Price, 25 Cents.

SMITHSONIAN MISCELLANEOUS COLLECTIONS.

— 291 —

THE TONER LECTURES

INSTITUTED TO ENCOURAGE THE DISCOVERY OF NEW TRUTHS FOR THE ADVANCEMENT OF MEDICINE.

LECTURE II.

DUAL CHARACTER OF THE BRAIN.

BY

C. E. BROWN-SÉQUARD, M.D.

DELIVERED APRIL 22, 1874.

WASHINGTON:
SMITHSONIAN INSTITUTION
JANUARY, 1877.

Charles Edward

SMITHSONIAN MISCELLANEOUS COLLECTIONS.

——— 291 ———

THE TONER LECTURES

INSTITUTED TO ENCOURAGE THE DISCOVERY OF NEW TRUTHS FOR THE ADVANCEMENT OF MEDICINE.

LECTURE II.

DUAL CHARACTER OF THE BRAIN.

BY

C. E. BROWN-SÉQUARD, M.D.

DELIVERED APRIL 22, 1874.

WASHINGTON:

SMITHSONIAN INSTITUTION.

JANUARY, 1877.

ADVERTISEMENT.

The "Toner Lectures" have been instituted at Washington, D. C., by Joseph M. Toner, M.D., who has placed in charge of a Board of Trustees, consisting of the Secretary of the Smithsonian Institution, the Surgeon-General of the United States Army, the Surgeon-General of the United States Navy, and the President of the Medical Society of the District of Columbia, a fund, "the interest of which is to be applied for at least two annual memoirs or essays relative to some branch of medical science, and containing some new truth fully established by experiment or observation."

As these lectures are intended to increase and diffuse knowledge, they have been accepted for publication by the Smithsonian Institution in its "Miscellaneous Collections."

The FIRST LECTURE of this series was delivered March 28, 1873, by Dr. J. J. WOODWARD, "On the Structure of Cancerous Tumors and the Mode in which adjacent parts are invaded." Published by the Smithsonian Institution, November, 1873. 44 pp. 8vo.

The SECOND LECTURE was delivered April 22, 1874, by Dr. C. E. BROWN-SÉQUARD, on the "Dual Character of the Brain," from a phonographic report of which the lecture has been printed. On account of absence from the country the author has not had the opportunity of revising the lecture or of correcting the proofs.

The Third Lecture was delivered May 14, 1874, by Dr. J. M. Da Costa, on "Strain and Over-Action of the Heart." Published by the Institution, August, 1874. 32 pp. 8vo.

The Fourth Lecture was delivered January 20, 1875, by Dr. Horatio C. Wood, on "A Study of the Nature and Mechanism of Fever." Published by the Institution, February, 1875, 48 pp. 8vo.

JOSEPH HENRY,
Secretary Smithsonian Institution.

Smithsonian Institution,
Washington, January, 1877.

LECTURE II.

Delivered April 22, 1874.

DUAL CHARACTER OF THE BRAIN.

By C. E. Brown-Séquard, M.D.

Gentlemen: I have to-day to put forward views which, if they have the value that I attach to them, deserve all your attention. I confess, however, that although I have come to a conviction myself (and I am, perhaps, rather difficult to satisfy in this respect), I do not accept as proved all that is drawn from facts. I confess, also, that I feel great embarrassment, since not only are the facts I have to present new, and not, perhaps, easily to be accepted, but besides, they require for their full understanding a knowledge of medicine, which probably does not exist among many of my hearers. I will, however, try my best to render the subject as clear as possible, even to persons who know nothing of medicine.

As you perhaps know, the subject is this, putting it in an interrogative form, Have we two brains or one? And if we have two brains, why not educate both of them?

As you will see by these questions, if the first is decided negatively, of course there is no reason for discussing the second. The very fact, therefore, that I am in your presence to speak about an hour on this subject, implies that I have come to the conclusion that we have two brains, perfectly distinct the one from the other. There are, however, views held in science on this subject different from mine. They consist in considering the left side of the brain as the exclusive organ serving to the movement and feeling of the right side of the body, and *vice versa*, the right side of the brain being the only organ serving for volition and sensation for the left side of the body. This view I will have first to disprove.

Beginning, however, with what relates to the noblest functions of the brain—that is, its capability to serve in mental phenomena —I shall say at once that I am not the first to put forward the view that we have two brains. Long ago Sir Henry Holland, and Dr. Wigan,[1] and a few others, insisted on the fact that each side of the brain is perfectly sufficient for the full performance of the mental functions. But they stopped there, and they have, therefore, left to others to go further. In regard to this I may say, if we adopt the view, that we have two brains, a conclusion will follow, which—although I shall have to speak of it more at length by and by—I must now allude to. It is quite certain that if we make use of only one brain for most of our actions, we leave inactive one-half of the total mass of brain matter, and, therefore, we leave quite useless one-half of the most important of our organs as regards manifestations of intelligence, will, and perception or sensation. If this conclusion is correct, you will easily understand how important it is to come to the point which I have in view in this lecture; that is, that we ought to give education to the two sides of the brain, or, rather, to the two brains.

As regards intelligence, it is hardly necessary to insist, after what has been said by the physiologists, Sir Henry Holland and Dr. Wigan. They both show that there are a great many facts which would seem to prove that either half of the brain may equally perform intellectual functions. It may be, however, that their proofs were not sufficient.

Dr. Wigan has insisted upon a feature of great interest, which is that in cases of insanity sometimes, and I may say

[1] The Duality of the Mind Proved by the Structure, Functions, and Diseases of the Brain, by A. L. Wigan, 8vo., London, 1844.

very frequently without any insanity, we have two different views on the same subject. There are a great many people who labor through life under the difficulty of being unable to make up their minds. It is because they have, unfortunately, two minds. Better would it be for them to have only one: but I hope you will not conclude from this that I intend to teach here, that to educate our two brains is a fallacy, on account of the danger of leading men to have two minds, and to be all the time hesitating between two views, two opinions, or two decisions. On the contrary, I shall attempt to prove that the fault in those individuals who cannot make up their mind is dependent in a measure on the fact that they have not developed sufficiently the power of their two brains.

Dr. Wigan especially insisted upon the facts which we observe in insanity: that a patient knows he is insane; that he knows that he has insane ideas; that he will put them forward, and immediately afterwards will say, "I know they are insane." He is perfectly rational, while at the same time he is completely insane. Dr. Wigan has concluded, without any positive demonstration, that in these cases one-half of the brain is normal and the other half is diseased; one-half is employed with the mental faculties in a normal way, the other is employed as regards the same faculties in an abnormal way. But there are cases which are, perhaps, more interesting, and which, I think, more clearly support the view, that there are two brains. I saw a boy, for instance, at Notting Hill, in London, who had two mental lives. In the course of the day, generally at the same hour, but not constantly, his head was seen to fall suddenly forward. He remained erect, however, if he was standing, or if sitting he retained this position; if talking, he stopped for a while; if making a movement, he stopped moving. After continuing one or two minutes in this state of falling or drooping of the head, appearing as if asleep with his eyes closed, he would suddenly raise his head, open his eyes, being quite awake, and then ask if there was anybody in the room whom he had not previously seen, who the person was, and why he was not introduced to him; being all the time in a state quite different from that of wakefulness. He had seen me many times, and knew me very well. Being with him once when one of these attacks occurred, he lifted his head and asked his mother, "Who is that gentleman? Why don't you introduce him to me?" His mother introduced me. He did not know me at all. He shook hands with me, and then I had a conversation with him, such as a physician may have with a patient. In another instance, when with him again, while he had the same kind of an attack, I found that he recognized me fully, and talked of what we had spoken of in our first interview. I ascertained from what I witnessed myself, and from what I obtained from his mother, a very intelligent woman, that he had in reality two lives, two mental lives, one in his ordinary state, and another occurring after those attacks of a kind of sleep for about a minute or two, when he knew nothing of what existed in his other state—in his ordinary life; that was all a blank. He knew nothing during that second state but what had occurred in previous periods of that same condition, but he knew full well all that had occurred then; and his recollection of everything was as perfect then as it was during his ordinary life concerning the customary acts of that state. He had, therefore, as I have said already, two absolutely distinct lives, in each of which he knew everything that belonged to its wakeful period; and in neither of which did he know anything of what had occurred in the other. He remained in his abnormal state for a time, which was extremely variable, between one and three or four hours, and after that he fell asleep, and passed out of that state of mind pretty much in the same way that he had gone into it. I have seen three other cases of this kind, and as so many have fallen under the observation of a single medical practitioner, such cases cannot be extremely rare.

As regards the faculty of speech, the fact that we have two brains perfectly distinct, one from the other, is not, perhaps, so easily proved as it may be in reference to the mind. We well know, however, that a lesion in the left side of the brain will produce loss of the faculty of speech; which belongs almost exclusively to the left side of the brain; but the very fact that the loss of speech depends on a disease in the left side of the brain is itself an evidence that the left side of the brain is quite distinct from the right side; that it is in fact a brain in itself as regards that particular function of the organ which we call the brain. Therefore, the well-known fact, that out of one hundred cases in which the loss of the faculty of speech had occurred, there is only one in which the disease was to be found in the right side of the brain, is extremely important in showing that the two sides of the brain may act independently of each other. I shall have to return to this again, as much of my argument depends on this point.

As regards sight, a theory has been advanced by a celebrated philosopher, Dr. Wollaston, of London, which has been adopted by a great many physiologists, although by no one without some hesitation. But as there was no better theory proposed, it was received as being at least probable if not demonstrated. Wollaston held the opinion that the right side of the base of the brain is the centre for sight in the right half of each eye. The right half of the right eye is, of course, the half farthest from the nose, and the right half of the left eye is the one nearest the nose. The inner half of the left eye and the outer half of the right eye have for their centre, according to this view, the right side of the brain, and, *vice versa*, the left side of the brain would be the centre for sight in the left or outer half of the left eye and the inner half of the right eye. There is, therefore, according to that view, a condition which is quite peculiar. If we admit it for a moment, then we ought to find that a disease in the left of the brain at the base must destroy only one-half of the power of sight, and objects then if seen are seen in half. Suppose a man to be looked at, there would be visible, if it is the left side of the brain which is affected, only the right half of the body. Wollaston himself had this trouble. One day, trying to read the name of an instrument, the barometer, he read "meter" only; the other part of the word, "baro," he could not see. Another eminent friend, while living in France, Professor Agassiz, had the same affection. He saw one-half of all objects. And a good many patients who are affected especially with certain disorders of movement and with diabetes have also this trouble; they see but half of objects. There are, therefore, cases which seem to be in favor of the view. But, continuing to consider what ought to take place, we find that, if the disease exists only in a small part of the left side of the brain, in that portion which serves for sight, we ought to find that then only one-half of one eye will be affected. There are such cases. If it is the other part of that same half of the base of the brain which is affected, then it is one-half of vision in both eyes which should be affected. There are also facts of this kind.

There are, therefore, three kinds of facts which seem to support the view of Wollaston. But what of that? Philosophers do not accept conclusions because there are some facts which support them. We accept conclusions when all the known facts are either in perfect harmony or clearly prove the conclusion; and also when there is no fact that seems to be in opposition. It is requisite, therefore, either that all the facts are in favor of the theory, or that while there are a number in favor there are none in opposition. Such is not the case here. There are a great many facts which show that a disease in one-half of the brain will produce complete loss of sight of one eye, either on the same or on the opposite side, or the two halves of both eyes. Therefore there are three series of facts, while one only would be enough, which demonstrate that the theory ought to be rejected.

But as regards sight we find this, and it is a point of importance, that a disease anywhere in one-half of the brain can exist without any alteration of sight whatever. A disease existing in that part where the optic nerve enters the brain, destroying that part altogether, may not be a cause of loss of sight; so that one optic fibre alone may be perfectly sufficient for the functions of the two eyes. Therefore I conclude that it is quite enough to have one brain to have our power of sight; and as it is so for each half of the brain, I can also conclude, and this is a point of importance, that each half of the brain is independent of the other, and that each of them possesses the powers of serving to the sensations of sight. You will ask how is it that a disease in certain cases in the brain will produce loss of sight, and that in other cases a disease in the same part will not produce loss of sight. As regards this, I cannot develop at length what I would have to say; but if any of you were present at my lecture in this city last year, or at the Academy of Sciences to-day, you know that an alteration in any part of the nervous system, whether in the brain or elsewhere, can, by producing an irritation, act on other parts, so as to produce the loss of a function of those other parts; and so it is especially with sight. In many experiments I have ascertained that injuring a small part of the spinal cord produces a loss of sight in the eye on the same side. An injury to the *medulla oblongata*, a little higher than the part of the spinal cord which produces loss of sight on the same side, will produce a loss of sight, but in the opposite eye. There is, therefore, a power of producing a loss of sight by irritation; and indeed there is nothing more common in children having worms than a diminution in the power of seeing. It is in the same way that an irritation existing in certain parts of the brain will produce, at a distance from the place where it exists, a loss of the function of sight. The cases that can serve as proof are, therefore, not those alone in which we find that the disease exists, since the loss of sight exists when there is a disease. The cases that can serve positively must clearly bring us to a conclusion; as those, on the contrary, which establish that an injury in any part or one-half of the brain—even in that part which receives the optic track—can exist without producing any loss of sight; and that fact has been observed—more than five or six times to my knowledge—and in those cases in the most decisive manner. Therefore the conclusion I have drawn is established. Either half of the brain may serve for the function of sight.

Now, as regards the volitional movements, the voluntary movements, if you like to call them so. Those movements, as you well know, have been considered as depending on each half of the brain for one-half of the body. Still, many physiologists have ascertained that there are muscles in our system in the neck, in the eye, in the throat, and in the back also, which escape paralysis when there is disease in one-half of the brain; and for these cases a theory has been imagined to explain how it was that the left half of the brain, for instance, is not the regulator of the movements in the right side of the body. I shall pass over that theory, and come to the point of importance in the object which I have in view.

As regards volitional movements, there are cases on record which leave no doubt that either the anterior lobe of the brain, the middle lobe, or the posterior lobe, the three essential parts of the organ, can be destroyed and voluntary movements not be interfered with at all. There are many cases—perhaps the word "many" is too strong, but there are at least seven or eight to my knowledge—of the destruction of the whole half of the brain without any interference with the voluntary movement. Therefore we are not to look upon one-half of the brain as being necessarily the organ serving to the movement of the body on the opposite side. And also another inference; we are to look upon one-half of the brain, in some individuals at least, as being able to control voluntary movements in the two sides of the body. If so, certainly the point I have in view—that is, to show that we have two brains—is established as regards voluntary movements. We have certainly two brains as regards voluntary movements; and if it is found in most cases that even a slight injury limited to a small part of the brain will produce a paralysis on the opposite side, or sometimes on the corresponding side—if that is found, it is on account of the principle which I mentioned a moment ago; that is, that an irritation in any part of the brain can affect functions in other parts through transmitted irritation. And I can say in regard to voluntary movements what may be said as to worms in the bowels, as well as an irritation in a tooth, in the stomach, in the lungs, in the heart, or an irritation in the skin; in other words, an irritation wherever there is a nerve subject to be irritated, all can produce a paralysis as well as an irritation in a part of the brain. And therefore, when we see a slight alteration in a very limited part of the brain cause a complete paralysis on the opposite side of the body, we are not to conclude that it is owing to the loss of function of voluntary power where the disease exists, but that it depends upon an irritation starting from the place where we see the disease, and acting upon remote parts so as to produce the loss of the function. The mere fact, that a disease exceedingly limited in extent can produce a complete paralysis in the opposite side of the body, is sufficient to show that it does not depend on the loss of the function of will; for the cause of motion of one-half of the body cannot be located in a very limited part of the brain. If it were the other side of the brain which produced that complete paralysis, if we found that paralysis is more or less extensive, more or less durable according to the extent of the disease in one-half of the brain, then we might conclude that the disease has destroyed the power of will in that half of the brain, and thereby produced the loss of voluntary movement on the opposite side. But that is not what we find. We see that the lesion which has destroyed one-half of the brain may allow voluntary movement, while a lesion which is not larger than a pea in any one part of the brain can produce a loss of voluntary movement. Therefore we are to admit that when the paralysis of movement comes in connection with disease of one-half of the brain, it depends on an influence starting from the place where the disease is acting upon remote parts so as to produce a cessation of activity there, or in other words a paralysis.

The same reasoning may be applied in regard to perception of sensâtion. Here also we find the same thing. I shall, therefore, not dwell on that point. We know a thousand cases of disease occupying one-half of the brain that has not produced the slightest alteration in the power of feeling. But, if it is so, it remains to be explained how it is, that the two halves of the brain come to be in some respects different, and that the physiological and pathological study of the two halves of the brain indicates great differences in this respect. If we pass in review what is known, we find very great differences indeed. These differences depend on the fact that, through the fault of our fathers and mothers, the faults that weigh upon us, and have led us to make use of only one-half of our body for certain acts, and one-half of our brain for certain other acts also—we find that it is owing to that defect in our education that one-half of our brain is developed for certain things, while the other half of the brain is developed for other things. As regards what belongs to the left side of the brain compared with the right side of the brain, allow me to say the most important feature in its physiology or pathology is what a French physician has discovered. It is, as I have said already, that to that side of the brain belongs the faculty of expressing ideas by speech Besides that mental faculty of speech, the left side of the brain possesses, in a much more marked degree than the right, the power of moving the tongue and larynx and muscles of the chest to produce the sounds of articulate voice. Articulation of sounds in speech in a great measure depends on the left side of the brain. I mean by the words "in a great measure" that it is chiefly the left side of the brain which has the power of acting upon the organs. So that more frequently in cases of disease of the left side of the brain do we find the difficulty in the mechanical part of the speech than in cases of disease of the right side of the brain. But that, although speech is, when defective, mechanical, and is something like a gesture, there is a mental sign in it, and I cannot but consider it as representing some mental trouble.

My pupil and assistant in London, who has become a very eminent man since, Dr. J. Hughlings Jackson, has also insisted on the point, that it is the memory for direction of movements of the muscles which serve to articulate, which is lost, and not the mere power of moving the muscles of the tongue, larynx, or chest. I have had proof of this in a great many instances, that, when told to do so, the patient could move the tongue in any direction, could move the larynx and utter sounds very well, but could not articulate, so that it was the mental part of that mechanical act—the mental part of which was altered, and not purely a mechanical action lost. The left side of the brain is also the one that leads in gestures, and that by a very simple reason, which is, that it is the left side of the brain which mainly directs the movement of the right arm, and it is chiefly with the right arm that we make our gestures. Still, it is likely, as pathological facts show, or at least appear to show, that even the motion of the left arm depends on the left side of the brain as regards gestures, as we find that in patients who have a disease of the right side of the brain the faculty is lost of making gestures with either the right or the left arm. That of course shows, or at any rate seems to show, that the left side of the brain is the organ for gestures chiefly. In a few cases, however, of disease of the right side of the brain, the power of making gestures has been lost as well as in case of disease of the left side of that organ.

As regards the power of writing, there is a difficulty which you will easily understand. Still there are many facts which show that the power of writing can be lost more easily, and is lost more frequently in cases of disease of the left side of the brain than in cases of disease of the right side of the brain—a difficulty which many of you have understood without my mentioning it. We conclude that the right arm is not rarely paralyzed in diseases of the left side of the brain, and as we write with the right arm, it is very natural that, on being paralyzed, we cannot write; but very few patients have lost altogether the movements of the fingers, and cannot form the least sign, though many of them cannot at all form a letter. They will be able, however, if they have a letter written by some one whose handwriting is not very much different from theirs (and sometimes when it is different), they will be able to imitate what is under their eye, but they cannot from memory write anything; at all events, they cannot express ideas by writing. They are attacked with what is called agraphia—that is, a loss of the faculty of expressing ideas by writing. In many of these cases of patients attacked with agraphia there is a perfect power of moving the right arm. The arm is not paralyzed in all cases where the left side of the brain is paralyzed; there is often no paralysis on the right side of the body or the left; no paralysis anywhere. In these cases, it has occurred sometimes that the patient could not write at all; so that it is clear that the loss of the faculty of expressing ideas by writing does not depend on the paralysis which in these cases had no existence.

Another thing depends on disease of the left side of the brain more than the right side of the brain, and that is intelligence. Alterations of the mind manifesting themselves in the various forms of insanity depend more frequently, I should say, on diseases of the left side of the brain than on diseases of the right side. This is all I know now which belongs to the left side of the brain. The right side of the brain is quite different. From all that I have stated about the left side, as you will see, that organ is chiefly the organ serving the mental faculties, either in speech, or in intelligence, or in gesture, or in writing. That organ, therefore, is the important organ in our system adapted to the life of communication between ourselves and our brethren in a mental way. But the other organ —the right side of the brain, in some individuals, as you will see, has the power of the left side, and in all, perhaps, it might have had it if the proper development had taken place; but this right side has also additional functions. The right side of the brain serves chiefly the emotional manifestations, hysterical manifestations included, and to the needs of the nutrition of the body in various parts. There is, therefore, taking a large view of the differences between the two brains, this difference, that one of them—the left—serves to what we call the life of relation, while the right serves to what we call the organic life. This view, which I put forward five or six years ago, has begun now to receive demonstration from several physicians, and I am, therefore, the more emboldened in maintaining its correctness. The right side of the brain is remarkable in producing alterations of nutrition either in limbs that are paralyzed, or in the back. It is perfectly well known that a number of patients die every month in every large city, of ulcerations taking place on the *nates* or on the *sacrum* originating from an irritation of the brain. These patients are more numerous among those attacked by disease in the right side of the brain than among those attacked with disease in the left side of the brain. Either œdema or bed-sores, either one or the other of those two kinds of lesions is more frequent in cases of disease of the right side of the brain than in cases of the left side. The proportion is considerable. It is as two-thirds for the right side of the brain and one-third for the left. There are many other points which show the same thing. An ulceration in the lungs, an ulceration in the liver, a hemorrhage, for instance, and sudden inflammation—all these disturbances can take place from an irritation of the brain, as I have shown; but in these cases it is chiefly the right side of the brain that has the power.

I have already said that hysterical and emotional symptoms are more common in cases of disease of the right side of the brain. This has been established already by a good many physicians—Drs. Briquet and De Fleury, and a good many others, besides myself. We have collected cases of paralysis in one-half of the body, caused by hysteria, and this proportion has been found; out of 121 cases of paralysis caused by hysteria (a paralysis which is usually merely transient, and very rarely lasts long)—in 121 of these cases there was disease of the brain on the right side 97 times, and disease on the left 24 times; so that the right side predominates in this class of affections. That paralysis exists on the left side of the body more frequently than on the right side you well know, and, as it affects chiefly the right side of the brain, it affects chiefly the left side of the body.

Now as regards other points, my pupil, Dr. Jackson, has ascertained that an inflammation of the retina produces amaurosis more frequently in both eyes from disease of the right side of the brain than the left side. Convulsions of the eye take place very frequently in cases of disease of the brain. I have ascertained, from a study of the cases published by Dr. Prevost, Dr. Charmel, and many others besides my own, that out of 69 cases in which these convulsions of the eye occurred there were 47 due to the disease in the right side of the brain, and 22 due to disease in the left side of the brain. Therefore there is a great difference between the two sides of the brain, as you will see. It is also so as regards general convulsions. Callender and myself have shown that general convulsions will occur much more frequently in cases of disease of the right side of the brain than in cases of disease of the left side. I have ascertained that both will occur far more frequently in cases of disease of the right side of the brain than in cases of disease of the same extent and the same location in the left side of the brain. Not only disease in the right side of the brain will have the greatest power in this respect, but it will also, if the patient does not die, produce a more marked paralysis; a more extensive and more permanent one. So that, as regards degree, as regards extent, as regards duration of the paralysis, the right side of the brain is by far worse than the left, showing again that that side has the greater power of nutrition. There are a good many other points showing a difference of the same kind. I pass them over, as time presses. There is, therefore, as you will see, a radical difference between the two sides of the brain. But now this depends, as I have said already, not upon the fact that the two sides of the brain are very different originally, but it depends on development. Every organ which is put in use for a certain function becomes developed, and more efficient in performing that function. Indeed, the organ shows it in size. The left side of the brain, which is used most in our system, is larger than the right side of the brain. The left side besides receives a great deal more blood than the right side of the brain, because it has a preponderance in our system, and every organ that acts much, receives more blood. As regards the influence of action on the brain, there is a fact which hatters know very well. If a person is accustomed for many, many years from adult life—say from 20 up to 40 or more—to go to the same hatter, the hatter will find after a time that he has to enlarge the hat of his customer; and, indeed, a person advanced in life, even having passed, as your lecturer has, 56, has a chance to observe such a change. There is no period of six months that has passed that I have not found that my hat, if neglected and put aside, became too small. The head, therefore, growing, is a very strong proof that the brain also grows. Action, therefore, is a means of increasing size, is a means of development; and I have no doubt that a good many among you have observed that, after they have paid great attention to a subject, they have not only acquired knowledge on that subject, but become much more able to solve questions relating to that subject—that they have developed the part of the brain which has been used for the acts in which they have been engaged, and that part has become far more able to perform its functions. This is perfectly well shown by everything in our system. We well know what a power a pianist can have, if he continues to exercise his fingers and brain on the piano. But such a pianist neglecting to perform the acts that he was accustomed to perform before, it is very soon found that there is a defect. We must go on, therefore, exercising the organs in which we desire to have the great activity of life. There is no doubt, therefore, that the left side of the brain, as is shown by its great enlargement compared with the right side, and as is shown also by the quantity of blood that it receives, that that organ is the one which is predominant in our system. But our being right-handed shows this also.

