electrical discharges were in proportion neither to their voltage nor to the quantity of electricity (in micro-coulombs) they contained, but to their electric energy measured in joules, taking the presence of thoracic respiration as evidence of life or death. It is worth noting that no such connexion between the amount of electric energy employed and the occurrence or not of a fatal result can be worked out in the case of animals exposed to shocks from the ordinary electric currents used industrially, or in the numerous experiments on animals already described. Young animals were generally more easily killed than old, weight for weight; the direction in which the shock passed made no difference to the result. Death was generally due to asphyxia, from central inhibition of the respiration without inhibition of the heart's action. A curious *post-mortem* lesion was sometimes found, especially in young guinea-pigs—namely, a loss of the elasticity and retractility of the lungs, which rendered recovery by the performance of artificial respiration impossible. It occasionally happened in the guinea-pig that the heart was thrown into a transient state of ventricular fibrillation; the amount of electrical energy available was not large enough to kill dogs.

In 1899 Cunningham independently made some experiments on the electrocution of etherized dogs, somewhat similar to those described a few minutes ago, and, so far as they went, with similar results. Using a continuous current at 115 volts, he found great differences in the strength of current that could be passed with impunity through different dogs; thus a large Newfoundland was killed by 300 milliamperes, while a small shaggy terrier survived 700 milliamperes, and currents smaller than 200 milliamperes were never fatal. Other experimenters have found direct currents of 200 to 300 milliamperes to be fatal to dogs; very possibly the discrepancy here may have been due to the occasional use by Cunningham of larger electrodes that did not serve to concentrate the current and make a sufficiently large proportion of it pass through the heart—a supposition confirmed by the fact that the recorded resistance (77 ohms) of one of his dogs from side to side of the chest was only a quarter of the resistance commonly found in their own experiments by Prevost and Battelli and by Weiss. Such deaths he attributed to the immediate and permanent cessation of the co-ordinated contraction of the heart caused by the electric current. He then went on to investigate the effect of electric currents applied directly to the central nervous system of the etherized dogs. He found that strong currents (1.6 amperes) through the brain caused a deep inspiration, and cessation of respiration while the current flowed; the heart kept on beating and the blood pressure rose steadily to two or three times its original value, returning again to the normal when the current was cut off and respiration began once more. But if the current was kept on for as long as four or five minutes, the heart gradually stopped. He therefore argued that death by the action of electric currents on the brain and medulla was due to asphyxia, and not to heart failure. The strength of the ordinary electric currents that may be sent through the dog's head without causing rapid death is surprising; Houston found that even 6 amperes were not necessarily fatal.

A few more recent investigations remain to be mentioned. Battelli, in 1902, electrocuted dogs, rabbits, guinea-pigs, and rats with discharges from large Ruhmkorff induction coils giving sparks up to 15 and 45 cm. in length. He was able to kill the smaller animals either by arrest of the respiration, or, using a condenser as well, by throwing the heart into fibrillary contraction. With the larger animals, however, death could only be produced by asphyxia after prolonged electrification, the available current—measured in milliamperes—being too small to cause the heart muscle to fibrillate. Battelli stated that no human being had ever yet been killed by the discharge of an induction coil, and estimated that the larger of his two coils would have required a minimum time of two minutes to kill a man, when death, had the experiment been successful, would have been by asphyxia and not by heart failure.

The fact that d'Arsonval believes death by electricity to be due to inhibition, or paralysis of the central nervous system, has been mentioned already. In 1910 he recorded a further experiment that appeared to him to prove that

death by electricity, if not due to material lesions of the nervous centres and the heart, was due to Brown-Séquard's inhibition or the action of electric shock on consciousness and the psychical functions. A dog is anaesthetized with chloroform and the cerebral cortex is exposed; stimulation of the cortex with the current from a single Daniell cell (1.1 volts) is found to produce movements of the limbs. If the dog is now killed by a current at 110 volts the heart is thrown into fibrillary contractions, the respiration stops, and the cortex ceases to be excitable by the Daniell cell. At the end of a few minutes respiration begins again, and then the cortex again becomes excitable, and, lastly, in some cases the heart begins to beat spontaneously once more. This experiment d'Arsonval takes to prove that all the vital functions are affected at the same time by an electric shock, so that in his view it is superfluous to inquire whether death is due to a paralysis of the heart or not. He admits that the recovery or death of an animal from a shock that may or may not be fatal depends entirely on the question whether the cardiac fibrillation is transient or is followed by permanent loss of the ability of the heart to beat spontaneously; and as it has been found that section of the vagi has no influence on the occurrence of this cardiac fibrillation, it is, in my opinion, impossible to agree with d'Arsonval when he attributes great importance to nervous inhibition in the large majority of the fatal accidents brought about by industrial electric currents.

