detect these metals, and, in order to be certain of their presence, of what confirmatory tests would you make use?

INORGANIC CHEMISTRY

Class I.

1. Describe the preparation and properties of Carbonic Acid Gas.

2. How do you detect the presence of common Salt in a sample of Superphosphate?

3. What are the chief uses to which compounds of Cobalt and Manganese have been applied?

4. How do you account for the presence of Nitrates in certain waters? What are the chief differences between Rain-water and Well-water?

5. Give some account of the manufacture of Carbonate of Soda from Sea-salt.

6. How do you examine a soil for Carbonate of Lime?

7. How do you detect severally the three metals present in silver coin?

8. Give the formulæ of Bone-phosphate, Fluor-spar, Apatite, Minium, Calomel, and Corrosive Sublimate.

9. I wish to convert 50 lbs. of Carbonate of Lime, CaO, CO_2, into Sulphate of Lime, CaO, SO_3; how much Sulphuric Acid, HO, SO_3, must I employ, and what quantity of Sulphate of Lime shall I obtain? The following atomic weights are to be used in the calculation:—Ca = 20, C = 6, O = 8, S = 16.

10. What is the action of heat upon Nitrate of Ammonia, and upon Nitrite of Ammonia? How do you ascertain the purity of commercial samples of Sulphate of Ammonia?

11. Arrange the most important metals according to some system of classification.

The Candidates for the Diploma, in addition to the Paper on Agricultural Chemistry, were also examined in Qualitative Analysis, as follows:—

1. Ascertain the three metals which are present in the solution marked A; and state precisely the methods by which your results were arrived at. (The solution contained salts of aluminium, iron, and magnesium.)

2. Examine the solution marked B for sulphuric, nitric, oxalic, and phosphoric acids. (The solution contained nitric, oxalic, and phosphoric acids.)

3. Solution C may contain several substances: examine it for starch and sugar only. (The solution contained starch and glycerine.)

4. Detect the acid, and base in any two of the substances marked D, E, F. (These three substances were—pyrophosphate of magnesia, 2 MgO, PO_5; anhydrous sulphate of copper, with suboxide of copper; nitrate of potash.) And in Quantitative Analysis a certain amount of two of the following substances was given to each candidate, a complete estimation of all the constituents being required :—guanos, soils, superphosphates, and oil-cakes.

MECHANICS AND HYDRAULICS.

THE PRINCIPAL.

1. On the screw shew that

$$\frac{W}{P} = \frac{2\pi R}{h}$$

2. The total breadth of a flood gate is 5 feet, the depth 6 feet, the hinges are placed 1 foot from the respective extremities of the gate: required the pressure on the lower hinge.

3. Shew that in cylindrical steam-boilers the thickness should be in proportion to the radius, and compare the strength of the transverse section with the strength of the longitudinal section.

4. A water wheel weighing 10000 lbs. turns upon an axis whose radius is .25ft.; find the work consumed by friction per minute, the wheel making four revolutions per minute and the co-efficient of friction being .075.

5. Explain what is meant by working an engine expansively, and state the advantages of doing so.

6. In a high-pressure engine, the area of whose piston is 500 sq. ins., length of stroke 6 ins., number of strokes per minute 16, the pressure of steam 40lbs.; required the effective horse power, not neglecting the resistances due to the atmosphere and friction.

7. Explain the use of buttresses, and determine the conditions of the stability of a pillar acted on by a pressure P, supposing the pillar to be capable of being overturned on the edge.

8. State the three laws of motion.

9. A stone let fall into a well is heard to strike the water in 3 seconds; required the depth of the well, supposing the velocity of sound to be 1125 ft. per second.

10. Prove that the resistance of friction in pipes is directly as their lengths and inversely as their diameters, the velocity being constant; and state the best forms of the transverse section of closed currents.

11. Shew that

$$U = W h + \frac{W}{2g}\left\{2 V V_1 - V_1^2 - V_2^2\right\}$$

is the general expression for the work done by a water wheel when the water impinges upon the paddles perpendicularly.

12 Prove that the velocity of a fluid issuing from a small orifice in the bottom or side of a vessel kept constantly full is equal to that which a heavy body would acquire in falling through a space equal to the depth of the orifice.

The Diploma candidates were expected to have an accurate knowledge of Surveying, and of the instruments used by Surveyors; being examined vivâ voce in the adjustments and use of all of them.

MECHANICS AND HYDROSTATICS.

The Rev. W. M. LANE.

CLASS III.