It is quite certain that right-handedness depends something on nature. As you well know, the wildest populations in the world are right-handed, as we are. There is no people anywhere in the world that has not been found right-handed. There is therefore in man a cause which makes the right side of the body to be selected as the one to be used the most, and together with that right side of the body the left side of the brain, which usually moves that right side, is increased considerably in power and in size. There is, therefore, primitively, a development given through some natural cause to the left side. We find that individuals who are left-handed make use of the right side of the brain, and when they become confused—when they lose the faculty of expressing ideas by speech—it is the right side of the brain that is affected, showing the connection between the development of one-half of the brain in the use of one arm, and the development of that same half of the brain in the faculty of expressing ideas by speech. There is, therefore, a connection between these two things, and on this point I shall dwell a little more in a moment. There is primitively a difference between the two brains, and Professor Gratiolet has discovered in children that the second convolution—the convolution of the left side of the brain—is developed quicker than the convolution of the right side. This may be in a measure owing to hereditary traits; but at any rate, as there is an evidence that there is a natural tendency to make use of the right arm, it is certain that a part of that ability of development on the left side is due to something natural—that something natural will be found, if it is examined, in the greater supply of blood to that part. Even parrots and birds show something very interesting as regards right-handedness. Parrots perch only on the right leg, or mostly only on the right leg. Very few parrots out of twenty taken at random, perch on the left leg, according to what Dr. William Ogle ascertained after having examined a great number of them. Parrots, of course, are known to have something like speech—a parrot's speech, of course. It is perfectly well known that the mechanical parts of speech belong to them, and it is remarkable that their left brain receives also more blood by far than their right brain. There is therefore a relation between all these things in the development of the right side of the limbs and the amount of blood received by the left side of the brain. There is another point of importance. Prof. Broadbent and others have found that in the left side of the brain the mass of gray matter is greater, and there are more convolutions than in the right side of the brain.

Now we come to four points of great importance in this lecture. They are the vital points, I may say, in the argument

I have presented here. The first of these points I have already spoken of. It is, that we find that agraphia is connected with the left side of the brain in persons who are right-handed, and with the right side of the brain in persons who are left-handed. This, certainly, is a very strong argument to show that the side of the brain which serves the motion of one side of the body, that side—if the side of the body be the one which leads, is the most important of the two—that side of the brain then is the one that serves chiefly to the mental life in our system. The mental life of our system, therefore, seems to be developed considerably in the organ which itself seems to be developed in a great measure owing to the action of will in one-half of the body. There is certainly a connection between these things, but that will come out more by and by.

The second point is, that in children who have not yet learned to talk, or who have already learned only a little, if disease comes in the left side of the brain, the one, I repeat, which is, usually, the most rapid in its development if disease comes to produce atrophy, so that the left side of the brain becomes useless, those children then learn to talk just as well, or nearly as well, as if they had no such affection, and they learn it with the right side of the brain, which is the only one acting. They were not born (the most of them, if not all of them, if there is any exception I don't know it) of parents who were left-handed, and there was no reason for their being left-handed. They had the misfortune of losing the half of the brain which served usually to the mental faculties, and other mental faculties became developed—the power of speech and action—and they make use of the left arm then just as well as any one of the right-handed people makes use of the right arm. There is in these facts clear proof that the right side of the brain can be educated to become a leader in mental faculties as well as the left side of the brain. There is a clear proof that the right side of the brain can lead movements and obtain execution with the left arm, just as most people who are right-handed obtain execution of movement with their right arm. These facts, therefore, are decisive in favor of the view that I have for my object in this lecture.

The third point of importance is that with a given number of individuals, out of 100 examined by Dr. Wm. Ogle, who were left-handed, four only had learned to write with the left arm. They had been taught by their parents, although they were left-handed, to make use of the right hand to write, and their writing with the left arm, the author states, was very clumsy. In one of the cases he had to learn the facts from what the patient had to say; the patient being paralyzed in the left hand, he could not write; but in the others he had the proof, and could see. Therefore, the left side of the brain, even in persons who are left-handed naturally—even in persons who make use chiefly of the right side of the brain—can be educated so as to produce a very good handwriting instead, and better than the writing by the left arm.

The fourth point of importance is one on which I shall not dwell, as it implies a knowledge of medicine that you have not, but I shall state it in only a few words. It is exceedingly rare that the leg is affected to the same degree by paralysis as the arm, and the leg, as you well know, is not a part which we develop as much in its movements as we do the right arm. If a patient is struck with paralysis, for instance, on the right side of the body, owing to a disease of the left side of the brain, he will lose more, if he does lose movement at all—he will lose more of it in the right arm which he has been accustomed to train than in the right leg. But, I repeat, that this argument cannot be understood well except by medical men. I pass it over therefore.

There is no reason whatever to object to our teaching children to make use of the two sides of the body. If you have been convinced by the arguments I have given that we have two brains, it is clear that we ought to develop both of them, and I can say, at any rate, as much as this, there is a chance—I would not say more, but at least I can say there is a chance—that, if we develop the movements of the two sides of the body, the two arms and the two legs, one just as much as the other, there is a probability that the two sides of the brain then will be developed, as regards the mental faculties, one as much as the other.

The facts that I have brought forward, the last especially—what I have called the four points of importance, and particularly the first three, show that there is a connection between the development of the brain as regards the mental faculties, and the development of the brain as regards leading movements in one side of the body. There is a great probability, therefore, that, if we give a good deal of attention, or, better, as much attention to the left side of our body as we give to the right, there is a great chance that we would have two brains, as regards mental functions, instead of one, as we have now. There is no doubt that we can improve the two sides of the body constantly. The facts I have mentioned as regards those children having atrophy on the left side of the body, do not leave room to doubt. It is clear we can develop the left side so as to make it exercise all the functions which exist in most of us in the left side of the brain, and, if so in cases of atrophy on one side of the brain, why not so in cases in which we have two brains? I think, therefore, the important point should be to try to make every child, as early as possible, exercise the two sides of the body equally—to make use of them alternately. One day or one week it would be one arm which would be employed for certain things, such as writing, cutting meat, or putting a fork or spoon in the mouth, or in any of the other various duties in which both the hands and the feet are employed. In this way it would be very easy indeed to obtain a great deal, if not all the undeveloped power possible to the individual. We know that even adults can come to make use of their left arm. A person who has lost his right arm can learn to write (with difficulty, it is true, because in adult life it is much more difficult to produce these effects than in childhood), and the left arm can be used in a great variety of ways by persons who wish to make use of it. It is perfectly well known that the left arm is employed in playing on the piano or on certain other instruments almost as well as the right arm. Therefore there is no difficulty in training children to make use of both sides of the body equally.

There is also another fact as regards the influence of training. Even in adults, who have lost the power of speech from disease of the left side of the brain, it is possible to train the patient to speak, and most likely then, by the use of the right side of the brain, the left side of those patients, with great difficulty, will come to learn. They always have more difficulty than do children, but they learn if they are taught in the same way. It is the same kind of teaching that we employ for a child when we try to make it speak; it is the same way that should be employed to teach an adult who has lost the power of speech. It is so, also, as regards gesture, and the rest. I have trained some patients to make gestures with the left arm, who had lost the power of gesture with the right, and who were quite uncomfortable because their left arm, when they tried to move it, at times moved in quite an irregular way, and without any harmony. There is an aptness acquired by training, therefore, even in adults, and, if so, that capacity exists in children, and as we well know that we can make a child naturally left-handed to become right handed, in the same way we can make a child who is naturally right-handed to be left-handed also. But the great point should be to equally develop the two sides. To point out this has been the principal object of this lecture; and I have now to thank you for having listened to these long and tedious details.

· ... e to the character of ... required to pro- ... (See PHONETICS.) The physical causes of linguistic change are accordingly to be understood, more definitely, as physiological causes. To the modern philologist, however, psychology is even more important than physiology. Its greatest contributions are to the ... of such problems as ... nted by the changes ... place in the meaning of w... those which are involv... the study of word order and the development of the sentence. The development of modern psychology and the strictly scientific character of its results are now bearing fruit to the advantage of philology. It is claimed by the veteran German psychologist Wilhelm Wundt, and with good reason, that psychology provides philology with the foundations on which its whole structure rests.

Philology as at present understood is an offshoot from the literary study of the Latin and ... ssics, and the traditions ... have been fetters ... ...aken off. So long as attention was concentrated on the written word, it was impossible to understand the true nature of language and the history of its development. It is essential to recognize that language is primarily that which is spoken, and that the written word in ancient and modern literature is an imperfect representation of the spoken word. In the scientific treatment of ancient languages we must endeavour to deal with them as far as possible in terms of speech. But, further, the language of books, or the literary language of a people, is a very small part of human speech, and must not unduly influence our conceptions of its essential character. Its distinctive features are peculiar to a very limited stage in the history of ... age; it is more ar- ... racter than other fo... ...h, and the moulding inn... of linguistic history are no... studied there to the bes... ntage. This leads us to ar... consideration: the starting-... of linguistic study should be ... modern languages with which ... are most familiar. Here our k...owledge is direct, and the record is fullest. This is particularly the case in the department of phonetics. We are never independent of the imperfect and misleading representations of writing except when we hear the speech of a people with our own ears. The postulate of the modern philologist in this matter is that the forces which operate to-day are those which governed the development of the past also. It is, in fact, the application of this principle which is the historian's chief protection against mere random speculation. The study of modern languages receives its most valuable supplement from the comparative study of languages belonging to the same family. Comparative philology illuminates in a most welcome manner the remoter periods of linguistic history. The special attention naturally devoted to the study of the Indo-European group of languages has proved in one respect prejudicial. It has too readily been assumed that the history of language in general might be judged in the light of the development in this one family. It is only within quite recent years that investigations into the structure and history of other languages of quite a different character have had their proper influence on the statements which are made regarding the general history of human speech.

Speech-sounds.—Man's capacity for producing sounds by the use of his vocal organs is the primary physical condition which has made the acquisition and development of language possible. The primitive nature of this capacity is evident from the extent to which it is possessed by the animal world in general. The expression of feeling by the involuntary utterance of sounds may be regarded as the initial stage in the development of language. The meaning of such utterances is in many cases easily comprehended, and often calls for an immediate response. The superiority of vocal expression over mere gesture, and especially its greater adaptability, has been the chief condition of its further development. The number of sounds used in any one language is comparatively limited, and although there are considerable differences between languages in this respect, the total number of speech-sounds in use is not very great. This may be explained as the result of a process of unconscious selection. The best sounds, those most easily produced and distinguished, are those which have survived. It is not to be supposed that primitive man used fewer sounds than his descendants now employ. The opinion that the earliest historical languages, such as the parent Indo-European speech, possessed a very simple vowel system, is no longer maintained. In any case, even such a language is very remote from the speech of primitive man. It is also an error to assume that very simple combinations of sounds were alone employed by primitive man. Complexity in this particular is not the result of invention or development; it is given from the beginning in the fundam... constitution of the human ... ism. The simplicity of prim... forms of speech does not ma... itself in the sound-combinations which they employ.

One of the best established results of modern investigation into the history of la... is the conclusion that a never-en... ing and never-resting process of sound-change is at work in every language. The fundamental conditions of this proc... chiefly these:—(1.) Wh... monly called the ... ciation of a word o... fluctuates within ... Even the pronun... individual is only ... mate... the same at diff... in different se... opens the door ... shifting or displa... pronunciation of a sound. (2.) Language is ... stantly being ... generation to ge... this process is partic... to alteration. Children ... the language of ... imitation, and ... acquire it perf... speaker is con... sporadic 'mis... most part th... common to man... they may final... was originally ...

The extent ... changes triump... area of a linguistic ... striking evidence of its ... Even when we d... not ... the causes ... changes, they may ... as empirical laws. ... are invariabl... the ... which they a... wherever the con... same the results are ... Philologists assume that ... no chance or arbitrariness ... changes that take place; ... effect has its ... may accordin... the uniform ... observed to ... form causes ... rate of speec... ment in the p... may produce ... These in tu... tion, and it ... times in the ... ture of other ... ally speaking, ... is to the ope... physiological ... causes. In t... phonetic chang... of physiology was ... nized than that of p... It may be maintained that ne... of them in isolation supplies a sufficient explanation of any sound-change at all, although sometimes the one and sometimes the other throws light on the dominating influence. For particulars regarding speech-sounds and their relations, see PHONETICS.

Word Forms.—Modern research into the origin of words and their history has been greatly influenced by the doctrine of 'roots.' The roots of a language were got by stripping off all the formative and inflectional elements in a group of words related in meaning. The common element in these words, when there was one, was regarded as the 'root' from which they were all derived. There are, of course, roots common to every group of cognate languages—Teutonic roots, for example, and Indo-European roots. These for a long time were supposed to be a part at least of the actual vocabulary of the parent Teutonic or Indo-European or other early language. According to this hypothesis, materials were available for a partial reconstruction of every parent language, and various propositions were laid down regarding the monosyllabic and uninflected character of such early forms of speech. A better understanding of the history of language has greatly shaken this hypothesis of a primitive root stage at the beginning of the development. Inflections and formative syllables are not all necessarily originally independent words. Some, at least, may have been integral parts of certain words in a pre-inflectional stage. Besides, once inflections exist, new words are created without passing through any root stage at all, having a complete set of inflections from the beginning. The abstract meaning assigned to most of the roots is also an argument against their primitive character. These and similar considerations make it hazardous to assume that the 'roots' ever had a real existence. They are merely abstractions from groups of related words. The common elements designated by the name have probably originated in many different ways, and do not all belong to the same date even in the same language.

Any attempt to determine the history of word-formation must begin with an extensive survey of the actual processes of creation. These are historically verifiable in languages of the most different types. There are words and groups of words which may be regarded as the direct result of linguistic creation. They admit of psychological interpretation, and may also be grouped according to their phonetic character. Assuming that the physical and psychological constitution of man has been essentially the same from the beginning of linguistic history, the methods of word-construction thus ascertained are transferable to the period of the creation of the earliest human vocabulary. Obviously there are types of word-formation which cannot be attributed to the earliest stages. At every stage except the earliest, pre-existing forms exert a powerful influence. The deliberate invention of words, again, is apparently confined to late periods and the languages of civilized peoples. There remain, however, at least two types of word-creation which may be regarded as primitive. (1.) Simple sounds or syllables are repeated in the production of such words as 'papa' and 'mama' (both of these are widely diffused words and necessarily very old). (2.) Man imitates the cries of animals and the sounds which he hears in nature. The words so produced are a subdivision of onomatopoetic words. Although most of the words of this class which are capable of identification are late products in the languages to which they belong, there is every reason to assume that they have been continuously created and re-created from the earliest times. Two methods of formation of special importance in the later history of language may also be named. (1.) New words arise by slight modifications of older words; sound differentiation supplies every language with new words. For example, English 'than' was originally the same word as 'then.' 'He is better than I' = 'he is better, then I.' (2.) Words are compounded together into new words. This is by far the most general and important means of adding to the vocabulary of a language. The originally separate elements coalesce more and more closely until at last every trace of the process is lost. English examples from different stages of the process are—'bag' and 'baggage,' 'upperhand,' 'greatcoat,' 'fifteen,' 'coverlet,' 'firstly,' 'king.'

Formative and inflectional syllables arise in the course of the development of the parts of speech. Languages differ very much in the extent to which they distinguish the forms and even the sentence position of these word classes. (See PARTS OF SPEECH.) Of all the classes nouns occupy by far the most important place. In every language, it is said, they exhibit a highly developed and complex variety of forms, and that even when the other classes, such as the verbs, are of the most rudimentary character. Closely related to the noun in the similarity of treatment accorded to it comes the adjective. Very often the two classes are not distinguished from one another. Of the pronouns the personal, possessive, and demonstrative pronouns are primary, and generally appear as distinct groups. The evidence of many languages makes it clear that the other pronouns are developments of these. Verbs, apparently, strange though it may appear to us, do not exist as a distinct class in most languages; but when they do appear, they assume highly specialized forms, and obtain a dominant position in the sentence. Interjections belong to the most primitive stage of language, and are everywhere represented. The use of adverbs, prepositions, and conjunctions is largely determined by the development of nouns and verbs. They are evidently differentiated for the most part from other parts of speech. Conjunctions, in particular, are late products in the history of language, and are still of no great importance in many living forms of speech.

Word Meanings.—The history of the relation of word forms to their meanings and of the changes which take place in the meaning of words is itself a vast field in philology. The causes of change are primarily psychological. Historical circumstances may are an important influence on the course of the development, but the law according to which change takes place is invariably psychological. That being so, the best classification of the phenomena is no doubt one based on the operative causes of change—*viz.* the various laws of association. A favourite classification is according to results, distinguishing cases of the extension or limitation of word meanings from others in which old and new meanings join side by side. This is not so instructive as the psychological classification, which makes prominent the causes of change. Every one is familiar with the manner in which a word acquires a new meaning because of the analogy perceived between the object it denotes and some other object: for example, the 'foot' of a table or of a hill is compared with the foot of an animal, and the word 'foot' thus acquires a new meaning. The constant use of the word 'town' for a particular town (say London) gives the expression 'town' a new meaning, and so forth. The very same psychological processes account for the changes in the meaning of terminations and grammatical forms in general. Prepositions and adverbs are frequently nouns in a specialized sense, which has been acquired from repeated use in circumstances which suggested more to the mind than the word originally implied. For example, Latin *circum* is an old accusative; English 'needs,' in 'I needs must,' is an old genitive; 'meantime' was originally 'mean time.'

Sentences.—It is now generally recognized that it is inaccurate to suppose that sentences are possible only after words have been created to become the materials used in their construction. Sentences expressing certain feelings and wishes and thoughts are at least as fundamental in speech as words that name objects. Words as independent elements, as linguistic facts with a recognized individuality, are certainly to a large extent the result of abstraction from sentences. There has been and is still much controversy regarding the correct definition of a sentence. Two recent definitions may serve as specimens. Paul defines it as 'the symbol of the combination in the mind of the speaker of several ideas or groups of ideas and the means of producing in the mind of the hearer the same combination of the same ideas' (translated somewhat differently, *Principles*, p. 111). Wundt has criticised this definition at length (*Völkerpsychologie*, I. ii. 228–231). His own is as follows: 'the linguistic expression for the voluntary analysis (*willkürliche Gliederung*) of a complex mental state (*Gesammtvorstellung*) into its logically related parts.' Wundt recognizes incomplete sentences and 'sentence equivalents' in addition to sentences proper. There is some diversity also in the current classifications of sentences. Affirmative, hortative, interrogative, and exclamatory sentences appear to be the possible varieties of the simplest speech, and to be deserving of separate mention (positive and negative forms are both included). Other sentence types are of a specialized character, and are peculiar to special languages. There is much diversity between languages in respect of the complexity of sentence construction. Simplicity of structure is by no means an evidence of poverty of thought or of defect in the means of expression. The manner in which words are arranged in sentences also varies greatly in different languages. A free word order, comparatively speaking, seems to denote an early linguistic type. The emphatic elements in each sentence then come first, and the remaining words follow as best they can. Everywhere, however, types of sentences with a fixed word order tend to appear. We can only speculate regarding the circumstances which have created a preference in each case for some particular order. The more definite the word order becomes, the more useful is it in defining the relations of words to one another. A fixed word order and the multiplication of particles make a language independent of inflections, and finally lead to their extensive disuse, as in English and Chinese.

Linguistic Families.—The variety of languages is so great, and the transition from one to another often so imperceptible, that it is difficult to discover any principle of classification. The supporters of the root hypothesis maintained a distinction between isolating, agglutinative, and inflectional languages, which represented, they supposed, three stages of linguistic development. Such a view takes no account of languages such as English, which are passing out of an inflectional stage into an isolating period. The terms may, indeed, still be used to denote (1) languages in which the absence of inflections is conspicuous, and which keep subordinate and main words equally isolated; (2) those in which subordinate words are attached loosely to the main words by agglutination; and (3) those in which the subordinate elements have lost all independent significance and have become mere inflections. But apart from the doubtfulness of the hypothesis itself, languages will not fit into the framework which is provided for them. It is better to rest satisfied with the actual grouping of history, so far as that is known, and to arrange languages according to their genealogical relations. Among the best determined of these linguistic families are:—(1.) Indo-European, including Sanskrit, Persian, Greek, Latin, French, German, English, Norse, Welsh, Gaelic, etc. (2.) Semitic, including Arabic, Hebrew, Assyrian, Aramaic, Ethiopic, etc. (3.) Indo-Chinese, including Chinese, Tibetan, Siamese, etc. (4.) Ural-Altaic, including Turkish, Hungarian, Finnish, etc. (5.) Dravidian, in southern India, including Tamil, Telugu, etc. (6.) Malay-Polynesian. (7.) Bantu, in S. Africa, including about 150 different languages. Many linguistic types are to be found within the bounds of the same family, and races which are regarded as quite uncivilized may possess very highly developed languages. Inflections are by no means confined to the Indo-European and Semitic groups.

The Origin of Language.—The historical investigation of the earliest known languages leaves us far away from the beginnings of speech. We trace the Romance languages back to the Latin stock from which they sprang, and Latin itself back towards its nameless parent, the ancestor of the whole Indo-European group. There we stop, but only because we can get no further, not because this is the beginning of the development. Whatever account is given of the origin of language, it is simply what to us is comprehensible or conceivable, an account which is in accordance with the physical and psychological constitution of man as we know it, and in agreement with the history of the development of language in its later stages. When the philologist speculates regarding the beginnings of language, he endeavours to account even for the acquisition of its simplest forms. He does not suppose that man started with more than those rudiments of speech that the animals possess. He asks how the involuntary utterance of sounds in circumstances of pleasure and pain came to be recognized as significant and to be transformed into a means of communication. He finds in the language of gesture a stage preliminary to speech and an aid to its development. The sounds and the words and the sentences of man's earliest attempts at speech are investigated in the light of the phenomena of animal and infant life, and of languages which may be regarded as stages in the progress onwards. Some probable conclusions regarding the speech of primitive man have already been alluded to. The later developments are manifold, and their value is not to be estimated by their conformity to any one linguistic type, such as that presented by Latin and Greek.

See Friedrich Müller's *Einleitung in die Sprachwissenschaft* (4 vols. 1876–88), A. H. Sayce's *Introduction to the Science of Language* (2nd ed., 2 vols. 1883), W. D. Whitney's *Language and the Study of Language* (4th ed. 1884, substantially the same as the 1st ed. 1867), H. Paul's *Principles of the History of Language* (revised ed. 1891; trans. of 2nd German ed. 1886, *Prinzipien der Sprachgeschichte*, 3rd ed. 1898), Strong, Logeman, and Wheeler's *History of Language* (1891; an English adaptation of Paul's *Principles*), F. Max-Müller's *Science of Language* (2 vols. 1891, new ed. of his *Lectures on the Science of Language*), Skeat's *Philology* (1905), G. von der Gabelentz's *Die Sprachwissenschaft, ihre Aufgaben, Methoden und bisherige Ergebnisse* (1891; 2nd ed. 1901), Franz Misteli's *Charakteristik der Haupttypen des Sprachbaues* (1893, 2nd ed. of H. Steinthal's *Charakteristik*, 1861), Otto Jespersen's *Prog-*

ress in Language, with special Reference to English (1894), W. Wundt's *Völkerpsychologie* (vol. i., *Die Sprache*, in two parts, 1900; 2nd ed. 1904), B. Delbrück's *Grundfragen der Sprachforschung* (1901), *Einleitung in das Studium der Indo-germanischen Sprachen, ein Beitrag zur Geschichte und Methodik der vergleichenden Sprachforschung* (4th ed. 1904), and vols. of *Journal of Philology* (Eng. ver.).

Philomela, in ancient Greek legend, a daughter of Pandion, king of Athens; her sister Procne was married to Tereus, king of Thrace. Later, however, he was seized with a passion for Philomela, and dishonoured her. She and Procne then took vengeance on Tereus by slaying his son Itys and setting his flesh before him to eat. Discovering this, he pursued them with an axe; and they were transformed—Procne into a nightingale, Philomela into a swallow, and Tereus into a hoopoe. Such is the usual form of the tale, but some versions make Procne the swallow and Philomela the nightingale. Thus in English poetry Philomela or Philomel is used as a synonym of the nightingale.

Philopœmen (252 to 182 B.C.), soldier and statesman of ancient Greece, was an Arcadian, a native of Megalopolis. His energies were devoted to increasing the military strength of the Achæan League. He is first prominent in 222 B.C., when Cleomenes, king of Sparta, surprised and sacked Megalopolis. In the next year he had a great share in the victory won by Antigonus of Macedon at Sellasia over Cleomenes. For the next few years he was engaged in warfare in Crete. On returning, he was in 208 elected general of the Achæan League, and totally defeated and slew with his own hand Machanidas, the tyrant of Lacedæmon. This tyrant was succeeded by Nabis, whom Philopœmen defeated in 201, and again in 192. In 188 he took a terrible revenge on the Spartans, who had the year before executed thirty of his adherents, by capturing Sparta, razing its fortifications, putting to death eighty of its leading inhabitants, and selling three thousand into slavery. In 182 Messene deserted from the Achæan League. Philopœmen led an army to force it into subjection, but was overpowered by numbers, taken prisoner, and compelled to drink poison. In his patriotism, his energy, his military ability, and his personal courage, Philopœmen well deserves the name of 'the last of the Greeks.'

Philosopher's Stone. See ALCHEMY and ELIXIR.

Philosophy. This term is used in a wider and a narrower sense. In the narrower sense it is identical with metaphysics. In the wider sense it includes, besides metaphysics, logic, ethics, and psychology; and this group is sometimes swelled by the addition of philosophy of religion, philosophy of law, etc. For this latter addition there is little to be said. The natural clue to follow in determining the meaning of philosophy is the distinction and contrast between philosophy and the special sciences; and the more we subdivide philosophy into philosophies in this way, the more we tend to confuse and obliterate the distinction. Moreover, the philosophies in question seem to duplicate unnecessarily sciences which already exist under other names—*viz.* theology, jurisprudence, etc. The old term 'natural philosophy' is still used as a variant for physics; but the 'philosophy' in the title of this science is compatible with a lively abhorrence of metaphysics on the part of its exponents.

We may turn, then, to the traditional group of philosophical sciences—logic, ethics, and psychology. Morality, or ethics, is a quite definite and limited sphere or subject-matter, and is therefore, presumably, the object of a special science. And if it be argued that the study of ethics raises difficult metaphysical problems (such as free will), the same may be said of any other science if pushed far enough back. In point of fact, there is on the part of present-day moralists a growing tendency to free their science from dependence on metaphysical theories. Psychology, some would say, is now definitely recognized as a natural science, to be studied by the same methods as any other natural science; it has become a science of experimental research carried on in laboratories. It is true, of course, that when we regard psychology as simply the complement of that part of physiology which treats of the nervous system and the functions of the brain, it does then belong to the domain of natural science. But the whole significance of mind is not exhausted by pointing to its correlation with a bodily organ. And if in one aspect mind is as particular as the body or brain which is its organ, in another it is as universal in range as the objects which it knows. And for this reason some of the most eminent psychologists have expressly recognized that we cannot define the science in terms of a special subject-matter, and that the differentia of psychology as a science consists, not in dealing with a special department of knowledge, but in dealing with all or any knowledge from the point of view of its growth in the mind of the individual knower. Accordingly psychology, in so far as it is concerned with knowledge itself in one of its more general aspects, is a philosophical and not a special science. A similar claim on the part of logic to the rank of a philosophical science will be more readily admitted. For logicians have now largely abandoned that purely formal conception of their science which went far to deprive it of all serious significance; and it is evident enough that a science of science, or theory of inferential thought and scientific method, cannot be a special science in the same sense as those sciences are whose procedure it analyzes.