NOTE.—The references to the literature will be given at the end of the third lecture.

THE USE OF PHYSICAL CONSTANTS IN TOXICOLOGY.

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In the course of toxicological examinations it is frequently necessary to identify various organic compounds, and the increasing use of synthetic remedies renders it imperative that toxicologists should have at their disposal methods by which such drugs can be recognized with the greatest possible certainty. In cases where reasonable amounts of the substance can be obtained there is usually no great difficulty, since quantitative analyses may be made of both the original substance and its derivatives.

It sometimes happens, however, that, after a compound has been separated from some food substance or excretion, the amount available for examination is exceedingly small, and becomes still smaller after it has undergone purification. In such cases, unless some definite chemical or physiological reaction can be applied, colour tests and other purely empirical methods are adopted, and consequently, although the investigator might be satisfied with the results he had obtained, such results might not carry, and very often do not carry, such weight with others.

It is, therefore, desirable to ascertain if any physical methods are available for a more satisfactory elucidation of such problems.

One constant—the melting point—stands out pre-eminently, since it can be obtained with a very small amount of material. During recent years a modification of the usual method of identifying a substance by taking its melting point has been largely used by organic chemists.* This method may be called that of "mixed melting points."

Speaking broadly, a pure organic substance that is fusible within ordinary limits will melt sharply—that is, at one particular temperature it will be a definite solid, and when the temperature is raised gradually it will assume the liquid phase within 1° C., or possibly 2° C. Now the admixture of foreign substances with the material under examination will totally upset this state of things, and instead of fusion taking place at a definite temperature characteristic of the pure substance, it will commence at an entirely different temperature. This is

* The mixed melting point method was apparently first used by Kipping and Pope (*Trans. Chem. Soc.*, 1893, 63, 558).

due to the fact that one constituent of the mixture is acting as a solvent of the other, and solution is only gradual. A series of compounds has been investigated to illustrate this point, and in each case two substances have been chosen whose melting points are fairly close together. The usual type of apparatus was employed in which the bath was sulphuric acid.

A tube containing one pure substance was attached to the left side of the thermometer, the second pure substance to the right side, and a third tube in the middle contained an intimate mixture of equal parts by weight of each substance. The temperature was gradually raised, and the three tubes closely inspected during the process by the aid of a lens. The pure substances retained their original appearance to within about 1° C. of the final fusion point, which in each case was complete within a range of 3° C. The mixture of the two substances taken commenced to soften at a much lower temperature, and fusion extended over a considerable range in each case.

It is clear from the following table that a pair of substances may have similar melting points, but a totally different one when mixed.

Table of Melting Points of Pure and Mixed Substances.

Substance.	Melting Point.	Melting Point of Mixture.
Antipyrin	110°-113°	57°-74°
Antifebrin	110°-113°	
Anisic acid	181°-183°	145°-172°
Succinic acid	187°-188°	
Aconitine	190°-193°	160°-175°
Veronal	190°	
Thymol	50°-51°	18°-30°
p. Toluidine	45°	
Cocaine	96°-98°	63°-95°
p. Chlor-formanilide	100°-103°	
Codein	150°-152°	75°-135°
p. Acet-toluide	150°-152°	
Cinnamic acid	133°-135°	95°-115°
Phenacetin	133°-135°	
Sulphonol	126°-127°	70°-90°
β Naphthol	122°-123°	
Cocaine	96°-98°	60°-85°
Betol	95°	
Strychnine	270°	230°-240°
Cinchonidine	260°	

During the past three years I have had on two occasions to examine specimens of urine for small quantities of abnormal constituents, and in each case succeeded in extracting about 0.1 gram of a crystalline substance closely resembling veronal.*

In both instances the compound was first carefully purified, but the amount of pure material obtained was much too small to be investigated by any known method other than that described. The agreement between the melting points of veronal, the material suspected to be this compound, and a mixture of both, left no doubt as to the identity of the drug.