1. How many cubic feet of water will an engine of 8 horse-power raise in 10 hours to a mean height of 50 feet, supposing the engine to consume one-fourth of its working power in useless resistances?

2. A beam is supported by two walls, its length is 18 feet, 4 feet project beyond one wall and 2 feet beyond the other, it weighs 20 cwts. Find the weight supported by each wall.

3. A uniform beam weighing 6 cwt. rests against a vertical wall at an angle of 45°. Find the pressure against the wall.

4. What system of pulleys is most convenient for hoisting heavy goods into a store house? Give

your reasons, and explain the principles on which the system of pulleys works.

5. Shew how to graduate the common steelyard.

6. What do you mean by the centre of gravity of a body? Weights of 12 and 20 lbs. are suspended from the ends of a uniform beam which weighs 30 lbs. and is 5ft. 2in. long. Find the centre of gravity of the system.

7. Explain what is meant by the neutral axis of a beam? Of what form should a cast iron girder be made to resist a transverse strain?

8. What must be the dimensions of a beam of Dantzic oak (1457) 20 feet long between the supports to bear a weight of 2 tons in the middle of its length.

9. Two cubic feet of copper (s. g. 9) are mixed with one cubic foot of zinc (s. g. 7). Find the weight and specific gravity of the compound.

10. A vessel contains 100 cubic inches of water, the area of the bottom is 12 sq. in. and the depth of the fluid 6 in. Find the pressure on the bottom.

11. Two substances, A and B, weigh 8 lbs. in water; A weighs 3 lbs. in air, B weighs 10 lbs. in water. Find specific gravity of A.

12. Describe the construction and operation of the common force pump. To what height can water be raised by this machine?

Dec., 1863.

SURVEYING.

Class II.

1. What is the difference between hypothenusal and horizontal measurement? Explain the method of finding the horizontal measurement in hilly ground with the chain only.

2. What is a tie line? In what cases is it employed?

3. Lay out 4A. 0R. 35P. as a triangle, in which the perpendicular is to the base as 2 to 3.

4. Plot and calculate the area of a field from the following dimensions:—

	D A	
	1055	
	1000	
From	⊙ D	go Left
	C D	
	756	0
	435	18—35
	320	15
	0	15
From	⊙ C	go Left

	B C	
	1286	30
	1000	
	900	0
	810	48
⊙ A 510	654	90
	0	0
From	⊙ B	go Left
	A B	
	845	0
	500	88
	444	60
	386	67
	320	35
	0	0
From	⊙ A	go S

5. Explain the use of a datum line in levelling. Complete the following notes and draw the section.

Distance.	Back Sight.	Fore Sight.
140	7.4	3.2
350	4.15	8.65
520	3.7	9.4
800	4.6	12.1
1050	15.3	2.5

6. Shew how to survey a road (1) with the chain only, (2) with the theodolite.

7. The angles which one side of a triangular field makes with the other sides are 64° 23′ and 59° 44′; the length of the first side is 15 chains: find the area of the field.

The vivâ voce examination was on Surveying instruments.

MENSURATION.

Class I.

1. In some wheat top-dressing experiments, made on the Farm, a manure of common Salt was used, costing 3*s*. per acre, and it produced a profit of 444 per cent. on cost of the manure; another, composed of Nitrate of Soda mixed with Salt, costing 33*s*. per acre, produced a profit of 291 per cent. on its cost: find total profit in each case per acre.

2. If the Steam Cultivator travels 3 miles per hour with a furrow of 36 inches, and loses $\frac{1}{5}$ of its working time in stopping and turning: how much land will it cultivate in the day?

3. Find the value of 44 tons, 8 cwt., 3 qrs., of hay at £4 6*s*. 8*d*. per ton.

4. Find the distance a cubic yard of manure should be spread, the quantity being 12 loads to an acre, and the distance between the rows 6 yards.

5. What quantity of marl will cover a piece of ground 3r. 18p. to a depth of $1\frac{1}{5}$ in.?

6. Define a logarithm. Find logarithm of 12500 and of .00125. Given, log. 2 = .30103.

7. The diagonal of a four-sided field is 1148 links, and the perpendiculars on it from the opposite angles 635 and 523 links: find the area of the field.

8. Find the number of cabbage plants necessary to plant 2a. 1r. 12p., the distance between the plants being 18 inches in the rows, and the rows 27 inches apart.

9. A court yard is 80 feet long by 70 broad: what will be the expense of making a pavement of stone 5 feet wide all round the interior of the yard, if the cost be 10*s*. 6*d*. per square yard?