We must now consider what is meant by philosophy in the narrower sense of metaphysics. It was with Plato that the distinction between philosophy in this sense and the special sciences began to emerge, and by Aristotle that the distinction was first clearly laid down. Plato's name for what we should now call metaphysics is dialectic; but this dialectic, as he conceives it, is not a higher science that exists alongside a number of special sciences, but rather is itself the only true or ultimate science. It is therefore contrasted by him, not only, in the first place, as knowledge with mere opinion and sense-perception, but also, in the second place, as completely organized knowledge with the inferior sciences, if we may so call them, that proceed upon unexamined and unexplained assumptions. These inferior sciences—it is the mathematical sciences that Plato has primarily in view—are thus for him only a sort of propædeutic, by which the mind is aided to rise from the level of mere unreflective opinion to the conception and pursuit of the only true or ultimate science. With Aristotle, to whom we owe not only the foundations of so many of our sciences, but also a classification of scientific knowledge and a theory of scientific method, the special sciences gain a much more distinct recognition. Consequently metaphysics—which by Aristotle himself was called first philosophy or theology, the word philosophy being then used in a much wider sense—though still the highest of all the sciences, does not simply swallow up or supersede the special sciences, but has a place of its own alongside these in the general classification of scientific knowledge. It is the highest of the theoretical sciences, and is defined as dealing not with any special aspect of what exists taken in abstraction from other aspects, but with 'being as such' or with the ultimate nature and principles of the real.

But the conception of philosophy has undergone many modifications since Aristotle's time. Philosophers may no doubt be said in one sense to have always had before them one single aim, the same for all—*viz.* the attainment of the most fundamental kind of knowledge within the reach of human reason. But naturally their conception of that kind of knowledge which is to be regarded as most fundamental, and of the ways by which and the extent to which it can be attained, has varied alike with external conditions and with individual bias, as, for instance, the subordination of philosophy to theology in mediæval times, or the special predominance in the modern period of particular tendencies of scientific thought, such as the mathematical or the psychological. We do not propose to discuss these historical variations in detail, but merely observe that the great schoolmen of the middle ages, in spite of all their reproduction of Aristotle's doctrines and their deference to his authority, were separated from him by the impassable barrier of ecclesiastical dogma. And in the modern period, when philosophy was able largely to release itself from ecclesiastical restraints, it had other problems to struggle with that were alien to the thought of the Greek masters—such as the Cartesian dualism of mind and matter, the related difficulties raised by the dualism between perception or ideas and reality, the controversy between rationalists and empiricists, and all the problems which philosophy had accepted from theology, even though treating them from its own standpoint. Many such controversies and problems with which Plato and Aristotle were little troubled, or not at all, had to be worked through by modern thought before it could occupy the position which these Greek thinkers, partly by reason of simpler conditions, partly by reason of their own insight and genius, had held so long before.

The primary and outstanding condition which affects philosophic thought at the present time is the enormous development of the special sciences, which has for its inevitable consequence an ever-growing emphasis of the distinction between these special sciences, each with its own definite sphere and task, and philosophy, which seems to be left with no definite task or sphere at all. In Greek thought, although the distinction between philosophy or metaphysics and the special sciences had attained a definite expression, it was impossible, in the nature of the case, that the distinction could have at that time anything like the significance which it has for us now. For science and philosophy were constantly united in the same person. The philosopher Plato was an expert mathematician, and, roughly speaking, mathematics was then the only science that had reached any great degree of development. His great successor, Aristotle, may be said not only to have summed up in himself the whole scientific knowledge of his time, but also to have done far more than any other single thinker to extend the bounds and organize the work of scientific inquiry. Even in modern philosophy the conjunction of scientist and philosopher had long its eminent examples. Descartes, the great name with which the period opens, was perhaps even greater as a mathematician and natural philosopher than as a speculative thinker. Leibniz, who shares with Newton the origination of the differential calculus, combined with his speculative power wide knowledge and learning. Kant, before he produced his great philosophical works, wrote on physical science, anticipating in his speculations on the *Theory of the Heavens* the later theory of Laplace. In Hegel the superiority of philosophy to empirical science was an explicit feature of his very conception of systematic philosophy; and although he was hardly a specialist in science like his predecessors, yet the materials of his system were derived from a very wide range of positive knowledge, and he is universally admitted to have exercised a deep influence on historical and humanistic studies by his treatment of these subjects in the relative parts of his philosophy. Nevertheless with Hegel—or at least with the subsequent reaction against the type of philosophy which he represents—there begins to make itself felt more and more strongly a profound change in the relations between philosophy and science. Hegel was not content to deal in his system with those departments of knowledge in which he was most at home—abstract speculation or logic on the one hand, and humanistic and historical studies on the other. By the very character and comprehensiveness of his system he was driven to treat of the subject-matter of physical science as well, and for this task he was by no means so well equipped. Consequently his philosophy of nature laid itself open to scientific criticism—criticism all the more damaging on account of the lofty pretensions of his absolute philosophy. Hegel's is the last great system by which such pretensions have been made on behalf of philosophy. When we turn to the writings of the philosopher who is perhaps the greatest since Hegel's time, but who wrote in the midst of the reaction against philosophical absolutism, we find a very different tone. 'Though I venture,' says Lotze, in the preface to his *Logic*, 'to describe the present work as the first part of a system of philosophy, I hope that this designation will not be supposed to indicate the same pretensions which it was wont to herald in times gone by. It is obvious that I can propose to myself nothing more than to set forth the entirety of my personal convictions in a systematic form—such a form as will enable the reader to judge not only to what degree they are consistent with themselves, but also how far they are capable of serving to unite the isolated provinces of our certain knowledge, in spite of the great gaps that lie between them, into a coherent view of the world bearing the character of completeness.' The change of tone, quite apart from mere reaction, was inevitable. The enormous extension and continually-increasing specialization of science have made it quite impossible for any one man to think of comprehending, in Hegelian fashion, within the framework of a formally complete and rounded system, the masses of material that are now available. Philosophers like Lotze, or among living thinkers Wundt, who do possess an extensive working knowledge of this sort, are few. But the ordinary philosophical writer and teacher cannot pretend to any such scientific standing, nor expect, on the ground of his own acquaintance with scientific methods and results, any great amount of deference from men of science.

In these circumstances many are disposed to deny that a metaphysics in the older sense of a theory of the ultimate nature and principles of the real can be attempted at all, and to hold that all that philosophy can aim at is a theory of knowledge. Our metaphysics can no longer be an ontology, they would say, but must be satisfied to be an epistemology. It is not easy to determine exactly what is meant by this epistemology or theory of knowledge. For not only is metaphysics itself, on any view of its scope and task, concerned with our knowledge of reality; but knowledge is also the subject-matter in some sense of the other two sciences which we have already recognized as being philosophical rather than special—*viz.* logic and (in one aspect at least) psychology. It will be convenient, therefore, to consider at this point the distinction and relations of metaphysics, logic, and psychology, in so far as they all treat of knowledge. The distinction of psychology from the other two is the most obvious point: for psychology is concerned simply with the growth of knowledge in the mind of the individual, not with the knowledge *per se;* whereas it is with the knowledge itself as a connected system of reasoned truth that logic and metaphysics are concerned. A second point of distinction is that, while psychology is concerned mainly with the ordinary knowledge of the plain man, logic and metaphysics have to deal with knowledge in the more exact forms which the sciences have given it. Evidently, then, the epistemology which is assigned to metaphysics as its proper business will not consist in a mere psychology. The distinction between logic and metaphysics, when logic is conceived not as mere formal manipulation of propositions and syllogisms, but, in the Aristotelian fashion to which our chief logicians have now reverted, as the theory of science and scientific method, is less easy to make clear in thought or preserve in actual study. Perhaps the best statement to make is that, whereas logic is primarily interested in scientific knowledge from the point of view of its form and methods, metaphysics is primarily interested in attaining a systematic conception of its total content and results. Logic asks, What does science, as such, consist in, and by what methods are the sciences built up? Metaphysics asks, How far, on the basis of the results which science yields, can we form a single coherent view of the world and of our place in it, a view of the ultimate nature of reality, and the ultimate significance of human life? But the distinction between form and content is, after all, a very relative and fluctuating one. To take a single example, the logician who treats of inductive methods is inevitably involved in some sort of explanation and discussion of the notion of cause and effect; and no discussion of this notion can go far without involving us in the most difficult and far-reaching problems of metaphysics. Thus, in spite of our distinction, we must be prepared to find our logic running out into metaphysics, and to treat the distinction itself as a matter of convenience rather than of principle. If now we bring into relation with this distinction so regarded the above-mentioned view, that the only possible metaphysics is an epistemology, we must take this view to mean that the philosopher must be content with a logic of science, and must abandon the effort after any metaphysical system. And the objection to such a view is obviously that it tends to draw a rigid line of demarcation where we have just recognized no more than a rough and fluctuating distinction. If the fundamental conceptions and principles involved in a theory of scientific procedure are at the same time those which are involved in a system of scientific results—and this must surely be the case—then it is impossible to lay down dogmatically that these conceptions and principles can be sufficiently ascertained for the purposes of logical analysis, and yet are incapable of being used for the purposes of metaphysical construction. All that we can fairly say is, that the work of metaphysical construction may be very much more difficult than that of logical analysis just in proportion as it attempts to be more concrete and synthetic. It is one thing to analyze the characteristic methods of the various types of special science; it is another and much more difficult thing to pursue the implications and results of these methods so far as to discern the outlines of the total system towards which all special and partial inquiries must ultimately point.

So great, no doubt, does the difficulty of metaphysical construction appear when we think of the vast material supplied by the special sciences, that we cannot wonder that many who have no anti-metaphysical prejudices have also little or no metaphysical enthusiasm, and that others, less free from bias, would fain see metaphysics driven out once for all, and the special sciences put in sole possession of the field. But this latter attitude, at any rate, certainly goes too far. For even if there were no longer teachers and students of philosophy to cultivate the history and criticism of metaphysical systems, the philosophical impulse is too deeply rooted in the human mind not to reveal itself sooner or later in other directions. The specialist himself is only too apt to turn philosopher; and ignorance of previous work in the subject is no more likely to be an advantage in philosophy than in science. And, after all, it is possible to exaggerate the difficulty produced by the mere extent and specialization of science. The more fundamental problems of human knowledge undergo, no doubt, great modifications as knowledge progresses, but they do not often undergo very profound or very sudden revolutions.

Another and perhaps a greater difficulty is raised by those who at the present time would supplant metaphysics, not by the special sciences, but by the doctrines of religion—who are willing, and even forward, to renounce all metaphysical speculation, since they see in the practical certainties of religious faith the true resting-place of man's belief. This view, which is often connected with an acceptance of the analogous philosophical theory of Kant, is in its developed form the doctrine of a theological school, and would by no means be accepted by theologians generally. But it has at least the merit of being definite; and when we leave it out of account, it is hard to say what account of the relations of philosophy and theology would satisfactorily represent the present state of opinion. For, on the one hand, theology itself is in a very transitional stage, and in their struggle with the problems opened up by historical criticism theologians are apt to pay but little heed to the more philosophical questions raised by their dogmatic creed. And, on the other hand, philosophers are apt either to ignore the doctrines of religion altogether, or, what is worse, to assume with easy confidence that, as philosophers, they know all about religion already, and need not trouble to ascertain the views of those whose faith and bent of mind have made religious thought the business of their lives. Perhaps the fairest general statement we can make is that in the meantime philosophy and theology pursue each its own way without much reference to the other. So long as the present transitional stage of theology continues it is difficult, if not impossible, for the philosopher and the theologian to come to terms.

The most generally serviceable introduction to philosophy is that of Külpe (trans. 1897). Croom Robertson's *Elements of General Philosophy* (1896) is rather more elementary, and has the advantage of a more historical plan. Sidgwick's *Philosophy: its Scope and Relations* (1902) and Paulsen's *Introduction to Philosophy* (9th ed. 1903; trans. 1898) appeal to more advanced students. Among the histories of philosophy, Windelband's (2nd ed. 1899; trans. 1900) may be specially mentioned on account of its plan of dealing primarily with the problems of the several epochs rather than with individual thinkers taken separately.

Philostratus (c. 170 to 250 A.D.), a Greek rhetorician, and a native of Lemnos, who spent most of his life at Rome. The most important of his works is his *Life* of *Apollonius of Tyana;* the others are *Lives of the Sophists; Heroica*, which treats of many points connected with the Trojan war; *Imagines* or *Pictures*, descriptions of a number of famous paintings; and *Letters*, mostly specimens of love-letters, written to show his versatile power. On the whole he is an interesting writer. His works have been edited by Kayser (1844).

Philotas, a son of Parmenion, one of the generals of Alexander the Great, distinguished himself as commander-in-chief of the Macedonian cavalry; but in 330 B.C. he was accused of conspiracy against Alexander's life, and was executed.

Philtre, a love-compelling magic potion or charm, common in decadent Greece and Rome, in mediæval Europe, and still in use in the East.

Phintias. See DAMON.

Phipps, CHARLES JOHN (1835–97), English architect, was born at Lansdowne, near Bath. In 1862 his design for the Bath theatre was accepted, and from that time onward his name is associated with theatrical works, of which the chief are the Gaiety, Savoy, Her Majesty's, and Garrick in London, and others at Sheffield, Liverpool, Nottingham, Edinburgh, and Glasgow.

Phiz. See BROWNE, HABLOT K.

Phlebitis, or inflammation of a vein, has a double connection with thrombosis, since a thrombus leads to inflammation of the adjacent vein wall, and, on the other hand, an inflammatory condition of the lining membrane of the vein induces thrombosis. The condition is painful, and is very dangerous if the thrombus be septic, or if it be loosely attached to the vein. In the latter case the clot may be carried to the heart by the blood stream, and give rise to embolism. Varicosity and weakness of the vessel walls predispose to the affection, and puerperal patients are liable to a form of phlebitis known as 'white leg.' The most essential part of the treatment is continued rest until the thrombus is organized and firmly adherent to the vein wall. Soothing applications may also be applied locally.

Phlebotomy. See VENESECTION and BLEEDING.

Phlegethon (*i.e.* 'the flaming'), in ancient Greek legend, the name of one of the rivers which encompassed the infernal regions. It is often called Pyriphlegethon, 'flaming with fire.'

Phleum, a genus of hardy grasses, with long panicles of one-flowered spikelets, belonging to the order Gramineæ. The common timothy grass or cat's tail (*P. pratense*), is a well-known example. See GRASSES.

Phlogiston, a 'subtle fluid' that was supposed by Stahl (1660–1734) to be combined with a 'calx' or ash in combustible bodies, and to be given off from them when burning took place. This hypothesis was strongly supported in the 18th century, but was eventually upset by the acceptance of Lavoisier's deductions leading to the theory of the conservation of mass.

Phlox, a genus of hardy plants belonging to the order Polemoniaceæ. They have salver-shaped corollas with five equal petals. Some of the species of phlox are large-growing border plants, others are of dwarf creeping habit, and suited for the rockery. Among these dwarf species are the ground or moss pink (*P. subulata*); while, of the taller phloxes, most of the garden varieties are descendants of *P. maculata* and *P. glaberrima suffruticosa*. There is another section of garden phloxes consisting of the numerous varieties of the half-hardy annual *P. Drummondii*.

Phocæa, an Ionian colony on W. coast of Asia Minor. It was a place of some prosperity, and founded other colonies, of which the most important was Massilia, the modern Marseilles. About 545 B.C. Phocæa was taken by Harpagus, general of Cyrus, king of Persia, and the bulk of the population emigrated to Corsica.

Phocæna. See PORPOISE.

Phocas. See BYZANTINE EMPIRE.

Phocidæ. See SEAL.

Phocion (402–317 B.C.), Athenian statesman and general, was elected strategus—one of the ten chief officers of state—as many as forty-five times. Yet he was neither a great statesman nor a brilliant general; but he was a man of incorruptible honesty and downright common sense and bluntness of speech. After Philip's victory at Chæronea he urged submission to the victor, and during Alexander's life he kept Athens from attempting any rash enterprise. In 376 B.C. he helped Chabrias to win the victory of Naxos; in 349 he commanded the Athenian forces in Eubœa; in 340 he aided the Byzantines against Philip, with success; in 323 he defeated a Macedonian force, which had made a descent on the coast of Attica. In 318 he was accused by his countrymen of having handed over the Piræus to Alexander, the son of Polysperchon, and was condemned to death.

Phocis, a country of ancient Greece, lay N. of Gulf of Corinth. Its territory was mountainous, containing Parnassus. Its history turns largely on the presence within its borders of the Delphic shrine. Delphi itself was held by a Dorian population, whom the Phocians on several occasions temporarily expelled, only to be expelled in their turn by the rest of Greece, in various so-called sacred wars, the last of which began in 356 B.C., and lasted until 346, when Philip of Macedon, at the summons of the Amphictyonic League, destroyed the Phocian power.

Phœbus and **Phœbe**, titles given respectively to Apollo, in his character of the sun-god, and to Artemis, as the goddess of the moon.

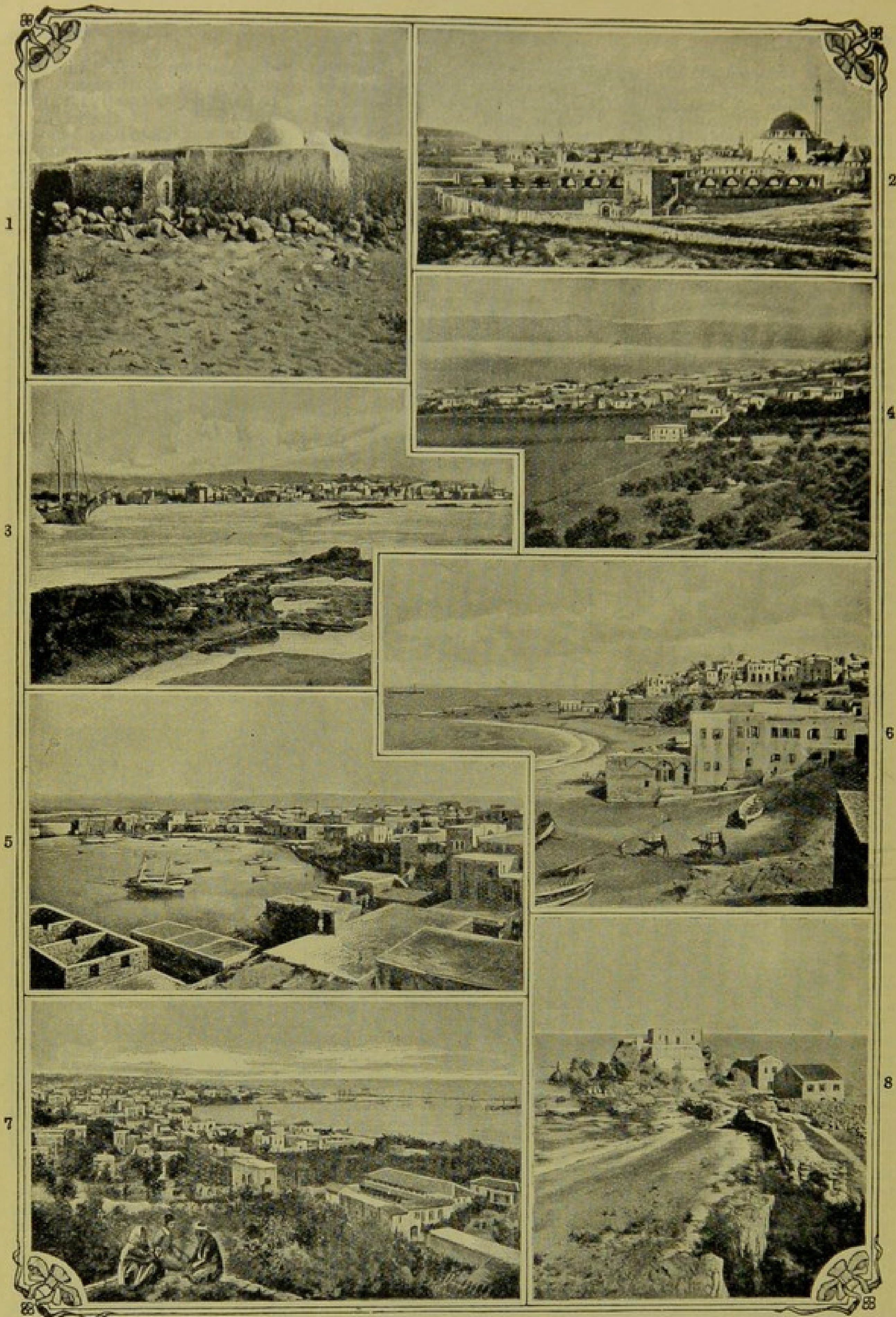
Phœnicia, the strip of Syrian coast between the mouth of the Orontes in the N. and Jaffa in the S., where Philistia or Palestine, the land of the Philistines, commenced. Phœnicia was essentially a land of seaports. The rocky slopes were terraced and planted with vines, olives, and other trees, and every available inch of soil was cultivated; but in spite of this, Phœnicia was never an agricultural country. It depended for its support upon the sea, and its prosperity was due to maritime enterprise and trade. The carrying trade of the ancient world passed into the hands of the Phœnicians; they had a monopoly of the precious purple dye, and their ships not only traversed the Mediterranean and Red Sea, but eventually made their way into the Atlantic. The Phœnicians called themselves Canaanites. The genealogical legends of a later day traced their descent from Khna or Agenor, but the origin of the name was really the geographical term Canaan, or 'lowlands.' In the cuneiform tablets of the Tell-el-Amarna (1400 B.C.) this is applied not only to Phœnicia, but to the larger portion of what we call Palestine as well. In the Old Testament it is employed in the same extended sense (*cf.* Num. 13 : 29). Arvad or Arados (now Ruad) was one of the most northern of the Phœnician seaports. It was built on a small island, but at a later date included a suburb on the mainland (called Antarados by the Greeks, Tartus by the Arabs), which stood near the older town of Marathos (now Amrit). Southward was the federal city of Tripolis, founded by Arvad; Sidon and Tyre, in the territory of Arka. Arka, the Arkite of Gen. 10 : 17, now Tell Arqa, was, like Zemar (Tell Sumra), inland on the slopes of the Lebanon. Arka and Zemar were fortresses of importance in the age of the Tell-el-Amarna tablets. Tripolis, on the other hand, is not heard of until the Persian period, and Delitzsch may be right in think-

Phœnicians trading with Early Britons.
From the painting by Lord Leighton in the Royal Exchange, London.
(*By permission of the Gresham Committee.*)

ing that it occupied the sites of the earlier towns of Makhallib, Maiz, and Kaiz. A long stretch of rocky coast divided Tripolis from Gebal (now Jebêl), the Byblos of the Greeks. Gebal was one of the oldest of the Phœnician cities, and was dedicated to the goddess Baalat. Here, too, the death of the god Tammuz was usually celebrated by the women when the floods of spring coloured the neighbouring river of Adonis (Nahr Ibrahim) with the red marl of the Lebanon. A few miles to the S. was Beruna or Berutu, Greek Berytos (Beirut), mentioned in the Tell-el-Amarna tablets, but owing its present importance as a commercial port chiefly to the events which followed the Damascus massacre of 1860. The ancient military road from Egypt to Asia led past Beirut, through the gorge of the Lykos (Nahr-el-Kelb), where the monumental records of the great conquerors of antiquity—Rameses II. of Egypt, Esar-haddon of Assyria, and Nebuchadrezzar of Babylonia—can still be seen. South of Beirut is Sidon (now Saida), the ancient cemetery of which has yielded many interesting monuments, including the sculptured sarcophagi of a Græco-Phœnician prince, now at Constantinople, which are among the finest productions of Greek art. Farther south again is Tyre (now Sur), originally built on an island 'rock' about 1,800 yards from the shore. On the mainland there grew up a town, to which the Greeks gave the name of Palætyrus, and which, it is probable, is the Usu of Assyrian inscriptions. In 332 B.C. Alexander the Great connected the island with the mainland by a mole during his seven months' siege of the city. Owing to the silting up of the sand, the mole has long since become an isthmus. Between Sidon and Tyre was Sarepta, the Old Testament Zarephath. Tyre claimed rule over the coast as far S. as Mount Carmel, the Rosh Qadesh (Kadesh) or sacred promontory of the Egyptian inscriptions of the eighteenth dynasty. The chief towns in this district were Achzib or Ekdippa (now Zib), and Akko (the modern Acre), which in the days of the Ptolemies received the name of Ptolemais. South of Carmel was the plain of Sharon, with its seaports of Dor (now Tantura), Arsuf (which preserves the name of the Phœnician sun-god Resheph), and Joppa or Jaffa. Here, too, Herod the Great transformed the tower of Strato into the magnificent city of Cæsarea. It is, however, questionable whether that part of the coast can, strictly speaking, be reckoned as Phœnicia. An Egyptian papyrus of the age of Solomon describes Dor as a city of Zakkal, who were related to the Philistines rather than to the Canaanites. At the same time, the whole of the coast was Canaanite before the incursions of Cretan pirates made it Philistine, and Jaffa was certainly of Canaanitish foundation.

According to their own traditions, the Phœnicians came originally from the Erythræan Sea (Herodotus, i. 1, vii. 89), which the fragments of Berosus identify with the Persian Gulf. Here were the islands of Arados and Tylos, in which Greek etymologists saw the names Arvad and Tyre. If we may believe Justin (xviii. 32-33), they had migrated from their home on 'the Syrian' (or, according to another reading, 'the Assyrian') 'lake' in consequence of an earthquake. This 'Syrian lake' is usually identified with the Lake of Nedjef, S. of the ruins of Babylon; Bunsen's suggestion that it represents the Dead Sea is out of the question. Equally unacceptable is the theory of Lepsius that the Phœnicians were colonists from the land of Punt on the Somali coast. The resemblance in physical type between the Phœnicians and the people of Punt, as depicted on the Egyptian monuments, can be accounted for by the fact that both belonged to the Semitic race. On the linguistic side the Semitic affinities of the Phœnicians do not admit of question. Their language—'the language of Canaan,' as it is called in Isa. 19 : 18—is

Bartholomew, Edin.



