vidual matter is one case, and a most important one, of the conservation of force; and, in a manuscript, he says, "Force cannot be annihilated or created at pleasure. It cannot act, then cease to act, then act, then cease to act, without being otherwise disposed of." In another manuscript, he says: "What I mean by the word force is the source or sources of all possible actions of the particles or materials of the universe; being often called the powers of Nature, when spoken of in respect of the different manners in which these effects are shown."

In order to avoid the indistinctness and confusion which come from using the word force at one time as the cause of an effect, and at another time as the effect itself; and, in order to confine ideas to the effect which alone can be the object of experimental research, the term conservation of energy is now adopted, instead of the term conservation of force. Thus, the word force, of the nature of which we know only that it is indestructible and inseparable from matter, is the cause of energy, and energy is the effect of force.

This diagram may perhaps render the use of these terms more clear.

The idea of the conservation of energy is, that the sum of the actual and potential energy in the world is constant. The force, or, as it is better called, the actual energy, that can be put into the cannon ball, is exactly equal to the latent or potential energy in the gunpowder, and this depends on the chemical force in the oxygen, hydrogen, and carbon. The ball gains only what the powder loses. As the potential energy, or tension, decreases, the actual energy, or motion, increases, and no loss or gain in the total amount of motion and tension can occur. Whatever the form of motion may be, it can only come either from some other form of motion: or from some form of tension.

It has been Dr. Joule's great work to exhibit experimentally the measurable relation between heat and gravity. He has determined that a certain amount of one kind of motion does produce an equivalent quantity of another kind. He proved that 772 pounds weight of matter falling one foot gives rise to enough heat to raise a pound of water one deg. Fahr. in temperature. He called the unit of mechanical motion one pound weight falling one foot = one foot-pound, and the unit of heat that quantity which raises one pound of water one deg. Fahr.; then the mechanical equivalent of heat is 772 foot-pounds.

The equivalence of other forms of energy has yet to be determined by experiment. Meanwhile, according to modern ideas, the different forms are so related to one another, that none can be lost, and none can be produced except by passing into or out of some other form of energy.

"But," says Mr. Faraday (*Researches in Chemistry and Physics*, p. 459), "after all, the principle of the conservation of force may by some be denied. Well, then, if it be unfounded, even in its application to the smallest part of the science of force, the proof must be within our reach, for all physical science is so. In that case, discoveries as large, or even larger, than any yet made, may be anticipated. I do not resist the search for them; for no one can do harm, but only good, who works with an earnest and truthful spirit in such a direction. But let us not admit the destruction or creation of force without clear and constant proof. Just as the chemist owes all the perfection of his science to his dependence on the certainty of gravitation applied by the balance, so may the physical philosopher expect to find the greatest security and the utmost aid in the principle of the conservation of force. All that we have that is good and safe, as the steam-engine, the electric telegraph, etc., witness to that principle. It would require a perpetual motion, a fire without heat, heat without a source, action without reaction, cause without effect, or effect without a cause, to displace it from its rank as a law of Nature." Finally, he says, "by admitting no hypothesis, and believing in no assertion of any fact opposed to the principle of the conservation of force, the natural philosopher is prepared to look for effects and conditions as yet unknown, and the way for him is open to any degree of development of the consequences and relations of power. By denying this principle, he opposes a dogmatic barrier to improvement; whilst, by admitting it, he has a fresh stimulus to investigation and a pilot to human science." (P. 450.)

In my next lectures, I shall show you how far the three stages of ideas on the separability of matter and force can be recognised in the history of sciences into which the idea of life enters; and I shall try to make some application of the doctrine of the conservation of energy to physiology, pathology, and therapeutics.

A CASE OF ANEURISM OF THE ASCENDING AORTA COMMUNICATING WITH THE PULMONARY ARTERY.

BY WILLIAM ROBERTS, M.D., F.R.C.P.,
Physician to the Manchester Infirmary.

CASES of aortic aneurism communicating with the pulmonary artery, and studied with some accuracy during life, are still of sufficient rarity to deserve separate record.