10. The mean girth of a conical haystack is 58 feet, and its height from the stand to the eaves 13 feet; the girth at the eaves is 62 feet, and the height of the roof 9 feet: find its cubical content.

11. Estimate the value of the stack in the last question, supposing it to be made of good meadow hay, and find the cost of thatching it at 1*s*. per

hundred feet, if the slant side of the roof be 13 feet.

12. Find the cubical content of a piece of timber 8 inches quarter girt, and 18 feet long. In a timber measurer's book what factor would you find under the area against the above quarter girt?

SYSTEMATIC AND APPLIED BOTANY.

PROFESSOR BAYLDON.

Class III.

1. Give the classes and sub-classes of the Natural System, with definitions.

2. Mention the uses of the wood and bark of Tilia Europæa (Lime), and the wood of Acer pseudo-platanus (Sycamore). Distinguish the last from Acer campestris (Field Maple).

3. Define the three tribes of Compositæ.

4. Describe fully the Natural History and agricultural merits of Trifolium hybridum (Alsike clover).

5. How may Medicago lupulina be distinguished by its leaflets from Trifolium procumbens, minus and filiforme?

6. What is the condition of the stamen in the flower-bud of Digitalis? Mention any Labiate

plants which produce their volatile oil in greatest perfection in this country.

7. Mention seeds, British and Foreign, marked by the presence of an aril.

8. Which of the species of the genus Quercus and Pinus are best suited for sea-side planting?

9. Describe the false cones of the Spruce Fir, and explain their production.

10. Mention any British plants with circumscissile dehiscence of the capsule.

11. Describe the Agrostis stolonifera (Fiorin grass of Ireland) and state the conditions under which it may be usefully cultivated.

12. Mention any grasses which disappear under the influence of cultivation.

13. Distinguish between Alopecurus pratensis (Fox-tail) and A. agrostis (Black Bent) in regard to form of spike and duration. How would you detect adulteration of the seeds of the former with those of the latter?

14. Name a British cultivated grass (*a*) which comes under Diandra Digynia, (*b*) which has yellow glumellæ when dry, (*c*) which has dark brown glumellæ when dry.

15. Describe the situation and peculiarities of the awn or awns in Anthoxanthum odoratum, Arrhenatherum avenaceum, Holcus lanatus, Holcus mollis, Bromus mollis, Bromus asper, Bromus sterilis.

Class II.

1. Enumerate the classes of the Linnæan system.

2. To what species does Kohl-rabi belong? Describe its peculiarities.

3. Give the characteristics of the natural orders Euphorbiaceæ, Chenopodiaceæ, Polygonaceæ.

4. Describe fully a Red Clover seed, mentioning the distribution of the colouring matter.

5. Describe the Cuscuta epilinum (Flax Dodder).

6. Describe and distinguish between the wood of the Oak, Chestnut, and Elm.

7. Note the history and peculiarities of the var. strictus (Irish Furze) of Ulex Europæus, and the var. fastigiata (Irish Yew) of Taxus baccata.

8. At what age do the following trees attain maturity:—Poplar, Chestnut, Larch?

9. What is the number of seeds contained in the seed vessels in the chief species of Trifolium, Medicago, Plantago?

10. In what Dicotyledonous plant is the presence of more than two cotyledons frequently observed as a variety? Explain their production. In what order is this condition a normal one?

11. Describe Lupuline or Lupulinic grains in regard to their situation, microscopic structure, and properties.

12. What are the results of the experiments of Godron and Grönland on Ægilops ?

13. Describe the inflorescence of Hordeum, and thence elucidate the peculiarities of the cultivated species or varieties.

14. Distinguish the inflorescence of Triticum repens (Common Couch) from that of a Lolium. What is " Onion-couch " ?

15. Note the chief commercial varieties of Rye grass seed : give the variations in its weight : and state also the weight of Italian Rye grass seed.

In this department the vivâ voce was an examination on specimens consisting of samples of seed, pure, mixed, or adulterated; grasses, woods, and various vegetable structures examined during the course.

THERAPEUTICS.

PROFESSOR MURRAY.

Class III.

1. What applications may be used to destroy vermin on the skin ?

2. In what class of cases should blisters be employed, and in what cases are they inadmissible ?

3. Describe the action of the Turkish Bath on the system, and the circumstances in which it may be employed as a therapeutic agent.