Scenes in Modern Phœnicia.

1. Site of Sarepta (Sarfeus). 2. Acre: view from the beach. 3. Sidon, from the sea. (Photo by Bonfils.) 4. General view of Kaiffa. (Photo by Bonfils.) 5. General view of Tyre. 6. View of Jaffa and the roads. 7. Beirut: the town and harbour. (Photo by Bonfils.) 8. General view of pier, Cæsarea.

practically the same as Hebrew, and the Tell-el-Amarna tablets show that it was spoken throughout Canaan before the Exodus. According to St. Augustine, the peasantry near Carthage, if asked who they were, still answered in Punic—the Carthaginian daughter of the older Phœnician—'We are Canaanites' (Chanani).

Sidon was the oldest of the Phœnician cities (Gen. 10:15). If Justin is to be trusted, Tyre was founded by refugees from Sidon after the sack of the latter city by 'the king of the Ascalonians.' Tyre, however, was itself of considerable antiquity. The temple of Melkarth, its patron god, was built 2,300 years before Herodotus (ii. 44), and in the Tell-el-Amarna tablets its riches are already celebrated. The city was at that time still confined to an island; and a century later, an Egyptian papyrus, which describes the adventures of a tourist in Canaan in the reign of Rameses II., states that drinking water was brought to it by boats. Arvad seems to have possessed at this period the largest and most formidable fleet; this at least is the conclusion which may be derived from the Tell-el-Amarna correspondence. The letters from Phœnicia in the Tell-el-Amarna collection are, like the letters from other parts of W. Asia, in the Babylonian language and script. But for many centuries the Babylonian kings claimed supremacy over Canaan and Syria, 'the land of the Amorites,' as it was termed; and the culture of Babylonia, including its language and literature, laws and theology, made its way to the shores of the Mediterranean. As far back as 3800 B.C. Sargon of Akkad had erected his image on the Phœnician coast, and made Palestine a Babylonian province. Khammurabi, the contemporary of Abraham, calls himself 'king of the land of the Amorites,' as did also his great-grandson Ammiditana. The limestone and cedar wood of the Lebanon had long since been imported into Babylonia for the temples and palaces of the kings.

Eventually Thothmes III. made Canaan an Egyptian dependency, and extended the boundaries of the Egyptian empire to the bank of the Euphrates. The Phœnician cities were placed under native governors. The Tell-el-Amarna letters were written when the Egyptian power was beginning to fail, and they set before us a curious picture of internal feuds and warfare between the Canaanitish governors, which the central authority was no longer able to suppress. Intrigues, moreover, were being carried on with Mitanni or Mesopotamia, with the Hittites, who had established themselves in N. Syria, and with Babylonia, which still hankered after the restoration of its ancient rule in the W. The fall of the eighteenth dynasty brought with it the loss of Canaan. Seti and Rameses II., indeed, of the nineteenth dynasty, once more restored the government of Egypt in Palestine and Phœnicia, but it was only for a time. The Phœnician cities became independent, though they lost their inland possessions; factories and colonies were established by them not only in the eastern and western Mediterranean, but even beyond the Strait of Gibraltar at Gadir or Cadiz, and their ships and trade multiplied until they became the richest people in the ancient world. Tyre gradually outstripped its sister states, and eventually occupied the position previously held by Sidon. Hiram, the son and successor of Abibaal and the contemporary of David and Solomon, first raised it to a commanding position. He restored and beautified the temples of Melkarth and the other chief deities of Tyre, enlarged and strengthened the city itself, introducing water into it from the mainland, and in conjunction with Soloman sent his fleet of merchantmen into the Indian Ocean. By the conquest of the old Phœnician colony of Utica he also secured a monopoly of the N. African trade. His sixth successor was Ethbaal, who cemented his power by an alliance with Ahab of Israel, to whom he gave his daughter in marriage, and by the foundation of Auza in Libya provided an outlet for the more adventurous spirits who might have been troublesome at home. During his reign the Assyrians first began to threaten the Mediterranean states of Asia, and it must have been soon after his death that the battle of Qarqar (Carcar) was fought (853 B.C.), in which they defeated a great coalition of the western kings, among whom were Ahab of Israel and Matin-baal of Arvad. In 842 B.C. Tyre and Sidon (which now formed part of the Tyrian kingdom) paid tribute to the Assyrian monarch Shalmaneser II. In the seventh year of the reign of Pygmalion or Pumai-yaton (820–774 B.C.), the fourth successor of Ethbaal, Carthage was founded by his sister Elissa, whom legend afterwards identified with the goddess Dido. A few years later we find Hiram II. paying tribute to Tiglath-pileser III. of Assyria, and his successor Metenna (c. 735 B.C.) compelled to purchase pardon for his resistance to the Assyrian king by a fine of 150 talents of gold (about £400,000). Under Metenna's successor Elulæus (Ulalai) Tyre was besieged unsuccessfully for five years by the Assyrian king Shalmaneser IV., and in 701 B.C. the same prince was attacked by Sennacherib at the time of his campaign against Judah, and fled for refuge to Cyprus. Tyre, however, remained uncaptured; but Sidon, Usu, Akko, and the other Phœnician towns over which it had held rule were lost to it for ever. Sidon rebelled against Assyria in 676 B.C., the result being that it was destroyed by Esar-haddon, who built a new town near it, called after his own name, while the trade it had enjoyed was diverted to Tyre. Tyre itself subsequently intrigued with Egypt against Assyria, and had to undergo another siege. This lasted into the reign of Assur-bani-pal, when its king, Baal I., submitted, and sent his son and heir Yahimelech on an embassy to Nineveh. After the fall of the Assyrian empire, Tyre, like Judah, resisted Nebuchadrezzar, and was besieged for thirteen years (587–574 B.C.). Its king, Ethbaal II., was eventually compelled to surrender, and the city thus became part of the Babylonian empire. For a time it was placed under *suffetes* or 'judges,' but a member of the royal family was at last allowed to return and govern the state in the name of its Babylonian sovereign. The Persian conquest made little difference in the condition of the Phœnician states. They were permitted to retain their native princes and to develop their trade. In return, the Persian kings had the use of their navies and maritime knowledge. It was this that made Alexander the Great especially anxious to destroy the power of Tyre. For seven months the city was blockaded, and was then taken with the help of a mole, partly constructed out of the buildings of Palætyrus. The inhabitants were massacred, and the town reduced to ruins. But it soon recovered, and seventeen years later resisted the attacks of Antigonus for eighteen months. Sidon had met with the same fate in 351 B.C. at the hands of Artaxerxes Ochus. Meanwhile trade was leaving the Phœnician towns. The Greeks were now masters of the Mediterranean, and their colonies were planted on its shores. Even Cyprus, one of the earliest of the Phœnician settlements, had become Greek. Carthage had driven the commerce of its mother land from the eastern Mediterranean, and Carthage itself, along with its Spanish possessions, was about to become a Roman dependency. The massacres and destruction which overtook the two leading cities of Phœnicia completed the downfall of the Phœnician states.

Phœnician religion was characteristically Semitic. Each locality had its Baal or divine 'lord,' who was supreme over the other deities of the place. He was absolute master of the locality and its inhabitants, but his power did not extend elsewhere. At Tyre, for instance, the supreme Baal was Melkarth, 'the king of the city;' at Beirut it was Eshmun. All good things were given by the Baalim; pain and misfortune were the consequences of their anger. Hence their worshippers sought to propitiate them by every means in their power. Parents sacrificed their first-born, and unmarried maidens prostituted themselves in the temples. The rite of circumcision, which was universal, may have had the same origin. The Baal was represented in human form, and though he acquired in time a solar character, his visible symbol being the sun, he ever remained a sort of divine king whose subjects were called upon to offer him all they had. By his side stood Baalat, the goddess, a pale and colourless reflection of the god. The chief goddess of primitive Canaan was Asherah, the goddess of fertility, whose symbol was a cone on the leafless stem of a tree; but she was thrown into the shade by Ashtoreth or Astarte, the Istar of Babylonia, from whence both her name and her cult were derived. Among the Phœnicians, however, Ashtoreth ceased to be the independent divinity she was in Babylonia; she became merely the consort and reflection of Baal; and at Sidon we even hear of an Ashtoreth who was Shem-Baal—'the essence of Baal.' Accordingly there were as many Ashtoreths as there were Baalim. Sacred stones were honoured as well as the gods. The worship of stones was a peculiarly Semitic custom, though in Phœnicia they came to be considered sacred not so much on their own account as because they were held to be Beth-els, or 'houses of god,' in which the divinity, or some particular divinity, was immanent. Certain trees also were accounted sacred, and were planted beside the shrines of the deities to whom they were consecrated, as were also the rivers and mountains, to each of which a Baal was attached. The temples, if we may judge from the one at Gebal, consisted of a long court, with a portico running round it, and an altar in the centre, and of the temple proper—a roofed building in shape like a rectangular box. The sacrificial tariffs of Carthage and Marseilles show that the sacrifices and offerings closely resembled those of the Israelites.

Phœnician art was a combination of that of Babylonia and Egypt modified in a special way. It is to the Phœnicians that we owe the alphabet, which they received possibly from Arabia in the 11th or 12th century B.C., and after adapting it to the expression of their language, handed it on to the Greeks, along with the names they had given to the letters. The manufacture of variegated glass, which was derived from Egypt, became one of the principal industries of Tyre; while Sidon was famous for its fine linen, the art of making which was probably a Babylonian invention. But the industry to which Phœnicia originally owed its wealth and fortune was that of dyeing with purple, obtained from the murex, or purple shell-fish. Factories and their colonies were established for the sake of the trade wherever there was a good harbour and the chance of a market, and Phœnician settlements grew up not only in the islands and on the coasts of the E. Mediterranean, but also in Sicily, Sardinia, and the northern coast of Africa. Tartessos and Gadir were founded in Spain, and Phœnician ships sailed northward through the Atlantic for the tin of the Cornish mines. According to Pliny, there were beams of cedar in the temple of Apollo-Reshpeh at Gadir or Cadiz which had been brought from Numidia 1,178 years before he wrote. See Perrot and Chipiez' *History of Art in Phœnicia* (1885); Bovet's *Egypt, Palestine, and Phœnicia* (1882); Rawlinson's *History of Phœnicia* (1889); and *Phœnicia* (Story of the Nations Series, 1889); Moore's *Carthage and the Phœnicians* (1905); and the works of Professor Sayce and of T. G. Pinches.

Phœnix Park, Dublin: The Viceregal Lodge.
(Photo by Lawrence.)

Phœnix, a southern constellation, located between Grus and

Eridanus by Bayer in 1603. The principal stars form a curved line. α Phœnicis, a solar star of 2·2 magnitude, was found by Sir David Gill to be in course of recession from the sun at the rate of 51 miles a second; β is a fine binary; ζ, θ, and κ are double. R Phœnicis varies from 7·4 to about 12 magnitude in a period of 270 days.

Phœnix, a genus of tropical palms. See DATE PALM.

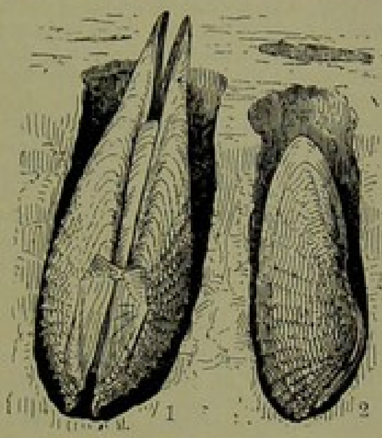
Phœnix, city, cap. of Arizona, U.S.A., co. seat of Maricopa co., on Salt R., a headstream of the Gila. Pop. (1900) 5,544.

Phœnix. (1.) In ancient Greek legend, a son of Amyntor, and king of the Dolopes, who took part in the Calydonian boar hunt; afterwards he fell out with his father, went to Peleus, and became Achilles's tutor, and accompanied him to Troy. (2.) A mythical bird, of which Herodotus tells us that it appeared at Heliopolis in Egypt once every 500 years, when it buried its father in the sanctuary there, enclosing his body in an egg made of myrrh. The bird was like an eagle, with feathers partly red and partly golden. Other stories tell that when the phœnix (of which only one existed at a time) drew near its end, it made a nest, out of which the new phœnix grew. The bird came to life in Arabia. Later stories told that the dying phœnix cast itself into flames, out of which the new one arose.

Phœnix Group, several small islands in the W. Pacific, about 1,200 m. N.E. of Fiji. They belong to Britain.

Phœnix Park, public resort, N.W. of Dublin, Ireland, 1,753 acres in extent, contains the Wellington Testimonial, Zoological Garden, and the Viceregal Lodge in the E. part. Near the last, Lord Frederick Cavendish, Chief Secretary for Ireland, and Thomas H. Burke, under secretary, were assassinated on 6th May, 1882.

Pholas, a genus of burrowing bivalve molluscs, whose members are known as piddocks in parts of England, where they are used as bait. The species of Pholas are found within such rocks as shale, chalk, limestone, and so forth. Like all burrowing bivalves, they have gaping shells, which are here pure white in colour, and have accessory plates of lime attached. The animal is furnished with long siphons, having fringed extremities, and during life these siphons are protruded from the burrows, so that water, containing food and oxygen, may pass in. Some doubt still exists as to the exact mode of formation of the burrow. The shell is delicately toothed, and some authorities believe that these teeth form a rasp with which the operation is performed; while, according to others, the large foot is an important agent in the process. In some parts of Europe and in parts of America species of Pholas are used as food. Common British species are *P. dactylus* and *P. candida.*



Pholas.
1, P. dactylus; 2, P. candida.

Phonetics is the science of speech sounds; it investigates their character, relations, combinations, and changes. Speech sounds are best defined in terms of the manner in which they are produced by the vocal organs. Acoustical descriptions in which words such as 'soft' and 'flat' are employed convey no clear conception of the character of a sound, and are altogether valueless as aids to pronunciation. A description of the position occupied by the vocal organs when a particular sound is formed provides a definite means of comparison with other sounds, and is also an indication of how an unknown sound may be produced. The physiology of the vocal organs is an important auxiliary in the study of phonetics. Speech sounds may be broadly classified according as the breath by which they are produced streams through the mouth channel or the nose channel, or through both together. (1.) When the breath passes through the mouth, the extent to which the passage is blocked is an important factor in the case. Sometimes (*a*) the breath is almost unimpeded (as in the case of vowel sounds); sometimes (*b*) the passage is narrowed so that the friction of the breath on the walls is generally noticeable (*f*, *th*); sometimes (*c*) the passage is completely blocked (*p*, *b*). (2.) Usually the entrance to the nose passages is closed when speech sounds are produced. It may, however, be open, whilst at the same time the mouth passage is in any one of the three positions just described. Hence there are three groups of nasalized sounds (*e.g.* nasal vowels as in French). (3.) In a third class of sounds the mouth passage is closed, and the breath streams through the nose passages only. These are nasal sounds in the strictest sense (*m*, *n*).

Several additional factors also contribute in the production of distinctive sounds. The part played by the glottis, the opening between the vocal cords, is important. When the stream of breath, as it passes, makes the vocal cords vibrate strongly, what is technically known as 'voice' is produced. (It is a kind of buzz in the throat which may be heard in *v* and *z* compared with *f* and *s*). Every voiced sound has a corresponding voiceless sound, and *vice versâ*, although both may not occur side by side in the same language. The glottis may also be used to add a peculiar force or emphasis to many sounds (as in the Semitic languages), and the manner in which the lips are set is another modifying influence.

The classification of speech sounds according to the character of the sound passage is not without its defects. The same sound passage may give rise to a fricative (friction sound), and to another from which friction is absent. In fact, the distinction between the groups 1 (*a*) and 1 (*b*), above, is merely of a general character. Besides, the classification separates certain sounds which are in certain aspects related. The factors which combine in the production of speech sounds are many, and the common character which some of these impart may be more prominent acoustically in certain languages at certain periods, and may affect sound change to a greater extent than the relations indicated by the classification.

All attempts to establish a complete distinction between vowels and consonants must be pronounced unsuccessful. The current opinion that a consonant cannot be pronounced except in combination with a vowel is quite erroneous. The sounds of *f*, *v*, *s*, and *z* are easily pronounced by themselves almost at the first attempt, and any consonants may be so pronounced after a little practice. Nor is it true, in languages such as English, French, and German, that vowels are essential elements in every syllable (*cf.* 'written' when pronounced *ritn*). In some languages there are words composed of consonants only. The vowel sounds are those included in groups 1 (*a*) and 2 (*a*) above; all the others are consonants. Consonants, with the possible exception of the 'stop' group, vary in length like vowels, but not so evidently. (See under L below.)

It is, of course, essential in phonetics that the signs used to denote sounds should be quite unambiguous, and that there should be one for each sound that is represented. Even English sounds are too numerous to be represented by the Roman alphabet which is in ordinary use. Six additional signs are required for consonants alone; but if digraphs are employed, two additions are sufficient. In this article *th*, *dh*, *sh*, *zh*, *ng*, and *wh* are used for the sounds in the words *thin*, *thee*, *shine*, *azure*, *long*, and *when* respectively. These sounds are, of course, simple sounds, not compounds, although two letters are here employed to represent each of them. On the same principle *kh* may represent the sound which occurs in 'loch' (Scotch). It is to be noted that *ch* in 'child' and *j* in 'joy' (or *g* in 'gem') do not denote simple sounds, and therefore are not referred to subsequently; *ch* = *t* + *sh*, and *j* = *d* + *zh*.

The phonetic representation of vowels is far more difficult because of their numbers, and because of the extreme poverty of the Roman alphabet in this direction. Murray (*New English Dictionary*) distinguishes fifteen simple vowels in English alone, without including those classed as 'obscure.' The English 'orthographical' representation of these is a perfect chaos, and is very remote from the original Roman system, to which most continental languages still approximate. (See articles on A, E, I, O, U.) In phonetics it is usual to give the vowel signs, as far as possible, their original values (found in such words as 'psalm,' 'men,' 'machine,' 'pull'). This is all the more necessary seeing that the English vowel letters in ordinary spelling represent largely diphthongs: the vowel in 'bone' is a compound o^u, and in 'name' a = e^i; English 'long i,' as in high, is, of course, a diphthong. It is important to observe that the vowels in 'pit' and 'peat,' 'men' and German *See* (French *été*), differ in quality as well as in length. The difference is that between what are called 'wide' and 'narrow' vowels. (See below.) Murray represents the former by i, e, etc.; the latter by the use of italics, *i*, *e*, etc. (so also this article). After the number of vowel signs has been in this way doubled, signs are still required, particularly for the English sounds in 'saw,' 'bird,' and 'bat.' For these Murray gives ǫ, ə, and æ. For the German sounds in *über* and *schützen*, ü^1 and ü^2 may be used; and for those in *schön* and *Völker*, ö^1 and ö^2.

What follows is a summary statement regarding the principal groups of speech sounds.

The stop consonants are formed by cutting off the stream of breath and suddenly releasing it again. They include *p*, *t*, *k*, *b*, *d*, *g*, in which the breath is cut off by the lips (*p*, *b*), point of the tongue (*t*, *d*), or back of the tongue (*k*, *g*); *b*, *d*, *g* are distinguished from *p*, *t*, *k* by being voiced, and at the same time more weakly pronounced. A very large number of different *t*'s (and *d*'s) are possible, according to the position of the point of the tongue as interdental, post-dental, etc. There are also a whole series of *k*'s (and *g*'s) according to the part of the palate which the back of the tongue approaches when the sound is formed. A front group and a back group are specially to be distinguished. The former is sometimes called palatal, and the latter velar.

In the Semitic languages a glottal stop is denoted by *aleph*. An ordinary cough is an exaggerated example of this sound. It is known to singers as the *coup de glotte*, and occurs frequently in German before initial long vowels.

Spirant consonants are also known as fricatives or continuants. Corresponding to the stop series *p*, *t*, *k*, *b*, *d*, *g* is a spirant series, *f* (*wh*), *th*, *kh*, *v* (*w*), *dh*, *gh*, in which the stream of breath is only checked, not stopped, by the lips, point of the tongue, and back of the tongue respectively. All the varieties noted above find their counterparts here, and in addition the degree of friction of the breath multiplies the possibilities. It is to be observed that English *f* and *v* are not pure lip spirants, but lip-tooth spirants (in which the obstruction is caused by conjunction of the lower lip with the upper teeth). A pure labial spirant occurs in the word 'nymph,' and was probably the sound of Greek ϕ. The aspirate combinations $p + h$, $t + h$, etc., are quite different from the spirants *ph*, *th*, etc. In Greek they appear to have been an intermediate stage in the transformation of stops into spirants. *wh*, when distinguished from *w*, is a voiceless *w*. Consonantal w is distinguished from the vowel u by a slight narrowing of the breath passage. A 'palatal' variety of the sound *gh* is represented by *y* in English 'yard.' (See letter Y.)

Another set of spirants are *the sibilants s*, *z*, *sh*, and *zh*. *z* is voiced *s*, and *zh* voiced *sh*. The blade of the tongue (Sweet's expression for the part immediately behind the point) seems to be prominent in the formation of *s*, but other factors also help to determine its character. There is a whole series of *s*'s, almost parallel to the *th* series, with which it is frequently confused by speakers whose native language contains no *th*. *sh* is defined by Sweet as 'point-blade.' The manner of its formation is still very obscure. *zh* is not common in English, but frequently occurs in French (as in *rouge*).

The *h* sounds may be reckoned throat spirants; but they are weak, and have a distinctly vocalic character. The strong Arabic ḥ is a throat spirant. Possibly the Semitic *ayin* is a voiced ḥ (Sweet). But it seems to commence with a glottal stop, and so to be closely connected with *aleph* (Sievers).

L and *R* are closely related in the manner of their formation, and therefore also in the history of language. The peculiarity of *l* is due to the breath escaping by the sides of the mouth or by one side. The centre is blocked by the position of the tongue. The greatest differences between *l* sounds depend on the extent to which the tongue blocks the exit of the mouth. English final *l* (as in 'ball') is a fuller sound than in French and German owing to its greater length, and to the hollow shape given to the tongue when it is produced. There are voiced, voiceless, and nasal *l*'s. Welsh *ll* (in 'llan') is a voiceless *l*, distinctly long and emphatic; it is a simple and not a compound sound. A shorter and weaker voiceless *l* occurs in French words such as *table*, and perhaps sometimes in English words such as 'plan.' The sounds denoted by *r* are a somewhat miscellaneous group. Those who are familiar with trilled *r*'s regard the trill as their most important feature. It may be produced in a variety of ways, principally by vibrations of the tongue (Scotch, Welsh, German), or by friction on the soft palate or uvula. The standard French *r*, the Northumbrian burr, and the Arabic غ are all varieties of uvular *r* (with or without friction of the palate). The tongue may, however, occupy an *r* position, and the breath be emitted without any trill at all. This is now the usual southern English initial *r*. Whether trilled or untrilled, a series of *r*'s may be produced by variations in the position of the tongue.

Nasals.—In the formation of nasal sounds the mouth passage is closed by the lips (*m*), the point of the tongue (*n*), or the back of the tongue (*ng*), and the breath escapes through the nostrils. There are varieties of nasals similar to the varieties observed in the case of the stop consonants. In particular the front and back varieties of *ng* are to be distinguished. Voiceless *m*, *n*, and *ng* occur regularly in Welsh.

Vowel Sounds.—The factors which determine the character of vowel sounds are chiefly the point of articulation by the tongue and the height to which it is raised;

further, the part played by the lips and the nasal passages. A classification based on the observation of these facts was first proposed by a Scotsman, A. Melville Bell, and has been adopted and developed by Henry Sweet and others. Three normal points of articulation of the tongue are distinguished—front, mixed (*i.e.* intermediate), and back; and three normal vertical positions—high, mid, and low. When the influence of the lips is taken into account ('rounding'=labializing), the result is eighteen typical vowels (3 × 3 × 2). Each of these eighteen positions of the vocal organs is said, however, to permit of the production of at least two vowel sounds by the intervention of another factor, which has not as yet been very successfully analyzed. It is described as narrowing, and the vowels so produced are 'narrow,' as distinguished from 'wide.' This gives in all thirty-six normal vowels, without taking account of nasal modifications. Actual examples of most of these thirty-six vowels are given by Sweet and Sievers, but of course the scheme is simply of a general character. The three points of articulation and the three vertical positions of the tongue are standards of reference from which there must be many variations in actual linguistic usage. In the second edition of his primer, Sweet attempts to classify the most important of these variations, and extends his table of 'elementary vowels' to include seventy-two in all. But the most doubtful part of the system is the separation between wide and narrow vowels, and the explanation that is given of the distinction between them. The place occupied in the scheme by the principal English, French, and German vowels is as follows:—

Back Vowels.—a and *a* are the signs for the unrounded mid-back vowels which occur in 'father' and 'but' (for *a* Murray uses *ɒ*). The rounded series are *u*, *o*, *ǫ* (high, mid, and low narrow) as in *sou* (Fr.) or *du* (Ger.), 'so' (Ger. and Sc.) and 'saw.' The sounds in 'full' and 'not' are the high-back and low-back wide vowels, u and ǫ respectively.

Front Vowels.—The unrounded wide series i, e, and æ (high, mid, and low) is complete in English (as in 'bit,' 'men,' 'man'); the narrow vowels *i*, *e*, and *ɛ* (high, mid, and low) occur in 'machine,' *été* (Fr.), and 'care.' Of the corresponding rounded vowels, *lune* (Fr.) gives the high-front narrow, and *peu* and *peuple* the mid-front narrow and low-front narrow or mid-front wide respectively (y, œ[1], and œ[2]). German ü[1], ö[1], and ö[2] (see above) are similar to but not identical with these.

Mixed Vowels.—Vowels of this class are not of frequent occurrence. The low-mixed narrow vowel is found in (southern) English 'bird' or 'curl,' and the mid-mixed narrow as the final vowel in German words such as *Gabe*. These and other mixed vowels occur also in diphthongs.

Nasal Vowels.—There are four nasal vowels used in French, in such words as *bon*, *banc*, *bain* (*fin*), and *un*. According to Passy, they are produced by nasalizing o, a, e, and œ[2] respectively. But the nasalizing of *o* and æ secures good results for the first and third, and a in the second case has some resemblance to English *ǫ* (*cf.* Vietor, § 71).

Supplementary consonantal signs.—Instead of *th*, *dh*, *kh*, *gh*, *sh*, *zh*, and *ng*, the signs þ, ð, χ or ɧ, ɣ, ʃ or š, ʒ or ž and ŋ are commonly used by phoneticians, and are scientifically preferable.