On October 9th, 1867, I was requested by Mr. Stocks, of Salford, to see with him a gentleman labouring under some obscure disease of the heart. The patient (Mr. J.) was engaged in business; and, in addition, acted as organist of a church in the suburbs of Manchester. He was a spare weakly-looking man, aged 28, of somewhat intemperate habits. It appeared that, about a month before, Mr. J. began to suffer from cough and difficulty of breathing. He thought he had taken cold, and for this he consulted Mr. Stocks about a week before my visit. On examining him, Mr. Stocks discovered in the præcordial region a loud harsh murmur, which was evidently different from the murmurs produced by ordinary valvular disease.

When Mr. J. was first seen by me, he did not keep his bed; he even went out a little occasionally. His face was pale and thin; the lips were somewhat livid. There was no dropsy nor oedema of any part. He complained of an irritating cough, with oppression in the chest, and occasional paroxysmal attacks of difficulty of breathing, which were relieved by ether draughts. There were no antecedents in his history bearing specially on the production of heart-disease; unless the fact that, owing to his irregular habits, he sometimes had to hurry and run on Sunday mornings, to keep his appointment at church, can be so regarded. He was subjected to a careful examination, and evidence was found of extensive disease of the heart and great vessels; but, as the physical signs differed in no appreciable manner from those found on November 1st and 4th, the detail of these, to avoid repetition, will be described from the notes taken on the latter of these dates. In the meantime dropsy had set in, and advanced rapidly; the strength declined, and the patient became confined to his room, and, finally, to his bed.

On November 4th, he was in the following condition. He was lying in bed, with the head much raised to facilitate his breathing. The face was calm and pale; the lips livid. There was considerable oedema of the legs and thighs, with some ascites. There was short frequent cough and somewhat abundant expectoration of a liquid aluminous matter, mostly airless, mixed with a little froth and a few specks of blood. Pulse 112, markedly jerking, and strongly visible in all the superficial arteries; respiration 32. The tongue was red and clean, and freely mapped with furrows. There were almost perpetual insomnia, considerable thirst, and failing appetite. On examining the chest, there was found some præcordial bulging; the heart's apex beat in the fifth interspace, half an inch outside the vertical line of the nipple. The superficial cardiac dulness was very extensive, reaching from an inch and a half to the right of the middle line to one inch outside the left nipple; it reached upwards as high as the third rib in the sternal region, and formed a parallelogram five inches across and four inches deep. The cardiac dulness was thus situated rather high up; the liver also reached as high as the fifth rib in the nipple-line. Both organs were evidently pushed up by the intestines, floated upwards by the peritoneal effusion. The visible cardiac impulse was not very great. A loud harsh double murmur was heard at the mid-sternal base; or rather, it was a single murmur consisting of two parts and covering completely both sounds. This murmur diminished rapidly in intensity towards the apex; where, however, both parts of it were distinctly audible. It was not heard beyond the apex. It was heard in moderate intensity at the ensiform cartilage. It was well conducted up the aorta, and into the great vessels at the root of the neck. But the murmur was heard far most loudly at the upper margin of the cardiac dulness, midway between the middle line and the left nipple. At this spot it was excessively loud, harsh, and rasping; it gave the impression of being produced very near the ear. It could even be heard by the naked ear at a distance of an inch from the surface of the chest. It diminished in intensity in all directions from this centre. Over the body of the ventricle it seemed so superficial, that it deceitfully resembled a pericardial friction-sound. The murmur was accompanied with an intense vibratile thrill. There was abundant fluttering pulsation at the root of the neck; but the parts hereabouts presented no unusual fullness. Both sides of the chest expanded differently; especially the left. Over both lungs there was a somewhat abundant liquid subcrepitant rhonchus. The voice was weak; the cough-voice a little metallic; and, both in its ineffectiveness and in this slight metallic quality, suggestive of mediastinal

tumour. There was no heaving pulsation of the mediastinal region. The patient suffered from occasional severe paroxysm of dyspnoea. The pulse-tracing taken by Marey's sphygmograph (see woodcut) was highly dirotic, and was remarkable for the extreme height and perfect verticalness of the upward stroke. It appeared suggestive only of aortic regurgitation.

tion. It was wholly wanting in the flattened summit, usually co-existing with rigidity of the aorta, and with aneurismal dilatation near the heart. The tracing is interesting as being the only one hitherto taken in a case of varicose aneurism near the heart, but it is rather disappointing in its want of any characteristic peculiarity.