It is hoped that this application of a simple physical constant may prove of great value to toxicologists.

* The veronal was extracted from the urine with ether after preliminary treatment with lead acetate, etc., according to method described by Fischer and Hoppe (*Muench. med. Woch.*, No. 28, 1909).

THE recently issued report of the Sceptre Life Association, an insurance company which caters for abstainers and non-abstainers and keeps the results attained in each section separate, again shows the effect of total abstinence on the longevity of its policy holders. In 1912, of 132 deaths expected among non-abstainers 92 occurred, whilst there were only 53 out of 139 expected deaths of total abstainers. The percentage of actual to expected deaths among the non-abstaining insured (69.70) was more than double that of the abstaining policy holders, who come out with the low percentage of 38.13. For the twenty-nine years 1884 to 1912 the percentage of actual to expected deaths has been, for non-abstainers, 79.33; for abstainers, 51.68. Seeing that at the time of acceptance each class of policy holders was examined as rigidly as the others and all the lame ducks cast out, the results recorded must be regarded as evidence that the use of alcoholic liquors shortens the duration of even picked lives.

THE INTRAMURAL SPREAD OF RECTAL CARCINOMA.

[WITH SPECIAL PLATE.]

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OPERATIVE measures for the eradication of cancer must be planned according to the pathological findings. That widely divergent views are held as to the particular operative treatment applicable to cancer of the rectum and pelvic colon is sufficiently evidenced by recent papers on the subject by Harrison Cripps, Paul, Miles, and Sampson Handley. It may reasonably be assumed that corresponding differences of opinion exist as to the pathological conditions which obtain; and, indeed, such assumption is amply confirmed by the perusal of these papers, as well as by the remarks made by speakers during the discussion on rectal cancer at the Royal Society of Medicine in 1910.

A convenient classification—adopted by Miles—of the pathological factors which must be considered in planning any radical operation for cancer of the rectum is as follows: (1) The spread of the disease in the bowel wall—intramural; and (2) that which occurs in surrounding or distant tissues—extramural.

This communication is concerned with the first factor, and an attempt has been made to determine its extent and significance.

Material.

This comprises 20 cases, in 18 of which the bowel investigated was removed by operation. Two *post-mortem* cases are included because they exhibit important features. The majority of these cases were operated on by surgeons at the Cancer Hospital, but for three I am indebted to Mr. Barker of University College Hospital, and for two to Mr. Gordon Taylor of the Middlesex Hospital. The operation in 13 cases was the radical abdomino-perineal, as described by Miles. In 3 cases the malignant disease was situated above the pelvic colon. The length of bowel removed in these 16 cases was from 9 in. to 23 in. In 2 cases a local resection was practised.

Technique.

The bowel was slit up immediately after operation, stretched by nailing to a piece of board, and placed in a fixative solution consisting either of formalin in normal saline or acid mercury perchloride. After fixation a strip the whole length of the bowel was taken and cut into inches. Each inch of tissue was embedded in paraffin, sectioned, and stained with muci-carmin according to the method which I have elsewhere detailed. In some cases two strips were taken.

Nature of Growth.

The growth in every case was an adeno-carcinoma. In 18 cases the appearance presented was that of a typical carcinomatous ulcer, in 1 there was a tendency to mass formation approximating to the papilliferous form, while 1 exhibited a diffuse colloid infiltration. The last specimen was obtained *post-mortem* from a male patient, aged 18, who rapidly succumbed, and illustrates the extreme malignancy of this form of growth.

The ulcers presented the usual features. Their edges were irregular, rolled, and everted. The long axis of the ulcer was transverse in every case, showing a tendency to involve the bowel circularly rather than longitudinally. Another point noted with regard to these ulcers was the frequency with which a narrow tract of mucous membrane was found to be involved in cases where clinical examination suggested that the ulcer had completely encircled the bowel. This narrow tract of apparently normal mucous membrane was always situated in the mid-line posteriorly. Examination of other specimens, preserved in the museum of the Cancer Hospital, indicates that this condition is so common as to be almost characteristic. The favourite site of origin of cancer of the rectum would appear to be on the anterior or lateral wall. From this point the growth spreads round the bowel, a partial