See L. Soames's *Introd. to English, French, and German Phonetics* (rev. by W. Vietor, 1899) is probably the best English book for a beginner. Other useful introductions are H. Sweet's *Primer of Phonetics* (2nd ed. 1902), P. Passy's *Sons du Français* (5th ed. 1899), W. Vietor's *German Pronunciation* (3rd ed. 1903), L. Soames's *Sounds of English* (ed. W. Vietor, 1897), Johannson's *Phonetics of the New High German Language* (1906). Larger works are Ed. Siever's *Phonetik* (5th ed. 1901), W. Vietor's *Elemente der Phonetik* (5th ed. 1904), H. Sweet's *Hist. of English Sounds* (1888), A. T. Ellis's *Early English Pronunciation* (1869, *sqq.*). J. Storm's *Englische Philologie* (2nd ed. 1892) contains full accounts and criticisms of the most important phonetic literature.

Phonograph. See TALKING MACHINES.

Phonography. See SHORTHAND.

Phonolite, or CLINKSTONE, a volcanic rock, consisting essentially of nepheline and sanidine felspar. It usually also contains some form of augite, hornblende, or biotite. Leucite, haüynite, and nosite are present in some varieties, but, like the nepheline, tend to decompose readily, and be replaced by fibrous or cloudy zeolites. They occur in Germany, Bohemia, France, and Italy.

Phormion, an Athenian naval commander of the 5th century B.C., who gained two victories over the Peloponnesian fleet not far from Naupactus, at the mouth of the Corinthian Gulf, in 429 B.C.

Phormium, a genus of hardy herbaceous plants, natives of New Zealand, and belonging to the order Liliaceæ. *P. tenax* is the New Zealand flax, and *P. Cookianum* is the small flax lily.

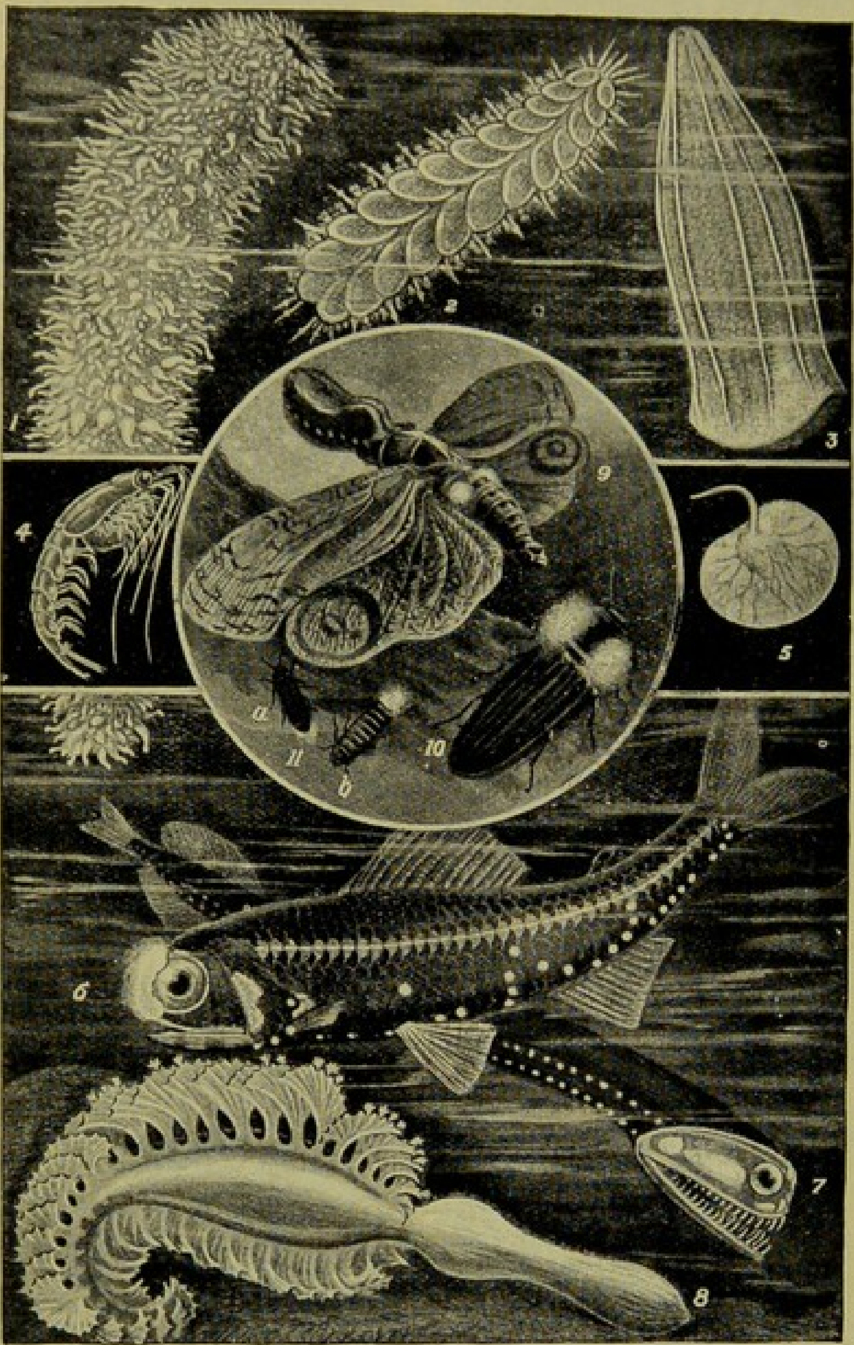
Phosgene, carbonyl chloride, $COCl_2$, the product obtained by the union of carbon monoxide and chlorine in sunlight, or by the oxidation of chloroform by sulphuric acid and potassium bichromate. It is a colourless, fuming gas, that produces violent coughing when inhaled, and is decomposed by water.

Phosphates, in agriculture, are the combinations of phosphoric acid with sodium, calcium, and ammonia. The ash of wheat contains as much as 50 per cent., while that of oats contains about 45 per cent., and that of peas about 33 per cent. This accounts for the value of such applications as bone, Peruvian guano, and superphosphate of lime.

Phosphatic Diathesis, a condition in which, owing to some defect in the digestive and assimilative process, the urine turns more or less milky, not being sufficiently acid to keep the phosphates in solution. Frequently the appearance recurs for a few hours about the same time each day. Any drug that renders the urine acid causes the disappearance of the symptom, but generally the best remedy is a more active, out-of-door life.

Phosphorescence, or THE PRODUCTION OF LIGHT, in plants and animals. Among plants the phenomenon is probably confined to certain bacteria and to some fungi. To luminous bacteria is due the phosphorescence of many decaying substances, especially rotten fish; sand-hoppers which feed upon such fish sometimes become themselves luminous. This association of luminosity with processes of putrefaction suggests an explanation of many sporadic cases of phosphorescence, whose causation is otherwise obscure. Luminous fungi belong to the genus Agaricus, several species of which attack trees and produce the luminosity of rotten wood.

The phenomenon is very common among marine animals, especially in pelagic and in abyssal forms. In terrestrial animals it is best marked in insects, where it is apparently always associated with sex, and is absent in land vertebrates. Among the pelagic Protozoa, Noctiluca is the usual cause of the phosphorescence of the sea. Among British forms of Cœlentera the following may be mentioned as strongly luminous—Beroë, the sea-pen (Pennatula), and the Portuguese man-of-war, an occasional visitor to our waters. Many jelly-fish are also luminous, as well as many deep-sea Alcyonarians. Among the worms luminosity occurs alike in terrestrial forms, such as the earthworm Photodrilus; and in marine forms, such as the common species of Polynoe, where the elytra or scales on the back are the seat of the light production. Among echinoderms luminosity is rare; while among the Crustacea it is common, especially among schizopods. In such a form as *Nyctiphanes norvegica*, for instance, there are special phosphorescent organs of complex structure in which the light is produced. Among insects, phosphorescence occurs in beetles and in Hemiptera (bugs)—*e.g.* the glow-worm and the fireflies. Phosphorescence is also known among the tunicates, the pelagic fire-flame or Pyrosoma being a conspicuous example. Among fish the phenomenon is frequent, the organs concerned in the production of light being often highly specialized in the deep-sea forms. A case of great interest is that of the deep-sea angler, in which the lure has a phosphorescent extremity.



Phosphorescent Animals.

1. Pyrosoma. 2. Polynoë. 3. Beroë. 4. Nyctiphanes. 5. Noctiluca. 6. Æthoprora effulgens. 7. Thaumatostomias atrox. 8. Pennatula (sea pen). 9. Lantern fly. 10. Fire fly. 11. Glow-worm: *a*, female; *b*, male.

Physiologically, phosphorescence is a phenomenon entirely parallel to the production of heat or of electricity, but the details of the process seem to differ in different organisms. The significance of the light differs also in the different cases. In land forms it would appear that it facilitates pairing by enabling the sexes to find one another. In pelagic forms it is believed to have some protective 'warning' significance; in Cœlentera, for example, its presence is associated with the power of stinging. In deep-sea forms, again, it is believed to be of use in illuminating the darkness of the great depths, and thus in enabling active forms to find their prey.

Physically, it is that form of luminescence in which a body which has been exposed to light and then placed in the dark emits light for a greater or less period. With some substances, such as the impure sulphides of calcium and barium (*e.g.* luminous paint, 'Canton's phosphorus'), the emission of light continues for some time after removal from the source; but with others, by far the greater in number, the phosphorescence is so momentary that a special apparatus, called a 'phosphoroscope,' in which by rotating screens the object is first exposed to the light and then to the eye, is required to detect it. Phosphorescence is affected by temperature; thus, warming up a surface covered with luminous paint increases its luminosity, whilst cooling it diminishes it. On the other hand, cooling some substances to the temperature of liquid air confers on them a power of phosphorescence they do not ordinarily possess. The wave-length of the light emitted by phosphorescence may vary with that of the source, but in general it is equal to or greater than it.

Phosphoric Acid includes several distinct compounds in which phosphoric anhydride, P_2O_5, is combined with different proportions of water; though, when used without prefix, it generally implies ordinary or ortho-phosphoric acid, H_3PO_4. This compound is obtained by boiling a solution of phosphoric anhydride in water, or, commercially, by treating bone ash with dilute sulphuric acid, and filtering and concentrating the solution. It forms a viscous liquid that crystallizes with difficulty, and mixes in any proportion with water to form a clean-tasting sour liquid. It behaves as a tribasic acid, forming three series of salts. Of these, common sodium phosphate, Na_2HPO_4, is one of the best known; while the yellow silver phosphate, Ag_3PO_4, obtained by adding silver nitrate to a soluble phosphate, serves as one of the characteristic products by which ortho-phosphoric acid can be recognized. On heating ortho-phosphoric acid to 250° C. water is lost, and pyro-phosphoric acid, $H_4P_2O_7$, is obtained—a tetrabasic acid that yields a white insoluble silver salt. On still further heating, meta-phosphoric or glacial phosphoric acid results

—a glassy solid that melts to a sticky liquid. It dissolves in water to form a sour solution that behaves as a monobasic acid, coagulates albumin, and forms a white and insoluble silver salt. Ortho-phosphoric acid is used to a small extent in medicine, and as a stage in the preparation of other compounds of phosphorus.

Phosphorite, an impure massive form of apatite, mined for the calcium phosphate it contains, and forming one of the chief sources of phosphorus and its compounds, and of artificial manures. It is found in Canada, Spain, Sombrero (island of W. Indies), and S. Carolina, and contains about thirty per cent. of phosphoric anhydride, P_2O_5.

Phosphorous Acid, H_3PO_3, is formed by acting on phosphorous trichloride with water or hydrochloric acid, and can be obtained crystalline by evaporating the solution. It behaves as a dibasic acid, and is decomposed on heating, giving off spontaneously inflammable phosphine and forming metaphosphoric acid. Phosphorous acid acts as a powerful reducing agent: for example, with mercury salts it yields metallic mercury.

Phosphorus, P, 31, an element occurring in allotropic forms—*viz.* 'white,' or 'ordinary,' and 'red'—which, though never found free in nature, is widely distributed in combination. Thus, it is an essential ingredient of the protoplasm of all living cells, and is present in well-marked amounts in nervous tissue and bones, composing in combination, as calcium phosphate, about 17 per cent. of the ash of the latter. Phosphorus is also widely distributed in minerals, the most important being the apatites, $3Ca_3(PO_4)_2CaF_2$ and $3Ca_3(PO_4)_2CaCl_2$, which are the main ingredients of the commercial phosphates derived from Canada, Spain, S. Carolina. The Redonda phosphate differs in that it consists of iron and aluminium phosphate. In preparing phosphorus by the older process, the phosphate, after being finely ground, is treated with sufficient dilute sulphuric acid to form ortho-phosphoric acid, the solution of which is filtered off from the precipitated gypsum simultaneously obtained. The liquor is then evaporated, and when sufficiently concentrated is mixed with crushed charcoal or coke and dried. The mixture is then charged into bottle-shaped clay retorts, a series of which are set in a furnace and heated to whiteness, when the phosphorus is displaced, and is led off, along with the combustible gases (H_2 and CO), through iron pipes into water, where it is condensed. The product is refined by fusing under water, and adding bichrome and sulphuric acid to oxidize impurities, the phosphorus being afterwards filtered and cast into wedges or sticks. The above method of preparation is now largely superseded by Readman's process of heating the crude phosphate with coke and sand in an electric furnace, when phosphorus distils off and a slag of calcium silicate is formed; the slag is then run off and fresh materials are added, so that the process may be carried on continuously.

Ordinary phosphorus is a waxy solid that is colourless when pure, and forms brilliant, highly refractive crystals when sublimed in a vacuum, though usually it is more or less coloured pale yellow or buff from the action of light or the presence of impurities. It has a specific gravity of 1·8; melts at 44° C.; boils at 278° C.; has a gas density of 64, and a specific heat of 0·19. It is practically insoluble in water, but dissolves freely in carbon disulphide and sulphur chloride, being also soluble, though to a less extent, in chloroform, aniline, and oils. Phosphorus is most marked chemically by the readiness with which it is oxidized: thus, it glows and gives off fumes of a garlic odour when exposed to the air, and the action which thus takes place often warms it up sufficiently to cause inflammation, which takes place a few degrees above its melting-point, and with exceptional readiness if the phosphorus is in the finely-divided state obtained by evaporating its solution in carbon disulphide. When set on fire in the open air, or oxygen, it burns with a dazzling white light, forming a snowy deposit of phosphoric anhydride, P_2O_5; but if burned in a current of air in a tube, the readily volatile and inflammable phosphorous oxide, P_4O_6, is produced. In chlorine, phosphorus burns with a livid flame, forming phosphorous trichloride, which is converted into the pentachloride with excess of the gas; while with metals fusible phosphides are, in general, obtained. Ordinary phosphorus is very poisonous, even small doses causing gastro-intestinal irritation; and though this may pass off, it is followed by fatty degeneration and internal hæmorrhage, which is usually fatal. Burns caused by phosphorus are very troublesome to heal; and the inhalation of the vapour, particularly by persons suffering from phthisis or carious teeth, frequently sets up necrosis of the jaw. When heated in the presence of its own vapour at about 250° C., ordinary phosphorus changes into an allotropic variety known as a red or 'amorphous' phosphorus, which is purified by grinding under water and boiling with caustic soda. The product is a hard, dull, purplish-red solid, without odour, and insoluble in water, carbon disulphide, or any ordinary solvent, and, although called 'amorphous,' is probably crystalline. It does not glow or fume in the air, and is probably incombustible as such, not catching fire till heated to a temperature above which its reconversion into ordinary phosphorus takes place. This occurs with increasing rapidity from 300° C. upwards. It is not poisonous.

Of the compounds of phosphorus the most important are the pentoxide; phosphoric anhydride, P_2O_5, a snowy solid that unites with water violently to form phosphoric acid; the chlorides, PCl_3, a fuming liquid, and PCl_5, a solid. The phosphide of hydrogen, phosphine, PH_3, formed by boiling phosphorus with caustic alkalis, is readily inflammable; the hypophosphites, simultaneously formed, are used in medicine.

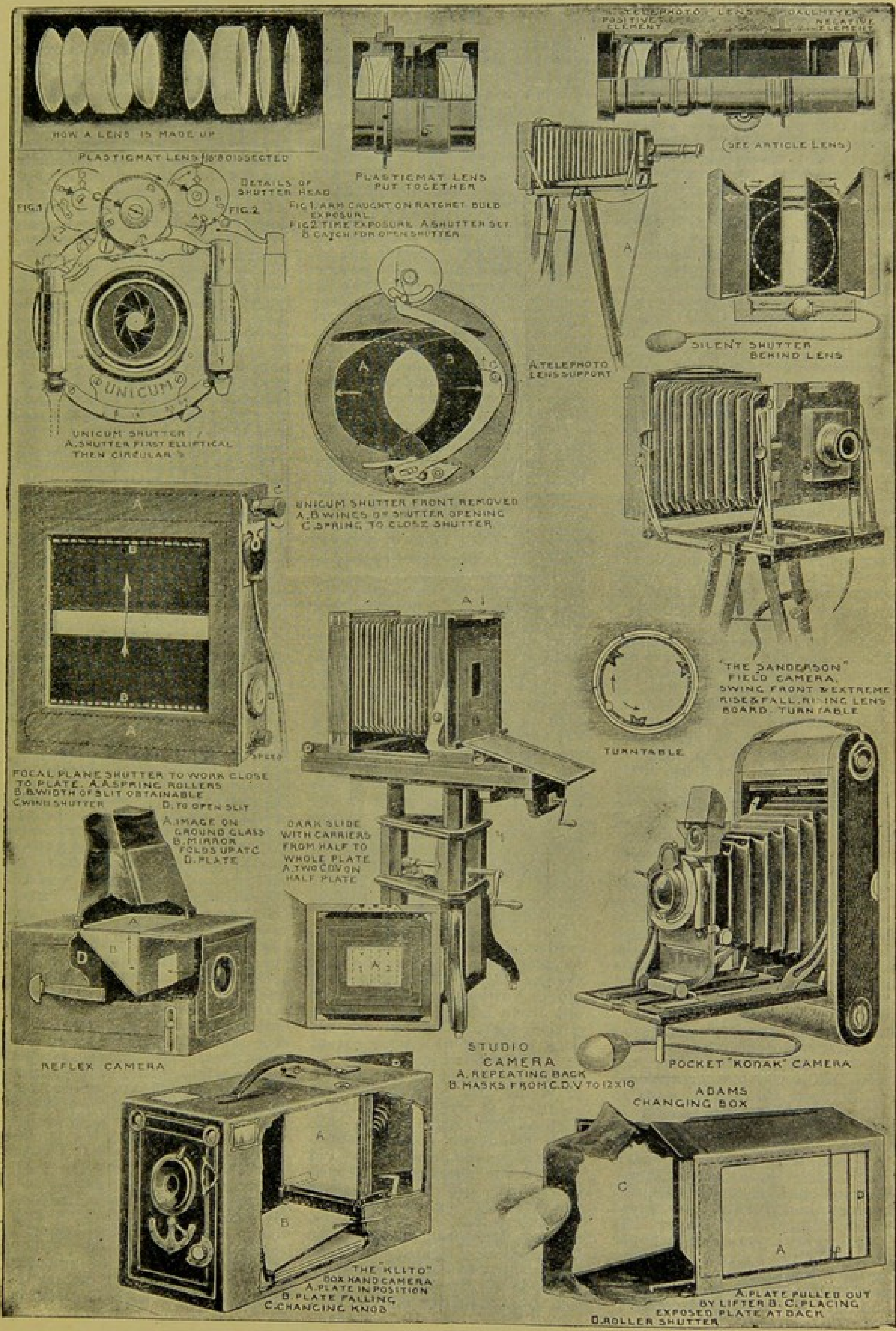
Ordinary phosphorus is mainly employed in match manufacture. Phosphorus sulphide is superseding common phosphorus to some extent, though matches made with it are more troublesome to strike. Red phosphorus is used for the rubbers of safety matches. Other uses of common phosphorus are for the manufacture of vermin-killer, the preparation of phosphor-bronze, to a small extent in medicine, and in the preparation of organic compounds. Of its compounds, phosphorus pentoxide is used as a desiccating agent; the chlorides of phosphorus in the preparation of hydrocarbon derivatives; and calcium phosphide for signal lights to be ignited by the action of water, which sets free from it spontaneously inflammable hydrogen phosphide.

Photius (*c.* 820–*c.* 891), patriarch of Constantinople, was suddenly elevated to that position from that of a layman by the Emperor Michael, in order that he might succeed the deposed Ignatius (857). This led to differences between the pope (Nicholas I.), who supported Ignatius, and the emperor. Photius, through a council held at Constantinople, effected the withdrawal of the Eastern from the Western Church; but in 867 the death of Michael forced him to flee. Ignatius was restored, and the union of the churches renewed. On the death of Ignatius, Photius was again installed (877), and recommenced his schismatic operations, though he did not effect the final separation of the churches. He was deposed (886) by the Emperor Leo, and banished to a monastery in Armenia, where he died. He left the *Amphilochia*, embracing treatises on theological and other subjects; as well as the *Myriobiblion*, a review of 280 books. His works are included in Migne, *Patrologia Græca* (101-4). See Hergenröther's *Photius, Patriarch von Constantinopel* (1867-9).

Photochemistry deals with those chemical changes that are brought about or accelerated by the action of light—*e.g.* those that determine the growth of green plants, are instrumental in the bleaching of colours, and are the basis of the various photographic processes. Photochemical change appears to differ in degree rather than kind from the action of heat, one form of energy being able to replace the other in, at all events, many instances. Thus, chlorine has comparatively little action on water in the dark; but in sunlight, or at a high temperature, oxygen is set free. In general it is found that the action is proportional to the intensity of the light; is not confined to particular wave-lengths, though special wave-lengths may be particularly active in specific cases, while the light loses its effectiveness by acting. It also seems probable that a certain minimum of light is needful to start action, which then increases more rapidly than the illumination, till a point is reached at which the two become more nearly proportional. The behaviour of light differs also as to whether it produces a visible or an invisible or 'latent' change, that requires the action of some reagent or developer to make it patent; and it is uncertain whether these are really different, or whether the second is only a stage of the first. It may be that such actions are rather of the nature of a strain, that makes the molecules more easily acted on than a positive formation of new chemical compounds. Most photochemical actions are primarily decompositions: thus, with chlorine and hydrogen mixtures, from experiments on which most of the exact photochemical data are derived, the first step in the action is probably the disintegration of the chlorine and hydrogen molecules into atoms, which are then free to combine to form hydrogen chloride. With elements such as yellow phosphorus, which is converted to the red variety, and in the formation of the latent photographic image, the nature of the action is not so clear, but probably indicates a molecular rearrangement. The presence of water and oxygen, and the formation of hydrogen peroxide (the production of which in sunlight has been shown to hinder putrefaction, and has probably much to do with bleaching), have very important bearings on the chemical action of light.

Photography is the art of preparing permanent representations of objects by means of the light they emit or transmit. The earliest experiments in this direction were made by Wedgwood and Davy, who obtained prints of ferns, lace, etc., by placing them on paper or leather treated with silver nitrate and exposing to light. An image was produced by the darkening of the unprotected paper, but could only be examined in dim light, or the whole surface became equally black. The first photographs produced in the camera were made by Daguerre and Niepce (*c.* 1839), who sensitized a polished silver plate with the fumes of iodine, exposed it in the camera, developed it by means of mercury vapour, and fixed the resulting image by dissolving the unacted-on iodide with potassium cyanide. The image produced was a delicate positive, and though the long exposure required was diminished by using bromine as well as iodine, the process had the disadvantage that the image was very fragile, and additional copies could not be obtained. The next advance was made in 1841, by Fox Talbot, who invented the 'calotype' process. In this method paper sensitized with silver iodide was exposed in the camera and developed with gallic acid; the resulting image being a negative—*i.e.* reversed as regards light and shade, yielding positives in any number by printing on to a sensitive medium as in Wedgwood's process. This process was greatly improved by Scott Archer (1851), who introduced glass plates coated with a film of collodion as the medium to support the sensitive silver iodide. This was called the 'wet-plate' process, as the plates were used as soon as removed from the bath in which they were sensitized. The image was developed by ferrous sulphate or pyrogallic acid, and fixed with potassium cyanide. By a modification of the process the images, which are negative to transmitted light, could be made to appear as positives to reflected light, the plates being either blackened at the back or the collodion coated on to thin sheet iron ('tin types'). The negatives produced are of unequalled quality, but are troublesome to obtain, as the manipulation is difficult and the apparatus cumbrous; so the process has, except for photomechanical work and enlarged negatives, almost entirely fallen into disuse, and been replaced by that in which the gelatino-bromide dry plate is employed. This form of plate was invented in 1871 by Maddox, and greatly improved in 1878 by Bennett, who discovered that the sensitive emulsion was made much more sensitive by gentle heating. The method of preparing the plates is almost exclusively a factory operation, and varies much with different makers, but is briefly as follows:—A warm solution of gelatin and water, containing a soluble bromide, is mixed with a solution of silver nitrate so as to form an emulsion containing a fine precipitate of silver bromide. The emulsion is gently heated, allowed to set, washed, and then melted and coated on to the glass plates, celluloid films, or paper on which it is required. After drying, the plates are ready for exposure, and retain their sensitiveness unimpaired for years.

The camera in which the image is impressed on the sensitive surface is a light-tight box in which the plate is fixed in such a position that an image of the object to be photographed is projected on to it by a lens or pinhole. In practice the instrument takes many forms, according to the use to which it is to be put and the idea of the maker. The following are the chief types:—(1.) Stand cameras. Cameras to be used on stands, either of the portable tripod variety or the mechanically adjusted kind for the studio, in general consist of a leather bellows connecting a board supporting the lens at the one end and a frame to receive the focussing screen or plate-holder at the other, the distance between the two being adjustable in order that the image may be focussed on the plate. The lens is, as a rule, fitted with a mechanical shutter, so that the plate may be exposed for any required time, and adjustments are also provided to alter the position of the axis of the lens with regard to the plate so as to include the image of objects much above or below the axis, and yet keep the plate vertical. The plate-holders are flat boxes to hold one or two plates, in the latter case back to back, and are provided with sliding shutters which can be withdrawn when the plate-holder is inserted in the camera so that the plate may be exposed to light passing through the lens. (2.) Hand cameras are rarely larger than sufficient to take a plate 5 in. × 4 in., and are generally of lighter construction than stand cameras. They may be of a folding type, like small stand cameras, or of a box type that requires no adjustment before use. If plates are used, they are generally held in single or double plate-holders in folding cameras, or in magazines of various patterns in box cameras, the magazine being so



Photography—some common Types of Apparatus.

constructed as to hold a dozen or more plates which may be exposed one by one as required. For hand camera work the sensitive emulsion is more often coated on a celluloid film than on a glass plate, the film being either cut to the shape of a plate and used like it, or wound in a long strip on spools, so that successive lengths may be exposed as required. Hand cameras are provided with sights or finders so that they may be pointed in the required direction, the most effective appliance of this kind being provided in the reflex camera, in which the full-sized image formed by the lens is visible until the moment of exposure.