I did not see Mr. J. after the 4th of November. He died on November 22nd. Mr. Stocks states that his condition did not change essentially. The orthopnoea continued without relief, accompanied with great restlessness and insomnia. The oedema of the legs went on increasing in spite of repeated punctures, and at length occasioned the appearance of sanguinolent vesicles and bullae, surrounded with wide red areolae; but no actual erysipelas or gangrene of the integuments took place. He died at length exhausted. The physical signs (according to Mr. Stocks) continued unchanged to the last.

AUTOPSY fifty hours after death.—The body was very emaciated. Much of the dropsical effusion had drained off after death. The liver was enlarged and congested; otherwise healthy. The lungs were engorged at the lower and back parts, and thrust aside by the enlarged heart. There was no pleuritic effusion.

Heart and Great Vessels.—The pericardium was adherent throughout; the two surfaces being joined together by fine connective tissue of uniform texture. The parietal layer was not thickened, nor did it bear any traces of past morbid action. It was, however, adherent to the pleura costalis, the lung being here pushed aside; so that a very large pre-cordial surface was in immediate contact with the chest-wall. A ligature was put on the inferior cava, and the heart and great vessels were removed in one piece. All the chambers of the heart were enormously engorged with loosely clotted blood; and the whole organ, thus distended, was of huge size, as large as the heart of an ox. It had an oblong subglobular shape, with blunt rounded apex. The heart was opened in the course of the circulation. The *right auricle* was much dilated; the tricuspid orifice was highly patulous, admitting the four fingers and thumb. The tongues of the tricuspid valve were, however, normal; but, of course, insufficient to close the dilated orifice. The *right ventricle* was also enormously dilated, and its walls at the thickest parts measured more than a quarter of an inch. On slitting up the *pulmonary artery*, the sigmoid valves were found healthy, and the orifice of the vessel very little if at all changed; but immediately above the valves there was seen a blunt conical elevation, projecting fully half an inch above the general level into the lumen of the vessel. In the centre of this projection was a round opening, which was large enough to admit a good sized pea. The edges of this perforation were very thin, quite smooth and membranous. On each side of the main opening, and opposite to each other, were situated two very small perforations; one was about half a line in diameter, separated from the larger opening by a thin translucent edge, not more than three-quarters of a line in breadth; the other was a mere pin-hole. The wall of the artery around the perforations, for about the area of a sixpence, was thin and diaphanous, perfectly smooth and free from atheromatous patches; as was likewise the entire surface of the pulmonary artery and its valves. The opening at the summit of the projection overhung the attachments of two of the sigmoid valves of the pulmonary artery; so that the blood spouting through it came within a quarter of an inch, or less, of the cavity of the right ventricle. The calibre of the artery was not dilated; and the sigmoid valves were competent. The *left auricle* was dilated and engorged. The mitral orifice was patulous to a moderate degree, admitting the points of four fingers. The *left ventricle* was enormously dilated and hypertrophied. Its capacity was at least four times as large as natural; and its walls, at the thickest parts, three-quarters of an inch thick. The tongues of the mitral valve were healthy, large, and supple. The aortic orifice was somewhat dilated; but the sigmoid valves were perfect, and closed the orifice almost, if not quite, effectually. On slitting up the aorta, the vessel, for a distance of an inch and a half from its origin, was found dilated to the extent of about one-third beyond its natural calibre. From this dilated portion, and immediately above the right and left sinuses of Valsalva, there sprang a wide mouthed aneurismal pouch, resembling in

size and shape the half of a large walnut-shell. The bottom of this pouch was funnel-shaped, and communicated with the pulmonary artery by the orifices already described. The surface of the aorta, in the dilated portion, was rugged and stiff, with thickly set atheromatous patches and nodules—none of which had undergone calcareous changes.