4. State the action of Belladonna and the cases in which it may be used.

5. Describe the action of anæsthetics.

6. Which are the most useful tonics, mineral and vegetable? State the circumstances which would guide your choice.

7. What is the proper dietetic system during an acute disease?

8. To what class does arsenic belong, and in what cases may it be used?

9. Enumerate the medicines employed as purgatives, and state the doses in which they should be administered to the different species of domestic animals.

10. What points require particular attention in the operation of firing?

PATHOLOGY.

1. What treatment should be adopted for choping?

2. On what peculiarity of conformation does parrot mouth depend?

3. What appearance do the lungs of a broken-winded horse present, and what treatment may be adopted to palliate that affection?

4. State the best means of extracting the fœtus in a breach presentation.

5. Describe the symptoms and treatment of specific ophthalmia or moon blindness.

6. What are the symptoms, nature, and treatment of canker in the foot?

7. To what injuries is the stifle joint subject, and how should they be treated?

8. Describe the following diseases of the foot. Corn, Quittor, Navicular, mentioning their probable duration and influence on the soundness of the horse.

9. What symptoms distinguish Colic from Enteritis?

10. Give the nature and treatment of Pleuropneumonia.

ANATOMY.

1. Describe the position and structure of the windpipe.

2. Trace the course of the jugular vein from its origin to its termination.

3. Give the anatomy of the heart and describe the circulation of the blood.

4. How do the ureters open into the bladder?

5. Give a description of the optic nerve.

6. Also of the fœtal membranes.

7. Also of the suspensory ligament.

8. Also of the milk gland, stating the causes which excite and diminish its secretion.

9. What are the characteristics of the teeth of a horse rising three and of one rising six ?

10. Mention the usual dentition of the ox, sheep, and pig at two years old.

The Students were also examined on Anatomical preparations, and on specimens of morbid Anatomy.

DRAWING.

Mr. MILLER.

Class III.

1. Design and draw the ground plan of a pair of cottages, to have a parlour, kitchen, back kitchen, pantry, and stair; also a closet, coal cellar, and ash pit, clear of the main building.

2. Draw the plan and elevation of a geometrical staircase with quarter space and windows; the well is 11 ft. 3 in. in width, and the height from floor to floor 12 ft. 6in., the tread to be $9\frac{3}{4}$ in., and the rise not to exceed 7 inches.

3. Draw a section shewing the arrangements of the different parts of a cistern for a dwelling-house, viz., the tank, main, ball-cock, standing waste, rose, service, &c.; the tank to be 4ft. 6in. long, by 2 feet wide and 1 foot 6 inches deep.

4. Shew by drawings the arrangement of the timbers in a double queen post truss.

Class II.

1. Draw the front and side elevations of a bevel wheel having a pitch circle of $8\frac{3}{4}$ inches, and 25 teeth, the teeth being inclined to the axis at an angle of 37°.

2. Make drawings shewing the working for finding the involute and hypocycloidal curves.

3. Make a drawing of a single square-threaded screw, the diameter being 5 inches and the pitch $1\frac{1}{2}$ inches.

4. Make a drawing shewing the different parts of an eccentric motion, viz., the sheave, strap, and part of rod, to produce a rectilinear movement of 4 inches.

5. Make a drawing of a cam disc to raise a point $3\frac{1}{2}$in. and let it fall instantly.

6. Make a drawing of a screw bolt, of 1 inch diameter and 10 inches long, and illustrate the method of determining the hexagonal nut and head.

The Drawings to be actual size.

Class I.

1. Draw the plan and elevation of a pyramid whose base is a regular pentagon of 3ft. 6in. on the side, and the vertical height 10 feet. The pyramid is standing on a base 2 feet high, and extending beyond and parallel to the side of the pyramid 2 feet.

2. Draw an elevation of the wing of a building whose plan is a semicircle of 20 feet chord over walls, having three windows 4ft. wide and 8ft. high; the piers between voids being equal, and the thickness of the walls 1 foot 6 inches.

3. Draw the elevation of a door, for a void of 3ft 9in. wide by 7ft. 3in high; to have six equal panels and double styles in the middle; the styles, top, and freize rails to be 6in., lock-rail 10in., and bottom rail 8½ inches.

4. Draw the plan of a chimney in brick work having eight flues, extending four flues in length.

5. Draw the section of a wall shewing the arrangement of the brickwork in a splayed jamb of an opening for a window 4 feet wide.

6. Shew, by drawing the side elevation, the construction in wood, of a series of gibbet brackets to support shelves in a pantry; the height of the lowest shelf from the ground is 3ft. 6in., the second from the first 1ft. 9in., and the upper from the second 1 foot 6 inches.

The scale to be half an inch to a foot.

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