After exposure there is no visible change in the plate, the so-called 'latent image' being probably of the nature of a molecular disturbance, and requires the application of a 'developer' to produce the darkened products constituting the negatives. Chemically these developers are reducing agents, such as ferrous oxalate, alkaline solutions of hydroquinone, pyrogallol or other benzene derivatives. Development is generally carried out in a 'dark room' lighted by rays that do not appreciably affect the plate—such as red light for ordinary plates—and is carried on until an image of sufficient density is obtained. The image is then fixed by immersing it in a solution of sodium thiosulphate ('hypo'), which dissolves away the unacted-on silver compounds, and leaves the plate more or less clear in those places on which but little light fell when in the camera. Prints are then obtained from the negative by placing it in front of a piece of sensitized paper and exposing to light. The light passes through the negative most readily in the clearer portions, thus darkening the paper most at the places where little light fell on the plate when in the camera, and hence reproducing the shadows of the object. Similarly the high lights of the object produce opacity in the negative, and this gives light places on the print.

Formerly most photographic printing was done on paper sensitized with albumin containing silver salts, which when exposed to daylight through a negative gives a visible image. This image can be improved in colour and rendered more permanent by 'toning' with salts of gold or platinum, and is fixed by dissolving away unacted-on silver compounds with sodium thiosulphate. Of recent years albuminized paper has been largely superseded by paper coated with gelatin, or more rarely collodion, containing silver compounds, but printed out, toned, and fixed in a very similar way.

Silver compounds are also the sensitive agent in the various kinds of 'bromide' papers, which are papers coated with an emulsion similar to that applied to plates, but of a less sensitive character, so that they can be worked with in yellow light, or, even in some cases, gas light. They are given a short exposure through the negative so that only a latent image is produced, and are developed and fixed similarly to plates. Bromide prints are of gray or black colour, but can be toned to an agreeable sepia by converting the image into silver sulphide. They give more permanent pictures than the printing-out papers mentioned above, though perfect permanence is probably only to be obtained by processes that avoid the use of silver in the image.

Of these the platinum process, in which paper coated with platinum salts is printed till a faint image appears, and is then developed with potassium oxalate, yields a delicate gray image of great beauty and permanence. A modification gives fine sepia tones, but colours other than gray or black are probably best obtained by the carbon process. In this method the paper is coated with gelatin containing any desired pigment in a finely-ground state and sensitized with potassium bichromate. On exposure to light the gelatin becomes insoluble where light has fallen, so that on washing the print with hot water the pigment is washed away to a greater extent the less the light has penetrated, thus leaving the paper more or less white at the dark parts of the negative. The gum-bichromate process is a modification of the carbon process, gum arabic being substituted for gelatin, and yields a softer image, which is capable of considerable modification for artistic purposes.

One of the difficulties of accurate representation of objects by photography is that the rays that are visually brightest—such as reds, yellows, and greens—have but little action on the photographic plate. This difficulty has been got over to a large extent by the introduction of isochromatic or othochromatic plates in which the gelatino-bromide emulsion is dyed with colours such as erythrosin, cyanin, etc., with the effect of greatly increasing the sensitiveness at the red end of the spectrum. If such plates are aided by filtering the light falling on the plate through yellow or orange glass, a much truer representation of the relative brightness of different colours is obtained. Such methods are essential when photographing pictures, flowers, etc., and are probably better in every case.

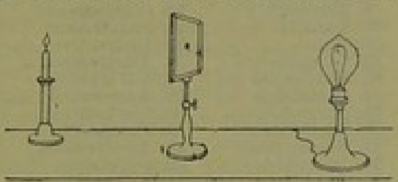
With regard to the photographic representation of colour itself, the results of a great mass of research are hardly encouraging. The only process by which colours have been directly produced in the camera is the interference process invented by Lippmann; but the process is extremely difficult to carry out, and the results have only a scientific interest. Indirect processes, such as the three-colour processes of Ives, Joly, Sanger Shepherd, and others, certainly produce coloured transparencies such as lantern slides, which are in some cases wonderfully effective; but the colours are produced by dyes, and the processes are cumbrous, and ill suited for the production of prints on paper. For the details of such processes, as for the special methods employed for photomicrography, telephotography, etc., one of the works mentioned below must be consulted.

The application of photography to pictorial purposes is more a matter of artistic sensibility, power of recognizing suitable subjects, and the like, than of skill in managing photographic apparatus. It is therefore unlikely that the application of any system of rules will produce pictorial work of a high order, though the following hints may be of service to the beginner. In the first place, the success of the picture must depend on its power to create pleasant thoughts and imaginations apart from any arising from a knowledge of the spot depicted. It must mainly depend for its effect on the arrangement of the lights and shades in harmonious masses, detail being judiciously suppressed, as it is usually only distracting. In selecting a subject a knowledge of the rules of pictorial composition may be of value, but this is doubtful if their application is conscious rather than intuitive. The subject is often best lit from a point in front of the camera, as the rendering of 'atmosphere' is improved, and detail is suggested rather than enforced. Moving objects must not be taken with too short an exposure, or unreal attitudes result—water in motion appears frozen, etc.—and the idea of movement disappears. In general, manipulation of the negative to remove detail and suppress defects is permissible; but practically nothing in the way of hand work should be done to the print, as it is almost impossible to imitate the same quality of image as is produced in the chemical process, though, as in other branches of art, the end may often justify the means. The following books may be consulted for further information:—Abney's *Treatise on*

Photography; Wall's *Dict. of Photography* (1897); Beck's *Photographic Lenses* (1905); Bolas, Tallent, and Senior's *Photography in Colours* (1900); Dallmeyer's *Telephotography* (1899); Robinson's *Picture-making by Photography* (1902); Spitta's *Photo-Micrography* (1899); and Horsley Hinton's *Practical Pictorial Photography* (1890).

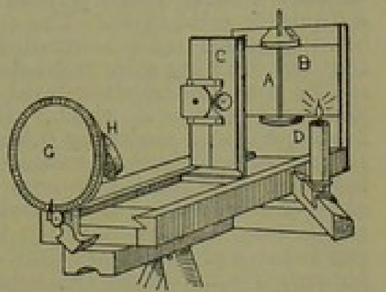
Photogravure. See PROCESS WORK.

Photometry is the measurement of the relative amounts of light emitted by different sources, by comparing them with a suitable standard. Photometer is the name given to the measuring or comparing instrument. The British unit of light is the candle-power, which is the light produced by a standard candle of weight six to the pound, burning 120 grains of spermaceti wax per hour. This standard is most unsatisfactory, as the candles may vary in composition and structure, errors may occur owing to slight inequalities of wick and cup during burning, also owing to draught, and even to a change from the normal temperature of



Bunsen or Grease-spot Photometer.

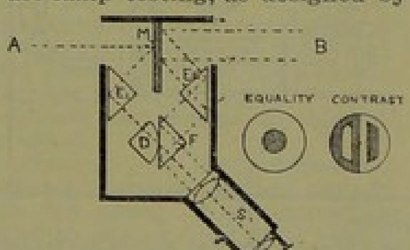
the testing room. The French standard is the Carcel lamp, a lamp burning 42 grams of colza oil per hour, with a flame 40 mm. high, and giving about 9·5 standard candles. In Germany a standard paraffin candle is used, and also an amyl-acetate lamp. Many attempts have been made to introduce more reliable standards. M. Violle, at the Paris Congress in 1888, proposed that the light emitted by a square centimetre of melted platinum at the temperature of solidification should be taken as standard; and another proposal was that it should be the light emitted by a square millimetre of the crater of a pure carbon arc. Mr. Vernon Harcourt has advocated a pentane standard. The Methven screen has also been proposed. It is simple and is much used in practical work. It consists of an Argand gas-burner, with chimney 6 in. by 2 in., and a flame, adjusted to 3 in. in height, placed behind a screen, in which there is a small vertical slot permitting the escape of light of about two-candle power. New glow lamps at their proper voltage are often used for rough tests after being standardized. There are many different kinds of photometers. Among the simplest are the Rumford and the Bunsen. The Rumford or shadow photometer is merely a thin rod fixed in front of a screen on which the two lights to be compared cast shadows. The lights are moved



Ayrton and Perry's Photometer.

B, Screen of blotting-paper to receive the shadow of the black rod A; C, frame, carrying lens with sliding shutter; D, candle holder; G, divided plate to show the angle which the ray of light under examination makes with the horizontal; H, plane mirror. The shadows of A formed by the electric light and the candle fall side by side on the screen B.

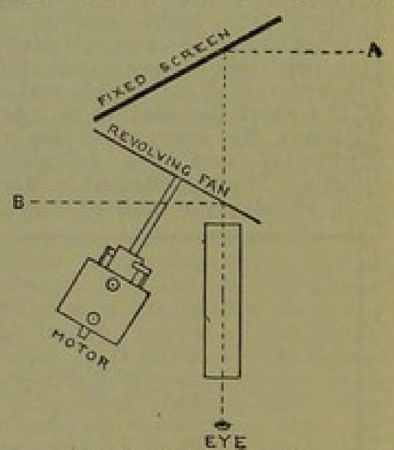
till the shadows are of equal intensity; the distances from the screen to the lights are then measured, and the comparative intensities deduced from the law of inverse squares. (See LIGHT.) The Bunsen, or grease-spot photometer, consists of a screen of rather opaque paper, with a star-shaped grease spot in the centre. The lights are placed on different sides of this, and moved till the spot disappears, when the distances are measured as above, and the same calculations made. A simple photometer may be made by clipping together two uniform cubes of paraffin with a piece of tinfoil between them. The blocks are placed in line between the two lights, and moved till equal illumination is obtained. In the dispersion photometer for arc lamp testing, as designed by



Lummer and Brodhun's Photometer.

A, B, The two sources of light; D, F, Lummer-Brodhun prisms; E_1, E_2, totally reflecting prisms; M, magnesia screen; S, telescope.

Professors Ayrton and Perry, a concave lens is used to disperse the rays instead of moving the lamp away to a great distance. Lummer and Brodhun's photometer is perhaps the most accurate, and consists of an optical arrangement by which the centre of one side of an opaque disc, that is illuminated by one light, is seen surrounded by a ring-shaped portion of the other side, which is illuminated by the other light. The brightness of illumination can thus be very accurately compared. With all the above instruments it is very important that the lights compared should be of the same tint, or it will be very difficult to decide which is giving the brighter illumination. This difficulty is got over in the 'flicker' photometer, in which the surfaces illuminated by the two lights are presented to the eye in rapid succession, when a peculiar flickering effect is produced if they are not of equal intensity; difference in tint does not cause any difficulty. Finally, in all photometric work it is important to exclude outside light and to prevent the lights compared from being transmitted except in the required direction. A specially darkened room lined

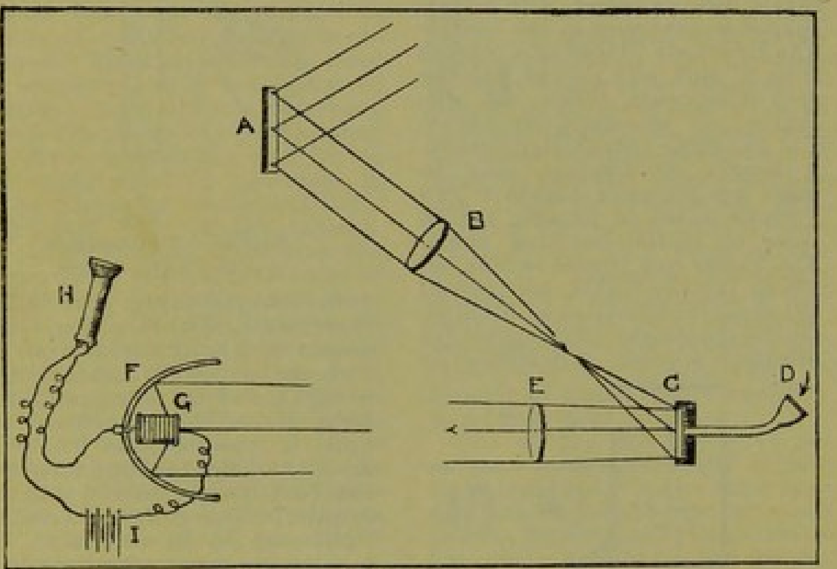


'Flicker' Photometer.

A, B. Two sources of light.

with non-reflecting material is therefore desirable. The illumination of a body depends on the distance between it and the source of light, and on the quantity of light given by the source. Its unit is the 'candle-foot'—the amount of light falling on a body one foot distant from a standard candle. When different coloured lights are to be compared, the results are most unsatisfactory, different observers giving totally different results. This difficulty is even felt in comparing an incandescent with an arc lamp. Colour-blind observers, though not troubled in this way, yet give different results from those given by normal observers. If in a beam of light the thermal and actinic rays were always in a definite proportion to the luminous rays, accurate results could be easily attained, as either the thermopile or the sensitive plate could be used. This, however, is not the case. See Fleming's *Handbook for the Electrical Laboratory* (1901).

Photophone, an instrument invented by Graham Bell and Sumner Tainter, by which sounds, including speech, can be transmitted to a distance by the agency of light. A powerful beam of light is made to fall on a very thin glass mirror, which forms a diaphragm in a bell-shaped receiver similar to that of the telephone. The light is reflected from the mirror through a lens, by which the rays are rendered parallel, and then pass to the distant station. At this point the beam is received in a parabolic mirror and concentrated on a cell composed of alternate layers of brass and selenium, which is placed in series with a battery and telephone receiver, and which has the property of diminishing in resistance when light falls on it. The current through the telephone thus increases. If, however, sound waves at the sending station come in contact with the thin mirror, it is distorted, and scatters the light instead of passing it on to the parallelizing lens, with the consequence that the beam of light which arrives at the receiving station is intermittent; the current varies accordingly, and the telephone speaks. The instrument is, however, of scientific interest only.

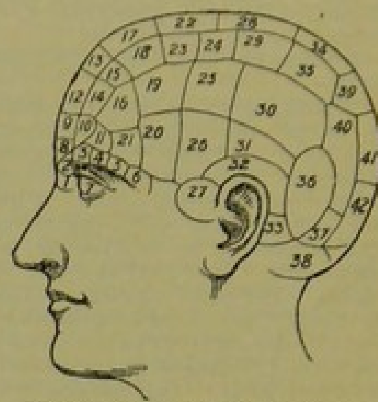


Photophone.

A. Mirror reflecting beam of light through lens B to second mirror C. Sounds sent through tube D impinge on diaphragm at back of C, causing it to vibrate. The ray passes through E to reflector F and photophone receiver G. I, Battery; H, receiver.

Photosphere, the sun's radiating surface, probably composed of incandescent clouds floating in a less luminous medium. Telescopically, it presents a mottled appearance like that of 'snow-flakes on a gray cloth' (Langley). Three-quarters of the solar emissions are estimated by Langley to proceed from brilliant granules, each about 100 m. across, and extending conjointly over no more than one-fifth of the photospheric area. Hence their temperature must greatly exceed the mean value of about 7,000° C. found for the integral surface. At such elevated grades of heat, no terrestrial substance could resist vaporization; yet the photospheric spectrum is of the continuous quality characteristic of a liquid or solid state. The conclusion seems indeed inevitable that the dazzling solar light-shell marks the condensation-level of mounting vapours, which, after having become cooled by intense radiation, sink back towards the interior. The shining canopy we observe thus sets a limit to the circulatory process by which the sun's stores of energy are diffused abroad. Its intrinsic bluish colour is modified to pale yellow, and its brightness considerably reduced by the action of the so-called 'smoke-veil,' a shallow envelope formed possibly of refuse particles from the photosphere. The darkening of the sun's limb, especially conspicuous in photographs, is due to the increasing depth of this envelope traversed by the photospheric rays as the limb is approached. The colour, too, is altered to reddish-brown in consequence of the predominant absorption by the 'smoke-veil' of the shorter wave-lengths. The 'photospheric network' consists of reticulated blurred patches interrupting the regions of sharp definition, frequently noted by M. Janssen in his photographs of the solar disc.

Phraates, four kings of Parthia, of whom the best known reigned from 38 B.C. to 2 A.D. In 36 B.C. Mark Antony waged war against him, but was compelled to retire. A few years afterwards Phraates was expelled by his subjects for his tyranny, but was restored by the Scythians. Tiridates, who had been placed on the throne, fled to Rome with Phraates's youngest son, whom Augustus restored to his father in exchange for the Roman standards and prisoners lost by Crassus (at Carrhæ in 53 B.C.) and Antony.



The 'Organs' of Phrenology.

1. Form.
2. Size.
3. Weight.
4. Colour.
5. Order.
6. Calculation.
7. Language.
8. Individuality.
9. Eventuality.
10. Locality.
11. Time.
12. Comparison.
13. Human nature.
14. Causality.
15. Agreeableness.
16. Mirthfulness.
17. Benevolence.
18. Imitation.
19. Ideality.
20. Constructiveness.
21. Tune.
22. Veneration.
23. Spirituality.
24. Hope.
25. Sublimity.
26. Acquisitiveness.
27. Alimentiveness.
28. Firmness.
29. Conscientiousness.
30. Cautiousness.
31. Secretiveness.
32. Destructiveness.
33. Vitativeness.
34. Self-esteem.
35. Approbativeness.
36. Combativeness.
37. Conjugality.
38. Amativeness.
39. Continuity.
40. Friendship.
41. Inhabitiveness.
42. Parental love.

Phrenology, a pseudo-science, whose devotees claim that the external features of the skull furnish an index to the mind and character. Dr. Francis Joseph Gall, a German, enumerated in 1796 some thirty faculties of the human mind. He believed the configuration of the skull to correspond closely with that of the brain, and declared that mental characteristics are recorded in relief upon the outer surface of the cranial bones. Spurzheim, a disciple of Gall, constructed a scalp chart, showing thirty-five areas, each of which he supposed to be associated with a special faculty. In 1807 a commission appointed by the Paris Institute to investigate the claims of Gall and Spurzheim reported unfavourably upon phrenology; but Dr. George Combe of Edinburgh became a convert to the 'science,' and contributed largely to the temporary popularity of Gall's doctrines. Gall was a skilful anatomist and a careful recorder of clinical and pathological observations, and his deductions stimulated research, and in a manner led to the more accurate localization of brain functions. Of the system of phrenology advanced by Gall, Spurzheim, and Combe, two facts are sufficiently condemnatory. (1.) The gray matter on the surface of the brain is not mapped out into thirty odd areas that correspond with such 'affective propensities' as amativeness, combativeness, and constructiveness, or with such 'sentiments' as self-esteem, benevolence, hope, and wit. (2.) The outer table of the cranial bones does not accurately represent the contour of the brain surface: the thickness of the skull varies in different individuals and in different localities in the same individual; while in parts air spaces, whose size and shape have no relation to the brain development, are interposed between the inner and outer tables of the bone. An attempt, however, has lately been made to advance a phrenological system that practically ignores the 'bumps' doctrine. Dr. Bernard Holländer in 1901 published a work, *The Mental Functions of the Brain; or, the Revival of Phrenology.* The author shows the association of certain types and symptoms of insanity with definite lesions of particular parts of the brain. Work of this nature is a departure from popular phrenology, but is only one of the usual methods by which physiologists attempt to localize mental functions. But Dr. Holländer, instead of reviving Gall's doctrines, gives the word phrenology a new significance.

Phrygia, two ancient divisions of Asia Minor. (1.) Phrygia the Lesser occupied the N.W. corner of that country, being bounded E. by Bithynia, and W. by the Ægean Sea. (2.) Greater Phrygia was inland. The distinction between Greater and Lesser Phrygia only holds good after about 550 B.C. The Phrygians were an Aryan race, akin either to the Greeks or to the Teutons, and migrated into Asia from Thrace; they passed as far south as Crete, as the Cretan place-names Ida and Pergamon show. Troy was one of their chief cities; the Trojans of Homer were very possibly of Phrygian race; the fact that he assigns to them Greek names and Greek customs is an evidence of their similarity to the Greeks. They were independent under national monarchs, among whom Gordius and Midas are two names known to fable rather than history, until conquered by the Lydians; then they were subject successively to the Persians, Greeks, and Romans. They exercised a great influence on Greek music and Greek religion, especially in regard to orgiastic and mysterious worships, such as those of Dionysus and Cybele.

Phryne, famous courtesan of ancient Athens, was a native of Thespiæ in Bœotia. She lived about 340 B.C. and later. Hyperides, the orator, and Praxiteles, the sculptor, were among her lovers. The latter took her for the model of his Cnidian Venus, as did Apelles for his picture of Aphrodite Anadyomene. Her neighbours erected a statue of her in gold at Delphi.

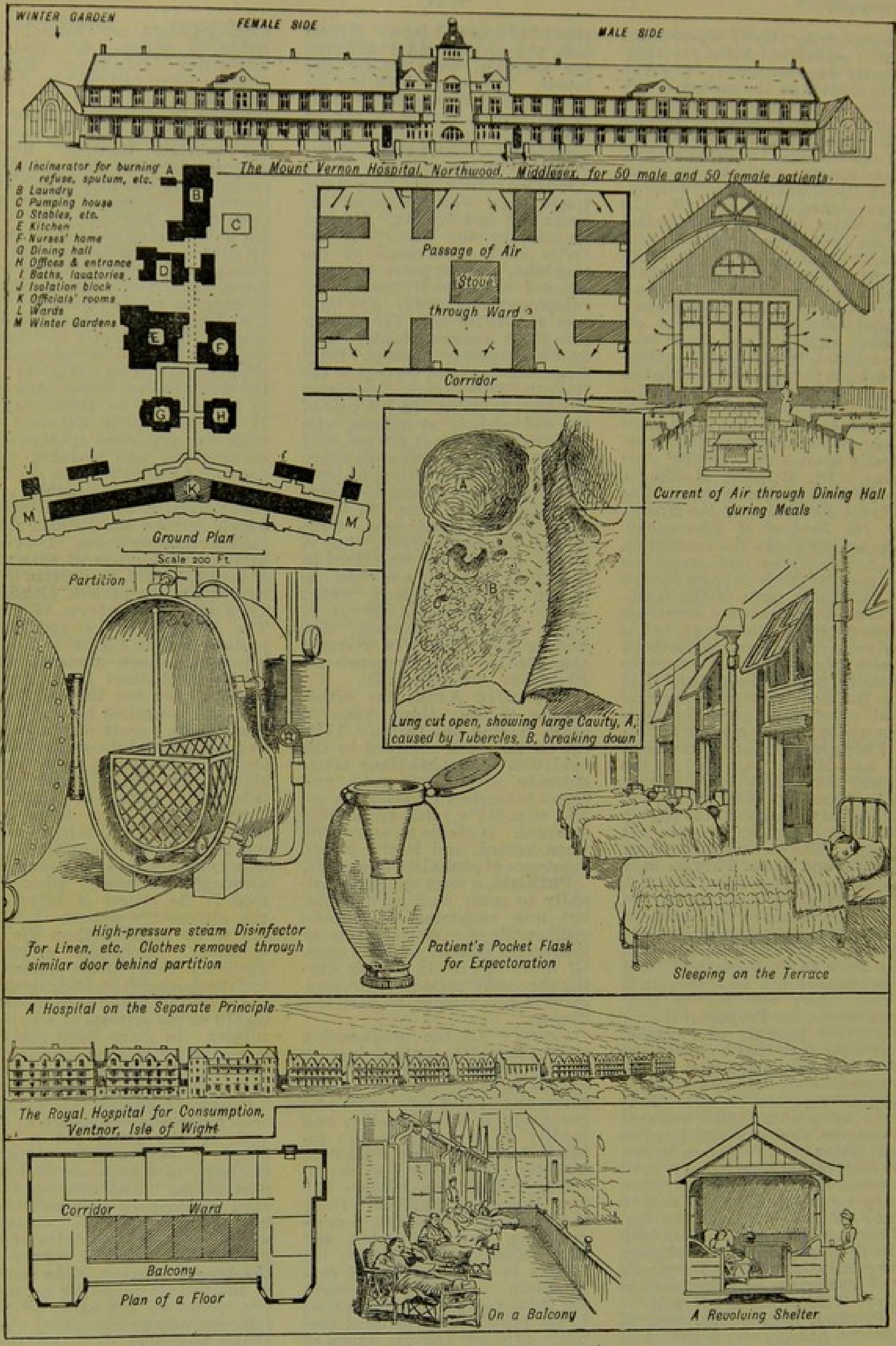
Phrynichus. (1.) An Attic tragic poet, who flourished between 511 and 476 B.C. He was famous for the beauty of his lyrics in the choruses of his tragedies, and appears to have assisted considerably in the development of tragedy. *The Capture of Miletus* and *The Phœnician Woman* were evidently plays on contemporary history. Only fragments survive, for which see Nauck's *Tragicorum Græcorum Fragmenta* (1856). (2.) A poet of the old comedy at Athens, who exhibited first about 430 B.C., and as late as 405 B.C. Ten plays are attributed to him. His fragments show much power and elegance. For fragments, see Meineke and Kock's *Comicorum Græcorum Fragmenta* (1880). (3.) A native of Bithynia, who lived in the 2nd century A.D.; he is known by the *Ecloga*, which studies the correct Attic use in many words and phrases. See Rutherford's *The New Phrynichus* (1881); also Brenous's *De Phrynicho Atticista* (1895).

Phthalic Acid, the ortho-variety of the three isomeric acids, having the formula $C_6H_4(COOH)_2$. It is obtained by the oxidation of naphthalene tetrachloride with nitric acid, and forms colourless crystals (sp. gr. 1·6; m.p. 213° C.) that are soluble in water. It yields an anhydride when heated, and is the parent substance of phthaleïn dye-stuffs.

Phthisis, a term applied originally to many wasting diseases, but now restricted to phthisis pulmonalis—*i.e.* consumption or tubercular disease of the lungs. Of those who die in Britain during the active period of life, one-seventh are victims to this fell disease.