REMARKS.—The abnormal communication between the aorta and the pulmonary artery, in the present case, had been established at least eight weeks before death; the characteristic murmur and the accompanying thrill having been known to exist for that period. The communication was evidently established, not by any sudden rent of the aneurism, but by a gradual progressive thinning away of its wall. There did not occur in this case any sense of something giving way in the chest, nor any sudden syncopeal attack. In this respect it agrees with the two cases of similar preternatural communication between the aorta and pulmonary artery, recorded by Professor Smith of Dublin and Dr. Hope. So far as I know, only eight cases of this particular lesion have hitherto been observed during life;* and in five of them the moment of rupture was plainly signalled by sudden faintness and other alarming symptoms. In one case, death took place in four minutes after the supposed time of rupture; in two others, in nine and twelve hours; in the remainder, after some weeks. The diagnosis formed during life in the present case was—dilatation and hypertrophy of the four chambers of the heart with aortic and tricuspid regurgitation; it was also conjectured that there was an aneurism at the root of the heart. Aortic regurgitation certainly did exist; but the reflux of blood took place not into the left ventricle, as in ordinary cases, but into the right ventricle, or, into the origin of the pulmonary artery. The sphygmographic tracing was considered to weaken the probability of the existence of an aortic aneurism—another proof of the untrustworthiness of the sphygmograph for the purposes of diagnosis; or, perhaps, a proof of our imperfect interpretation of its indications. Looking at the case in the light of the *post mortem* examination, it seems to me that sufficient weight was not attached to the locality of the point of maximum intensity of the murmur, and to its lines of conduction. The point of maximum intensity was precisely over the left limit of the origin of the pulmonary artery, and the murmur diminished markedly in intensity along all lines radiating from this centre. The hypertrophy and dilatation of the chambers are easily explainable on the principles which govern the production of compensating hypertrophy from ordinary mechanical impediments. The left ventricle was enlarged, because there was a leak at the origin of the aorta, which required increased effort on the part of the ventricle to sustain the mean lateral pressure in the arterial system, and maintain the equilibrium of the circulation. The enlargement of the right ventricle was evidently due to two obstructions. In the first place, there was the bulging protuberance of the aneurism, which encroached seriously on the available bore of the pulmonary artery. In the second place, the funnel-shaped summit of the protuberance overhung the orifice of the ventricle, in such a manner, that through the opening thus situated a powerful rush of arterial blood encountered and partially neutralised the column of venous blood propelled by the simultaneous contraction of the right ventricle. It is not doubtful which of these two opposing streams was the most powerful. The funnel in which the aneurism culminated was directed from the arterial towards the venous channel—clearly indicating that the current always ran in that course.

OBSTETRIC MEMORANDA.

A CASE OF TRIPLETS.

By FREDERICK TURTON, L.R.C.P., Wolverhampton.

M. S., AGED 36, had a child fourteen years ago, and no subsequent pregnancy until the present one. She was attended by a woman, and delivered at 2 A.M. on February 18th, 1868, of a living male child, after having been ten hours in labour. The placenta came away soon afterwards, and in due course the patient was left quite comfortable. When her husband came home to his dinner, about twelve hours after the birth of the child, he found that, during the temporary absence of her attendants, she had just given birth to two lively girls. I was sent for, and on my arrival, found that the placenta had been expelled; one five or ten minutes after the other. Although the first after-birth followed soon after the first born child, and there was the long interval between that and the birth of the others, the patient had comparatively little hæmorrhage, and has made an excellent recovery.

* Five cases are cited by Thurnam in the *Medico-Chirurgical Transactions*, vol. xxiii; one is recorded by Professor Smith, *Dublin Journal of Medical Science*, vol. xviii, p. 164; one by Dr. Bennett, *Clinical Medicine*, third edition, p. 595; and one by Dr. Wade, *Medico-Chirurgical Transactions*, vol. xlv, p. 211.