Causes.—Of the predisposing causes, heredity bulked largely in the minds of our ancestors, and to some extent with reason, since the child of phthisical parentage is often weakly, and readily falls a prey to the tubercle bacillus. Any condition, however, that produces constitutional weakness favours the development of phthisis. Thus, malnutrition, syphilis, overcrowding, lack of fresh air, and defective hygiene are all factors in the causation of consumption. Equally important are those occupations which lead to the inhalation of irritant particles of dust, and the lungs of coal-miners, stone-masons, and steel-grinders are exceedingly liable to become the seat of tubercular infection. Again, phthisis often follows bronchitis, pneumonia, and injuries of the lungs. In all cases, however, the more immediate cause is the tubercle bacillus. Koch's demonstration of this organism ranks among the highest achievements of medicine. The tubercle bacillus can, however, only flourish and develop in tissues whose vitality is already lowered by disease and debility, or by irritants. Practically all mankind is exposed to its infection; but healthy tissues withstand the attack. The tubercle bacillus is a minute thread-like rod, usually slightly curved, and often two of the organisms are found lying end to end, making an obtuse angle. It can be readily detected by smearing phthisical sputum on a cover glass, and staining with fuchsin, for which it has such an affinity that it resists subsequent decolorization by mineral acids, which remove the fuchsin from the surrounding tissue. Tubercle bacilli withstand great extremes of heat and cold, and retain their vitality for long periods, although dried and in the form of dust. The sputum of a phthisical patient is thus a great source of infection. Koch contends that bovine is distinct from human tuberculosis; but the weight of evidence is against his view, and the interim report of the Royal Commission on tubercular disease (June 1, 1904) points to the probability that phthisis and other tubercular affections may be communicated from lower animals to man. If this be so, milk must be held responsible for many cases of infantile tubercle, although, obviously, when the food is the source of infection, the alimentary system is more apt to be infected than the respiratory. Domestic animals, however, suffer from phthisis, and discharges from such animals are as heavily laden with tubercle bacilli as the sputum of a human subject. In many cases phthisis is secondary to some tubercular affection of another organ or tissue, as the intestine or the skin.

Course of Disease.—Most generally phthisis originates at the apex of the lung, but in old people it frequently develops at the base, as a sequence of basal pneumonia. The disease, as a rule, commences as a catarrhal inflammation of the alveolar walls, and small nodules of inflammatory products appear in the lung substance. The centre of the nodule may become caseous, while an extension of the inflammatory process takes place at the periphery, so that various nodules coalesce, and form dif-



Phthisis—Modern Treatment of Consumption.

fuse areas of softening. From such centres the tubercle bacilli may be absorbed, and lead to disseminated tuberculosis. In other cases the nodule is encapsulated by a sheath of connective tissue, which, under favourable circumstances, may contract into a cicatricial puckering. On the other hand, the irritated and weakened tissue may break down and suppurate, with the result that a cavity is formed, which has a constant tendency to increase in size. Several small cavities may unite, and as their walls are practically ulcers, considerable destruction of the lung tissue ensues, the smaller bronchioles and arteries are opened, and the cavity is filled with pus and blood. Around such a cavity there is often an area of bronchopneumonia. As time goes on, the process extends, until an entire lobe, or even the greater part of a lung, is involved. The duration of the process varies with the strength of the tissues and with the severity of the infection, and is often markedly modified by treatment. While, on the one hand, phthisis may run so acute a course as to be called 'galloping consumption,' the great majority of cases exhibit, in their earlier stages at least, a tendency to recovery by cicatricial contraction around the nodules or tubercles, which are thus isolated and healed. Fresh irritation, however, reawakens the process, and by successive attacks the disease slowly advances until the cavities are too large to admit of repair.

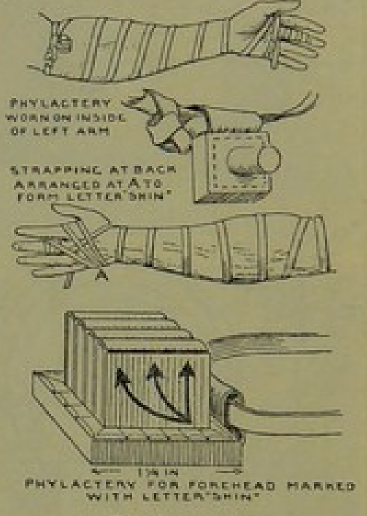
Complications. — Pleurisy is a common complication of phthisis when the inflammatory process nears the surface of the lung. Diarrhœa is frequent, and is generally caused by the bacilli in the sputum, which, being swallowed, leads to infection of the alimentary tract and intestinal ulceration. A similar infection of the laryngeal mucous membrane produces phthisis laryngea, a most painful and intractable form of tubercular disease.

Symptoms.—The leading symptoms of phthisis are hæmoptysis, night sweats, and loss of flesh. Hæmoptysis, or spitting of blood, may occur at any stage of the disease. The night sweats are characteristic, and are associated with derangement of the temperature, which usually exhibits a typical evening rise and morning fall. Along with these symptoms there is often marked hectic flush. The loss of weight is gradual, but it is progressive while the disease is advancing. On the other hand, improvement in the patient's condition is speedily manifested by an increase in weight, which thus forms the most reliable index to the progress of the disease. Pain is not usually a symptom of phthisis. The breath sounds and the percussion note are altered by consolidation around the tubercles, by formation of cavities, and by effusion of pleuritic fluid; while dry pleurisy is accompanied by sounds of friction.

Treatment.—The patient should be removed from overwork, and from bad hygienic surroundings. Should circumstances allow of it, great benefit often follows a residence in warmer climates. Sunlight and fresh air seem to be the most effectual antagonists against the tubercle bacillus, and most satisfactory results have been secured in recent years by keeping patients night and day in the open air, and this treatment may be carried out even in England. A generous diet, with tonics and those drugs which have a food value, such as cod-liver oil, maltine, and glycerin, should be given. Local applications of iodine and fomentations containing laudanum are of use, should pleuritic pain be severe. When hæmoptysis is a feature of the case, rest in bed is essential; and the patient may be given ice to suck, as well as small doses of ergot. Ice may also be applied to the chest wall. The cough may be treated by the administration of hydrocyanic acid and morphine, or another preparation of opium. Nepenthe is of special service in checking the night sweats, as well as in subduing the cough. Niemeyer's pill is also of great use for these purposes. The diarrhœa, which is often so distressing, calls for opium, either by the mouth or in starch enemata. Although the stools are often fœtid, purgatives should be rigidly avoided in all cases where there is a suspicion of tuberculosis.

There have been, and still are, great differences of opinion as to the most fitting climate for a phthisical patient. Most medical men now agree, however, that the essentials are a pure atmosphere, an equable temperature, and a maximum amount of sunshine. The climate need not be specially warm: many patients do well in the equable cold of Davos or of Colorado. Altitude and dryness are not essential, for the sea-levels and humidity of Florida and Torquay are usually beneficial, and sea voyages are generally of great service to those who are good sailors.

Phylactery, a cubical leather box from half an inch to one and a half inches in the side, containing, inscribed on parchment or vellum, Exod. 13:1–10, 11–16, and Deut. 6:4–9, 11:13–21, and worn, one on the head, another on the left arm (inside, next the heart), during week-day prayers by the Jews, in literal fulfilment of the law. Made from the skin of a clean animal, stitched with twelve stitches, fastened symbolically with straps and knots to represent, with the letter *shin*, *Shaddai* = Almighty, put on with appropriate benedictions, they began to be worn (conjecturally) from 140 to 105 B.C., the commandment being figuratively interpreted up to 250 B.C., as still by the Karaite Jews.



Phylacteries.

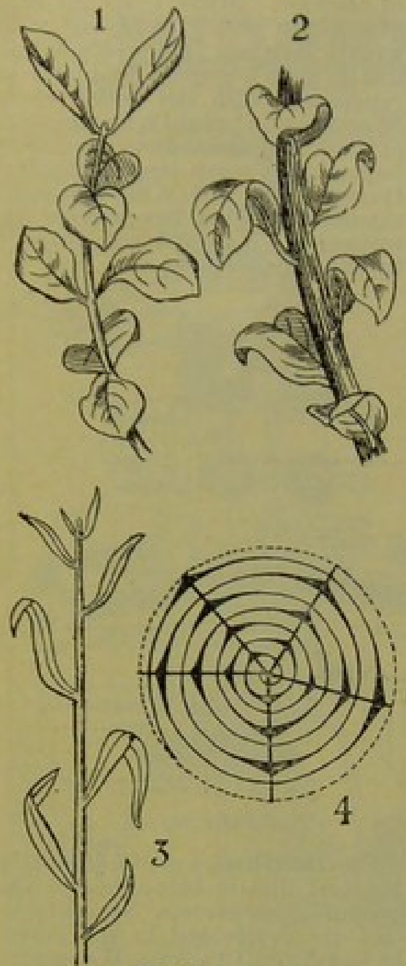
Phyllanthus, a genus of mostly tropical plants belonging to the order Euphorbiaceæ. Several species are cultivated in the stovehouse, a light peaty soil containing broken bricks and charcoal being the suitable compost.

Phyllite, a clay rock, resembling a slate, but containing a large percentage of fine, silky, pale-coloured mica. It splits readily, and has a shimmering lustre on the surface.

Phyllocactus, a genus of tropical, epiphytal shrubs belonging to the order Cactaceæ. They mostly bear brightly-coloured flowers, and many species are cultivated in stovehouses and warm greenhouses. They like all the sun obtainable, and a very small quantity of light porous soil containing a little leaf-mould. Water should be given sparingly at all times, and almost withheld during the winter.

Phyllostachys, a genus of arborescent grasses, natives of Japan and China. They bear loose panicles of flower-spikes, and the stems are semi-terete. *P. nigra* yields whangee canes. This species and *P. bambusoides* are occasionally cultivated.

Phyllotaxy, that branch of vegetable morphology which discusses the modes in which foliage leaves are arranged on the branches of plants. When the leaves grow opposite to each other in a plane at right angles to that plane in which the pairs of leaves above and below are de-



Phyllotaxy.

1. Opposite and decussate leaves. 2. Alternate in five rows. 3. Alternate in two rows. 4. Diagram of 'two-fifths' phyllotaxis.

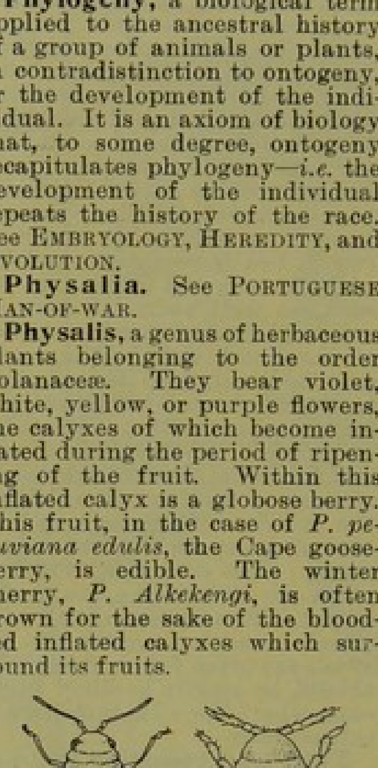
veloped, the arrangement is called decussate. Sometimes the leaves are arranged 'alternately'—*i.e.* in two vertical lines on opposite sides of the stem. In other plants there are three, four, five, or more vertical rows.

Phylloxera, a genus of aphides, one of whose members (*P. vastatrix*) has wrought havoc among the vineyards of Europe. It was apparently introduced in the early 'sixties from N. America. In its broad outlines the life-history does not differ from that of other plant-lice, except in its migrations. In America it seems to attack the leaves to a greater extent than in Europe. All summer the insects are confined chiefly to the roots, but at the approach of autumn winged females appear, which migrate to the leaves, and there lay their eggs. These eggs develop into winged males and females, and the latter lay fertilized eggs (winter eggs) under the bark of the stem. In spring, these eggs, of which but one is laid by each female, develop into wingless forms, which usually migrate to the finer fibrils of the roots, and there reproduce themselves parthenogenetically with great rapidity. Owing to their attacks, the roots develop galls, become greatly deformed, and eventually cease to be functional, so that the affected plant dies. In autumn the winged forms appear, and, by migration to new plants, may spread the disease. With these winged forms the life-cycle begins anew. Structurally Phylloxera is related to the genus Chermes, which forms destructive galls on conifers. Besides the vine parasite there is at least one other species, *P. quercus*, of the oak and other forest trees. Phylloxera is of a yellow or reddish brown colour.

Phylogeny, a biological term applied to the ancestral history of a group of animals or plants, in contradistinction to ontogeny, or the development of the individual. It is an axiom of biology that, to some degree, ontogeny recapitulates phylogeny—*i.e.* the development of the individual repeats the history of the race. See EMBRYOLOGY, HEREDITY, and EVOLUTION.

Physalia. See PORTUGUESE MAN-OF-WAR.

Physalis, a genus of herbaceous plants belonging to the order Solanaceæ. They bear violet, white, yellow, or purple flowers, the calyxes of which become inflated during the period of ripening of the fruit. Within this inflated calyx is a globose berry. This fruit, in the case of *P. peruviana edulis*, the Cape gooseberry, is edible. The winter cherry, *P. Alkekengi*, is often grown for the sake of the blood-red inflated calyxes which surround its fruits.



Phylloxera.

Winged adult, wingless young, larvæ, and eggs.

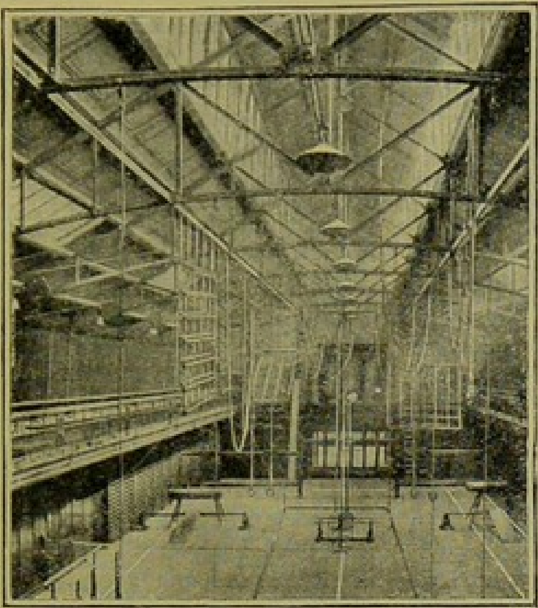
Physeter. See CACHALOT.

Physical Degeneration. In response to the Home Secretary's inquiries, the Royal Colleges of Physicians and Surgeons reported in 1903 upon the conditions which for the preceding half-century had tended to impair the health and physique of the working classes in Britain. Of primary importance in this respect is the overcrowding that results from the excessive migration of rural labourers to large cities. Associated with the growth of towns, increased employment of girls and women in factories and workshops, altered diet, and changes in the habits of the labouring classes all contribute to diminution of the birth-rate, to the birth of puny offspring, and to the neglect of young children. Too often infants suffer and perish from the administration of unsuitable food. To combat these evils, many have advocated the establishment of day-nurseries and the supply of sterilized milk by corporations or other public authorities. Such measures are excellent; but in addition, means should be employed to prevent overcrowding at schools and to secure for children and young people more opportunities for outdoor exercise and development of the bodily powers. Playgrounds and open spaces in thickly-populated districts are of the first importance. A more widespread knowledge of simple physiology and elementary dietetics would also conduce to the health and physique of the young. An Inter-Departmental Committee on physical deterioration, appointed in 1905, reported that if exception be made of the very lowest and poorest of the people, there does not exist deterioration of a progressive nature in the physical characteristics of the nation. At the same time the committee call attention to one grave and serious result—namely, that owing to the diminishing birth-rate in the most desirable classes, from the point of view of good citizenship, in the community, the 'unfit' and 'incapable' are increasing at a greater rate than the 'fit.' The subject was discussed at the meeting of the British Association at Cambridge in 1904, and also in the *British Medical Journal* (1904).

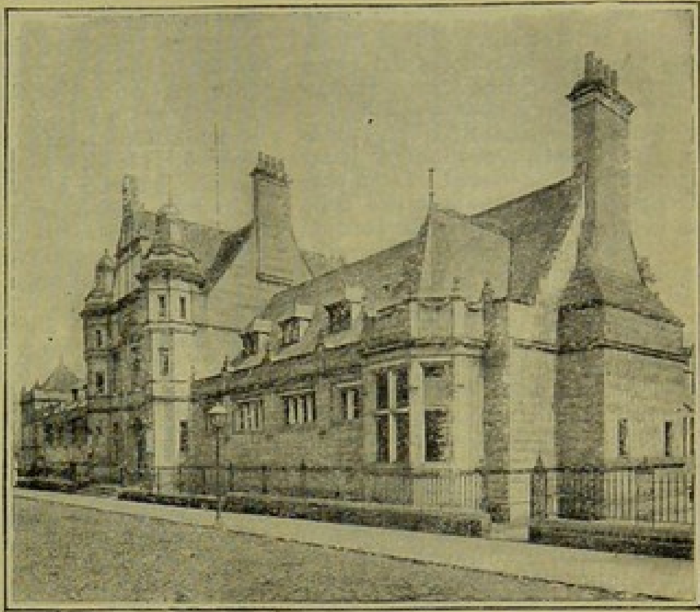
Physical Training, the science of developing and training the body by means of systematic physical exercise. Physical and musical drills, gymnastics, and games are the principal exercises depended upon. Games are only considered educational when taught systematically and subordinated to the other subjects. An official 'model course' for use in schools has been published by an inter-departmental committee as the *Syllabus of Physical Exercises for use in Puble Elementary Schools* (1904). In July 1905 a new edition appeared containing slight alterations.

Systems.—Without taking into account systems not recognized in any way by the Board of Education or the London County

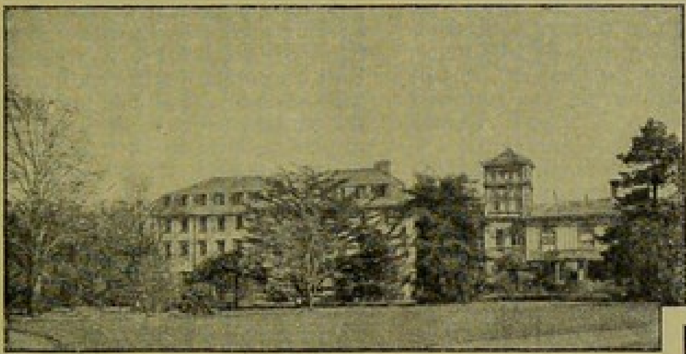
1



2



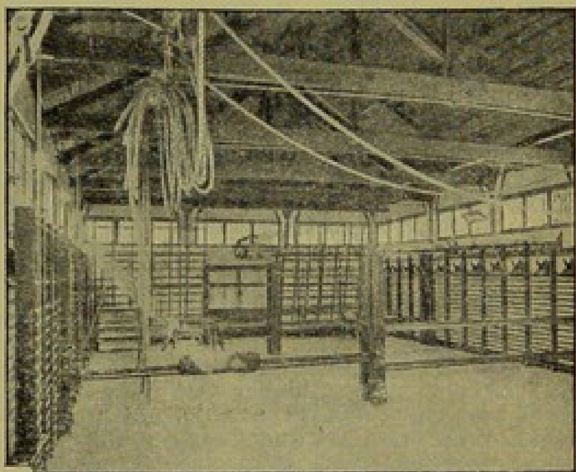
4



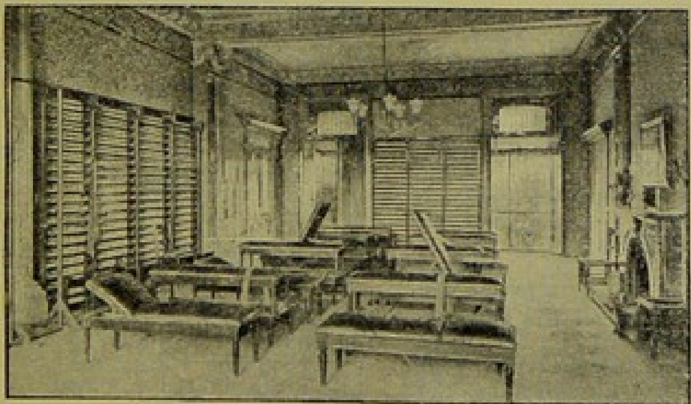
3

7

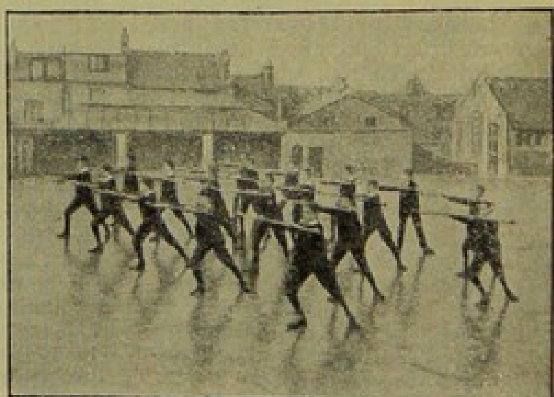
5



6



8



Physical Training—Modern Developments.

1. Gymnasium, Carnegie Dunfermline Trust College of Physical Training. 2. Exterior of the College. 3. Swimming Pond. (Photos by Norval.) 4. Physical Training College, Kingsfield, Dartford. 5. Gymnasium of the College. 6. Medical Gymnasium. (Photos by Barnard.) 7. Indian club exercise, and 8, barbell exercise, Wix Lane School, L.C.C., Clapham Common.

Council, there are only four taught in Britain. These make use of a great variety of drill and gymnastic appliances. Indian clubs have long been used by exponents. Musical drill—*i.e.* class exercises with or without hand apparatus, executed to music chosen carefully to suit the type and speed of movement performed—is a characteristic. The military is sometimes spoken of as the British system, but is in reality only a small part of the latter. Military gymnastics are only suited for 'setting up' men already sound and comparatively strong. The German is a system of drills and gymnastics. The drills are sometimes performed to music. Short wands are more commonly used than bar-bells. The 'German' teacher in Britain uses Indian clubs, but they do not belong to the German system. There is a great variety of gymnastic exercises. The Swedish consists largely of what is known as free-standing exercises, arranged systematically, and founded on the teaching of P. H. Ling. No hand appliances are used, and no music.

Examining Bodies.—Certificates for teaching are granted by the National Society of Physical Education, Exeter Hall, Strand, London; the Incorporated British College of Physical Education, Johnson Street, Notting Hill Gate, London; the Gymnastic Teachers' Institute, 19 Temperley Road, Balham, London; and the Ling Association, 19 Briston Grove, Crouch End, London. The two first named examine in British, German, and Swedish; the third in German only; and the fourth in Swedish only. Holders of certificates of the three first mentioned of these bodies obtain a higher rate of pay from the London County Council and many other educational authorities.

Training Colleges.—Although men have to pass a higher test than women, they, as a rule, obtain their practical knowledge in an evening gymnasium and their theory in evening classes; but there are several resident and non-resident physical training colleges for women, where a complete two-years' training in theory and practice may be obtained. The fees range from £25 per annum (St. Bride Physical Training College, Bride Lane, London) to £112 per annum (Dartford Training College). See Chesterton's *Manual of Drill and Physical Exercises*, Broman's *School Gymnastics*, Puritz's *Code Book of Gymnastic Exercises*, Jenkin's *Gymastics*, and Lagrange's *Physiology of Bodily Exercise*.

Physicians, ROYAL COLLEGE OF, the principal chartered medical body in England, was founded through the instrumentality of Linacre, who obtained, by his interest with Cardinal Wolsey, letters patent from Henry VIII., dated 1518. During the reign of James I. (1614) a house was taken at the bottom of Amen Corner, London, which became the seat of the college till 1666. A new building was afterwards erected in Warwick Lane, which was opened in 1674, and there the meetings were held till 1825, when the present building in Pall Mall was opened. The government of the corporation is vested in the president and fellows only, and the members of the college are alone eligible to the fellowship. No candidate can be admitted to the membership who is engaged in trade, or who dispenses medicines, or who practises medicine or surgery in partnership, or who refuses to reveal, when required by the president or censors, the nature and composition of any remedy he uses.

The Royal College of Physicians of Edinburgh was founded in 1681, when a royal charter was granted by Charles II. A new charter was obtained in 1861. The college, in conjunction with the Royal College of Surgeons of Edinburgh and the Faculty of Physicians and Surgeons of Glasgow, grants students facilities for obtaining, after one series of examinations, a 'triple qualification'—*i.e.* the qualifications in medicine and surgery of the three Scottish corporations. The Royal College of Physicians, Dublin, was founded in 1667, and reincorporated in 1692.

Physic Nut, a bush or tree (*Curcas purgans*) belonging to the order Euphorbiaceæ. It is a native of tropical America, and bears cymes of small, greenish, bell-shaped flowers. It is occasionally cultivated in the tropics for the medicinal oil which its seeds yield. In the Philippine Is. this oil is also used as an illuminant. As an aperient, the oil is very irregular in action, and is apt to give rise to very unpleasant symptoms.

Physics, that department of science which is concerned with the fundamental laws of the material universe. These laws are best studied by means of the simpler configurations which constitute inanimate nature; but the same laws are found to hold for organic nature, although the complexities of function and structure associated with life add enormously to the difficulty of following in detail the action of these physical laws. The broad distinction between chemistry and physics is that the former science considers more particularly the molecular changes of matter; but the two branches of science overlap, so that it is not possible to draw a clear line of division between them. The various branches of physics are treated under separate headings, such as HEAT, LIGHT, SOUND, ELECTRICITY.

Physiocrat, the name now usually applied to the French *économistes* of the 18th century. The founder and leader of the school was François Quesnay (1694–1774), a French physician and economist. This school held that land was the source of all wealth, and agriculture the only industry that increases wealth. The best that can be said for other industries is that, like domestic service, they set free from menial employments the energies of the real producers, who are the agriculturists. Agriculture is the only industry that yields a net product; other industries exist out of the *produit net* created by agriculture. Since agriculture provides the sole revenue of a country, it was held that the state should claim from the landowner and the farmer all the contributions it required. The physiocrats were thus strenuous opponents and critics of the mercantile system and its doctrine of the balance of trade; and from them Adam Smith learned much during his sojourn in France. In his *Wealth of Nations* the Scottish economist hardly does justice to his teachers. Among the physiocrats were Quesnay, Turgot, probably Dupont de Nemours, Gournay, Mirabeau, and Morellet.

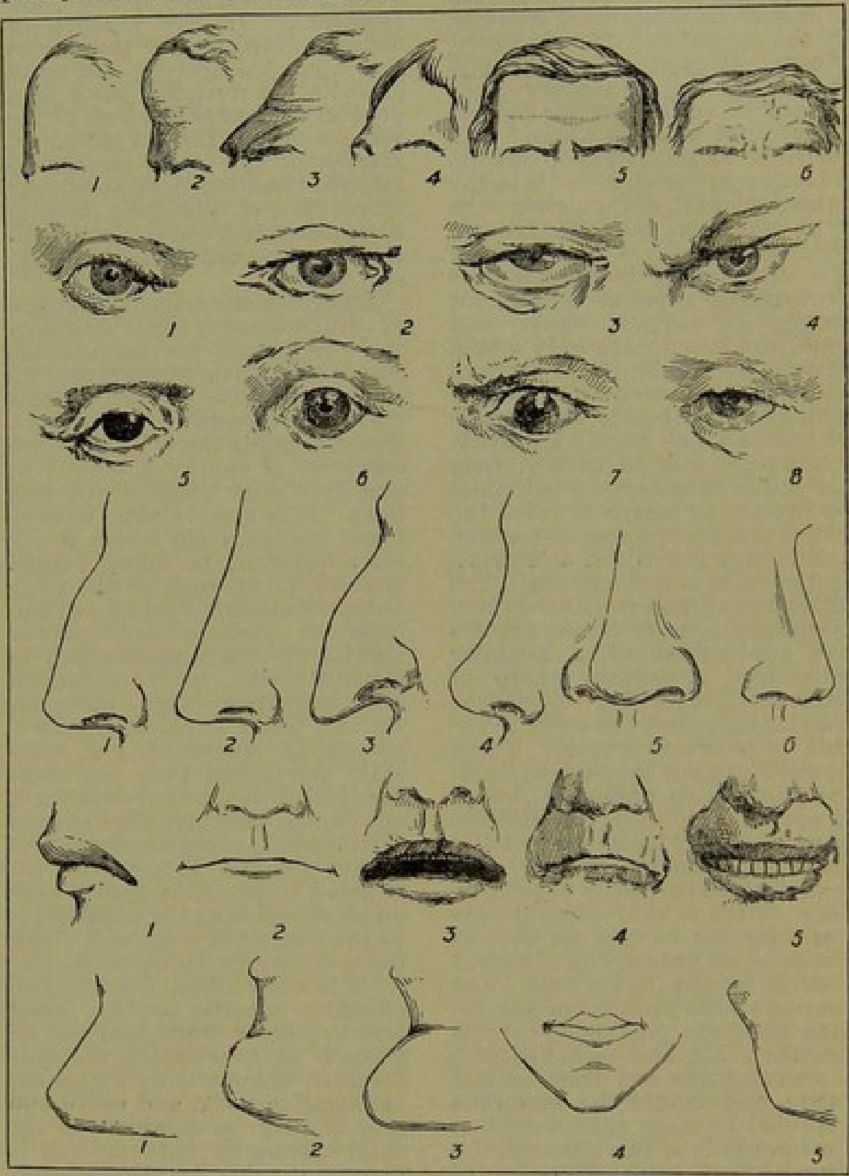
Physiognomy, nature or character-judging from externals, claimed both as art and science, overlaid by older writers with unreliable detail, but remodelled by Darwin on broadly scientific lines on the basis of evolution. (See his *Expression of Emotions in Man and Animals*, 1873; followed by Mantegazza's *Physiognomy and Expression*, 1890.) Pathology and criminology have made the study their handmaiden, and anthropology seeks for tokens of 'retardation' or 'acceleration' (the depressed or elevated nose-bridge, for instance), and takes note of quadrumanous features, embryonic types, prognathism, short femora, and facial angle. (See *Knowledge*, 1883.) Aristotle had detected in men the qualities of animals which they resembled; Porta (*De Humana Physiognomia*, 1586), and Lavater (*Fragmente*, 4 vols. 1775–8) professed to read 'the mind's construction in the face.' The head to the eyebrows revealed the intellectual, the nose and cheeks the moral, the mouth and chin the animal life of the man, all being combined and resumed in the eye. The Act 17 George II. c. 5, however, threatened all professors of physiognomy with a whipping or six months in jail. See *Physiognomy Illustrated*, by Simms (1887).

Physiography, the name given by Huxley to the systematic description and scientific discussion of the general properties of our earth and atmosphere. It is practically synonymous with what used to be called physical geography, including the discussion of such things as the distribution of sea and land, of rivers and mountains, the succession of the seasons, the meteorological phenomena of the atmosphere, and the broad relations between animate and inanimate nature.

Physiologus. See BESTIARY.

Physiology, as contrasted with anatomy, which deals with organic structure, is concerned with the functions of living organisms, and with those laws or principles upon which vital processes and life itself depend. While all living organisms, be they plants or animals, are ultimately composed of inorganic matter, they are sharply differentiated from the non-living by the possession of certain faculties or processes. During life the organism is a centre for the transformation of energy, and it responds to certain outside influences or stimuli. The speck of protoplasm known as amœba in virtue of life exhibits growth, maintenance, and reproduction, and these three activities are common to every plant and to every animal. Animals, as a rule, have in addition the faculty of locomotion, and both the higher plants and animals pass through a stage of decay which terminates in death.

Every living being commences life as a minute speck of protoplasm, which is fundamentally the same whether the organism belongs to the animal or to the vegetable kingdom. In the course of development the cells are differentiated in diverse directions and to varying degrees. Some animal cells build up such a product as bone; certain cells of the higher plants elaborate chlorophyll, a product of protoplasm, by means of which these plants are enabled to fabricate their food out of inorganic materials. Animal cells, again, for their food require substances already organized by pre-existing cells. In both cases the cells elaborate the raw food matter into more complex substances before they assimilate it. From inorganic materials in the soil, from carbon dioxide, and from water, plants build up starch and sugar. From the food particles which it infolds the protoplasm of the amœba extracts certain substances and rejects others. By anabolic, or building up, processes it forms highly complex molecules which are capable of assimilation; by katabolic, or breaking down, processes it splits up these substances into others of more simple character, and thus transforms the potential energy of the food partly into heat and partly into the kinetic energy displayed in the animal's movements or work. In the cell, however, should the potential energy of the food be in excess of the expenditure of heat and work, growth results; while if the food energy merely balances the loss of heat and the work done, it is evident that maintenance is the result. But a certain amount of inevitable waste ensues, much of the potential energy being frittered down and lost as heat.



Physiognomy—Classification of Types.

Foreheads.—1, Profound thinker, cold and calculating; 2, quick intelligence and irritability of character; 3, irreflective, despotic, eccentric; 4, imbecile; 5, well balanced intelligence; 6, criminal. **Eyes.**—1, Calm; 2, ardent; 3, apathetic; 4, cunning; 5, phlegmatic; 6, anxious; 7, passionate; 8, indolent. **Noses.**—1, Roman—strong force of character; 2, Grecian—refinement; 3, Jewish—avaricious; 4, snub—weakness of character; 5, negro—secretive; 6, divided—keen perceptive powers. **Mouths** (indicative of)—1, Firmness; 2, coldness; 3, indecision; 4, coldness and cruelty; 5, irritability. **Chins** (indicative of)—1, Selfishness; 2, benevolence; 3, violent love; 4, desire of love; 5, cold nature, lacking affection.

By the division of labour which results from aggregation of cells a great economy of energy is effected. Were the colony of cells which compose a human body to be resolved into amœbæ, the sum total of the kinetic energy produced in the forms of heat and work might not be less, but the waste would be incalculably greater, and the proportion of the potential energy transformed into work would be considerably lower. By union and differentiation the loss of heat is minimized, and the individual is rendered more capable of adaptation to changing environment.

At one time all biological phenomena were explained by the view that there exists a special vital force essentially different in nature from such manifestations of energy as heat, electricity, or chemical action. This view cannot be upheld. Vital phenomena are to be explained only on those mechanical principles which apply to the inorganic world, but they are rendered more complex by the special activities of protoplasm. Thus the absorption of food from the alimentary canal cannot be accounted for by diffusion and osmosis alone. The response to stimulation, and the selective power of the cells in the intestinal wall, differentiate such a phenomenon from the absorption of water by a sponge. For the exercise of these activities protoplasm requires a constant supply of oxygen, water, and food, and it can work only within certain narrow limits of temperature and pressure. Cell anabolism probably builds up a series of bodies which have a katabolic tendency—that is to say, they are liable to undergo a splitting-up process by means of which the molecular groups are rearranged and energy is evolved and manifested in heat and motion. The explosion of such compounds may be spontaneous, or it may require the application of a peculiar stimulus. A certain group of substances, some of which are constantly present in every living cell, is known as proteid. These proteids are not themselves liable to spontaneous explosion, but it is not unlikely that the addition of oxygen may temporarily unite some of them into a new compound which is readily decomposable. Such a view explains the necessity for oxygen as well as the constant production of carbon dioxide by the living cell. The sources of the proteids of the human body are previously-formed proteids, fats, and carbohydrates from vegetable and from animal food; and should the materials supplied be more than sufficient for the needs of the moment, the living cell can store them up for future use. The tissues in which such storage chiefly occurs are those of muscle, of the liver, and of the body fat. In the production of heat and in the performance of work muscle is the tissue which in man expends most energy. The quantity of proteid material used up during muscular work may be estimated by measuring during rest and after severe exertion the amounts of carbon in the carbon dioxide given off by the lungs, and the amounts of nitrogen in the urea eliminated by the kidneys. For practical purposes the loss of carbon and nitrogen by the skin and bowels may be disregarded in such a calculation. It is noteworthy that, unless the work be excessive, the excretion of nitrogen shows little or no increase during exertion, as, unless the proteid destruction be considerable, the waste nitrogen is used up again by the muscles, and is recombined with fresh carbon, hydrogen, and oxygen to form new muscle 'ammunition.' In the absence of sufficient food supply the tissues live upon themselves, the more essential performing work and producing heat at the cost of the less essential. Thus in prolonged starvation the heart muscle diminishes but little, although the stored fat of the body largely disappears and the skeletal muscles decrease considerably in size and weight.

Alongside the muscular system as a liberator or spender of energy must be placed the nervous tissues, although for obvious reasons the expenditure cannot, in this case, be reckoned in foot-pounds. Before leaving the body the nervous form of energy is wholly or almost wholly transformed into heat. It is closely akin to electrical energy, from which it differs, however, in many points. Several fishes, such as the gymnotus or electric eel and the torpedo or electric ray, possess special electric organs which in structure and in development have affinities with muscular tissue. Their nervous supply is peculiarly abundant, and when fully developed they are most formidable weapons of defence or of offence, although after several discharges in rapid succession the organs become temporarily exhausted. The exhaustion of such an electrical organ is comparable to the fatigue of a muscle. This form of energy is, however, confined to a few fishes. No mammal possesses electric organs. Heat and muscular work may be regarded as practically the sole forms in which energy leaves the mammalian body, and nerve and muscle may be regarded as the chief tissues by which energy is expended. All the other tissues, if we leave reproduction aside in the meantime, as being more concerned with the race than with the individual, are subservient to these two supreme developments of protoplasm. The integumentary tissues clothe and protect the muscles and nerves, and also act as excretory organs. The respiratory system provides the oxygen necessary for muscular and nervous activity, while the alimentary system, with all its accessory glands, supplies fresh energy by the ingestion and assimilation of food stuffs containing new stores of potential energy. The circulatory systems of blood and lymph convey oxygen and pabulum to these all-important tissues as well as to those of secondary importance in the economy, and they remove such products of katabolism as are deleterious or of no further use to the active cells. They also carry the waste products to the excretory organs, whose function is the discharge of useless or effete material formed by the splitting up of the complex proteids.

It has already been stated that protoplasm can work only within certain limits of temperature. Great heat destroys an organism, while a reduction of temperature to freezing-point paralyzes it. Much more extreme degrees of cold, however, are borne without destroying life. Vegetable seeds, for example, have germinated after a six-hours' immersion in liquid hydrogen, and tubercle bacilli withstand exposure to the temperature of liquid air without losing much, if any, of their virulence. The amount of heat produced by vegetable cells is too insignificant to raise their temperature appreciably above that of their surroundings, and cold-blooded animals, such as fishes and reptiles, resemble them in this respect, and have therefore a variable temperature. Mammals and birds, on the other hand, have a comparatively high body temperature while they are in health. The heat of such animals is ultimately derived from their food, and is due to combustion or oxidation within the tissues of the body. This combustion takes place chiefly in the muscles; but the rate of production and the dissipation of the heat are alike under the control of the nervous system. In man, should great muscular activity or large quantities of food increase the heat production, the regulating mechanism accelerates the breathing and flushes the skin, so that heat is lost in the expired vapour and in the perspiration. If, on the other hand, starvation or inactivity of the muscles diminishes the production within the body, respiration is retarded and the skin becomes blanched. In a similar way the regulating mechanism meets changes of the atmospheric temperature, and so delicate is the adjustment of the bodily conditions to the environment that a man may step from the hot chamber of a Turkish bath into an ice-cold atmosphere, or *vice versâ*, without variation of his body temperature.

In considering the phenomena of growth, certain cells, the leucocytes of the blood and the wandering connective tissue corpuscles, may be looked upon as embryonic residues of undifferentiated amœboid organisms.

Comparatively simple cells such as these grow and reproduce their kind in the same fashion as an amœba. When the anabolic processes exceed the katabolic processes—that is to say, when the organism assimilates more nourishment than it uses up in its production of heat and kinetic energy—the surplus is stored within the cell, and increase in bulk results. But it must be remembered that protoplasm requires an ample supply of oxygen, which the amœba acquires by its surface. Increase of a cell's bulk may make it impossible for the whole of the protoplasm to be sufficiently oxygenated, since, according to a law first enunciated by Herbert Spencer, and simply stated thus, 'volume tends to outrun surface.' The amœba solves the problem of immoderate bulk in this way. After growing to a certain size it divides, and two complete amœbæ separate as distinct units, each of which grows, divides, and repeats the parental life-history *ad infinitum*. In cells more highly differentiated than white blood and connective tissue corpuscles reproduction is less simple and easy; but even muscle fibres multiply by fission. As a rule, however, in wounds of complex tissues, a tendency towards repair by the formation of the comparatively simple connective tissue manifests itself. Amongst the higher vertebrates, nerve cells, which are the most highly specialized of all, lose in early embryonic life the faculty of multiplication. Their number is fixed early in the existence of an individual. But they preserve the power of individual growth to a remarkable extent, and even in late adult life they increase in size and extend their communications with other cells.

For the continuation of life a process of reproduction is necessary. Throughout the entire organic world this process consists essentially in the detachment of a part of the parent. In the higher plants and animals reproduction is sexual, the female element undergoing development only after fusion with the male element. The periodic detachment of a portion of an organism for reproduction becomes possible when growth and development are ceasing. While there is still an excess of repair over waste, the organism, instead of growing larger, sheds a part of itself to continue its kind. In various ways the embryo is supplied with pabulum, in order that its anabolic processes may be carried on; and both plants and animals require a certain amount of heat for germination. From the food and energy supplied by the parent the embryo builds up its tissues until it is fit for separate existence. The special form which the individual ultimately assumes depends upon qualities inherited by the embryo in the parental elements.

For the physiological details of human tissues, organs, and functions, see such articles as CIRCULATION OF THE BLOOD, DIGESTION, RESPIRATION, REPRODUCTION; for vegetable physiology, see PLANTS.

Physoclisti. See BONY FISHES.

Physostigma, a genus of climbing herbaceous plants belonging to the order Leguminosæ. The only species is the central African *P. venenosum*, the Calabar bean. See CALABAR BEAN.

Physostigmine. See CALABAR BEAN.

Physostomi. See BONY FISH.

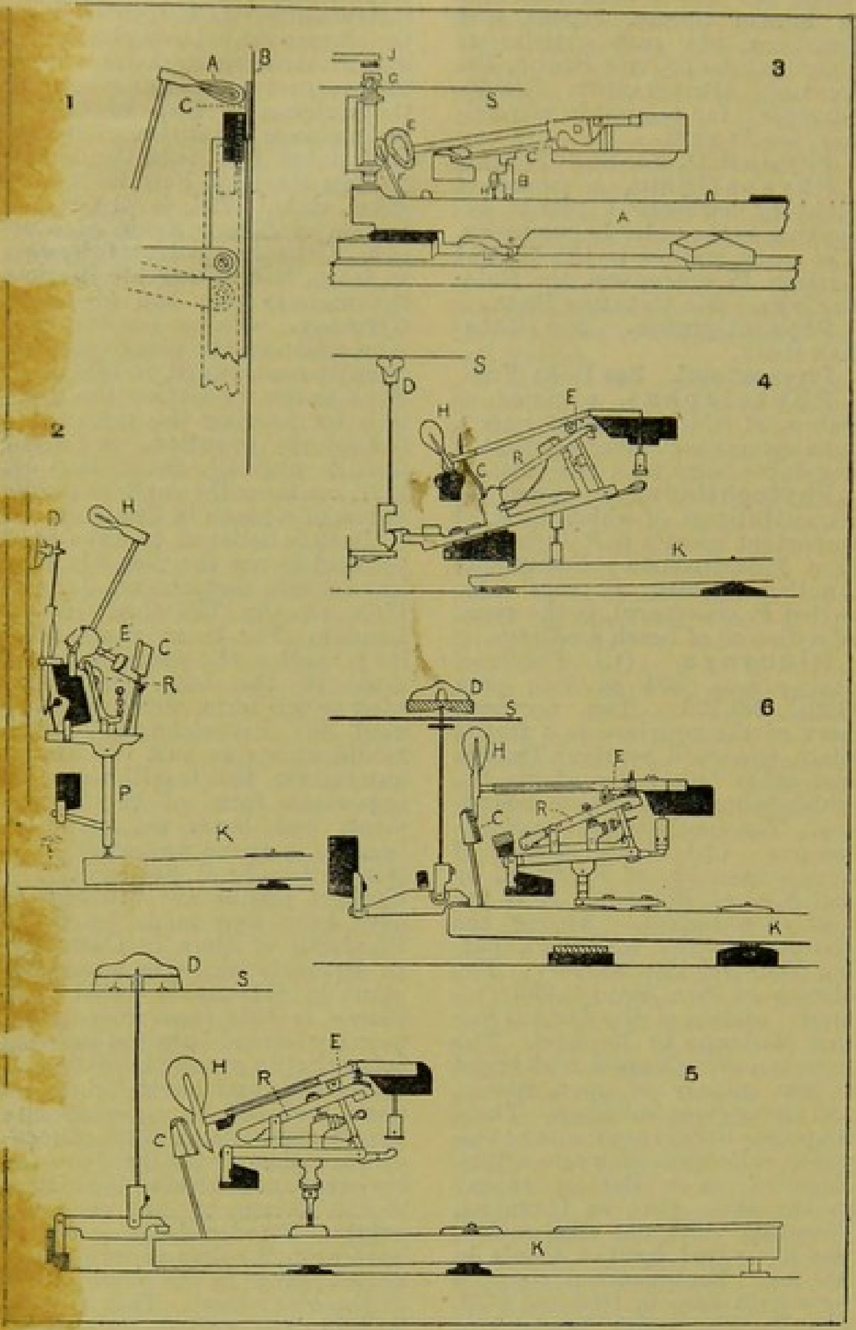
Phytelephas, a genus of palms, of which the most important species is *P. macrocarpa*, the vegetable ivory tree. See PALM.

Phytophthora, a group of parasitic fungi, of which the most important species is *P. infestans*. (See PERONOSPORA; POTATOES.) Another species, *P. fagi* (also called *P. omnivora*), is the cause of a disease of beech seedlings.

Piacenza. (1.) Province, Italy; area, 954 sq. m.; pop. (1901) 245,126. The northern part of the province is a fertile plain, traversed by river Trebbia and other tributaries of the Po, which forms the northern boundary. The southern part is mountainous. (2.) Town, capital of above, on r. bk. of Po, 92 m. by rail N.W. of Bologna. It is the seat of a bishop. Among the churches is the cathedral, dating from the 12th century. The church of San Sisto (1499) formerly contained the famous Sistine Madonna by Raphael. The town is nobly planned, with broad streets, plenty of open spaces, and picturesque buildings. There is a public library containing a valuable collection of manuscripts. Founded as a Roman colony at the same time as Cremona, Placentia, as it was then called, was destroyed by the Gauls in 200 B.C. Ecclesiastical councils were held here in 1095 and 1132. The French, under Louis XII., took it, but it was recaptured by Pope Julius II.; and it remained a papal domain until 1545, when Paul III. gave it to his son, Peter Farnese. It formed part of the duchy of Parma, until incorporated in 1860 with the kingdom of Italy. Pop. (1901) 36,064.

Piana de' Greci, tn., Sicily, Italy, 9 m. S. by W. of Palermo. It was founded in 1488 by Albanians, who fled their country from the invading Turks. The Greek ritual still prevails. Silk and woollen goods are manufactured. Pop. (1901) 8,470.

Pianoforte, THE, was invented about 1709 by Bartolommeo Cristofori (1651–1731), a harpsichord maker in Florence. This instrument differs essentially from its now practically obsolete precursors—but also stringed keyboard instruments—the harpsichord and the clavichord, in having its strings set in vibration by hammers; in this respect the piano resembles the dulcimer. Two of Cristofori's pianos are still in existence. One, dated 1720, is in the Metropolitan Museum, New York; the other, dated 1726, is in the collection of Signor Kraus at Florence. Cristofori had few followers in Italy, but during his lifetime the manufacture had begun in Germany. Claims for the German origin of the piano were frequently made, until, in 1881, A. J. Hipkins finally settled the question by proving the priority of Cristofori's invention. A Covent Garden playbill, dated May 16, 1767, contains the earliest public notice of a piano in England. J. C. Bach is believed to have been the first to use the piano in public as a solo instrument, June 2, 1768, at the Thatched House, London. For many years after its invention the piano was only made in the large horizontal wing or tail form, which was that used for harpsichords. With modifications to suit various requirements, this is still the most important form of the instrument, and bears the name of 'grand,' a name first applied to it in Britain by R. Stodart (1777). Upright pianos are thought to have been first made by C. E. Friederici of Gera in Germany. In Brussels there is a vertical piano by this maker dated 1745. Pianos in this form were subsequently termed 'upright grands,' being simply grand pianos turned up on end, and having their actions modified to accommodate the altered position of the strings, which, rising vertically above the keyboard, necessitated the instruments being of an unwieldy height. Friederici is also said to have been the first to make horizontal pianos in the oblong form of the clavichord. This form in Britain was called a 'square' piano, and from its portability it soon became immensely popular. In 1800 Isaac Hawkins patented a new form of upright piano, which was only from three to four feet in height, and had the strings descending below the keyboard to near the bottom of the instrument; previous to this the strings in upright pianos did not go below the keys. The method of stringing introduced by Hawkins made his instrument the prototype of the 'cottage' piano. Hawkins was also the first to adopt overspun strings for the bass. Thomas Loud (1802) introduced diagonal stringing in upright pianos; he was also the first to invert the position of the wrest-plank or tuning-pin block, placing it at the upper instead of the lower ends of the strings. These were notable improvements. The new position of the wrest-plank was used in the 'cabinet' pianos (patented by T. Southwell, 1807), which were also vertical, about six feet in height, and popular for some time after the lower form of upright pianos had been introduced. In 1811 R. Wornum patented a diagonally strung, low, upright piano with an improved action; this form, now known as the 'cottage' piano, has—at least in Britain and France—entirely superseded other forms of upright pianos and also the so-called square pianos. 'Pianette,' 'oblique,' and 'piccolo' are names given to smaller forms of the familiar cottage piano, which is usually about four feet in height. The name 'upright grand' is given by some makers to a larger form of cottage piano; but the title is misleading, as all vertical pianos are constructed upon the same general principles. The grand proper, being a horizontal instrument, differs materially from the other not only in the arrangement of its parts, but in its tone-producing powers, which are infinitely greater.



Pianoforte Actions.

1. Celeste pedal, causes the hammer A to strike through a strip of felt, C; B is the string. 2. Modern upright pianoforte action (Broadwood's): S, string; K, key; H, hammer; E, escapement; C, check; R, repetition spring; D, damper; P, prolong. 3. Cristofori's action: A, key; B, hopper; C, escapement lever; D, hammer butt; E, hammer head; F, check; G, damper; H, hopper check; J, damper stop; L, spring regulating play of hopper; S, string. 4. Erard's action (1821), on which all modern grand pianoforte actions are based. 5. Modern grand action (Broadwood's), at rest. 6. Modern grand action (Bechstein's) after the key has been struck. References to 4, 5, and 6: S, string; K, key; H, hammer; E, escapement; R, repetition lever; C, check; D, damper.

By varying the proportions and adjustment of parts makers can produce differences in tone, power, and touch; but certain essential parts are common to all pianos. Besides the case there are the 'frame,' which sustains the tension of the strings; the 'sounding-board,' which is the voice of the instrument; and the 'action,' which is the term applied to the mechanism by means of which the strings are set in vibration and the tone is controlled. The frame may be of wood or metal, or a combination of both. Cast-iron frames were used in America for square pianos as early as 1825. W. Allen, a Scotsman, patented (1831) the first cast-iron frame used in Britain, and since about 1860 iron frames of some sort have been much used, especially in Germany and America. At one end of the frame there is a wooden wrest-plank, containing the tuning-pins, into which the strings are fastened, the other ends of the strings being secured to hitch-pins placed round the opposite end and side of the frame. The strings rest upon hard-wood bridges, which are glued to the sounding-board. The latter is an important feature, as its proportions and properties determine to a large extent the tone-producing qualities of the instrument. It is always made of some sort of pine, frequently of the spruce fir, is slightly convex, and is strengthened by a number of bars, also of pine, which are glued to its inner and concave surface. The strings, when vibrating, have their tremors conveyed by the bridges to the sounding-board, which is thus set in vibration. The action is a wonderful piece of mechanism, but here only its general principles of construction can be indicated. When a key of the piano is struck, the inner end of the key causes a hammer to strike certain strings and set them in vibration; but were the hammer-head to be simply the termination of a vertical rod fixed to the key, then, unless by an impracticable method of manipulation, the hammer, after striking a blow, could not be made to leave the strings quickly enough to allow them to vibrate freely, and the