BRONCHO-DILATOR NERVES[1]. By W. E. DIXON AND FRED RANSOM[2].

(*From the Pharmacological Laboratory, Cambridge.*)

History. In 1903 one of us with Dr T. G. Brodie[3] gave the first clear evidence for the presence of broncho-dilator fibres in the vagus. We found also that the vagus contained broncho-constrictor fibres, but failed to find any evidence in the sympathetic of efferent nerve fibres for the bronchial muscles. In this paper a complete account of earlier observations is given, and it need not be repeated here. These results have been amply confirmed both as regards the presence of constrictor and dilator fibres in the vagus nerve by Prevost and Saloz[4]. Januschke and Pollak[5] also using the method of Dixon and Brodie obtained evidence of slight broncho-dilatation on the administration of adrenalin (0·1 mg.), but the effect of adrenalin was much more decided when the bronchioles were first thrown into contraction by means of muscarine. They suggest tentatively that sympathetic broncho-dilator nerves may be present. Dixon and Brodie had failed earlier to obtain this effect, but they were of course working with crude suprarenal extract. Möllgaard[6] has recently extirpated one lung from the dog or cat and after varying times traced the degeneration. He found in the dog that the nerve stations were for the sympathetic in the lung the middle cervical ganglion, and for the vagus chiefly the ganglion nodosum. He noted that some of the fibres of the sympathetic from the two sides cross. In the cat he found that the ganglion stellatum was the chief station for nerve cells.

Methods. Animals. Anæsthesia. We have employed the Dixon-Brodie oncometric method of recording the changes in lung volume

[1] The expenses of this research were defrayed by a grant from the Royal Society.

[2] Beit Research Fellow.

[3] Dixon and Brodie. This *Journal*, XXIX. p. 97. 1903.

[4] *Arch. Internat. de Physiol.* VIII. p. 327. 1909.

[5] *Arch. f. exp. Path. u. Pharm.* LXVI. p. 205. 1911.

[6] *Skan. Arch. f. Physiol.* XXVI. p. 315. 1912.

during artificial respiration. It is hardly necessary to point out that each thrust of the pump should deliver constantly throughout the course of each observation the same volume of air, and we adopted the same precautions as were adopted by Dixon and Brodie. The recorder employed was a tambour covered with very thin rubber, and applied quite loosely, so that it could measure considerable alterations in volume without any marked variation in pressure: any pressure which hinders the free entrance of air into the lung invalidates the experiment in proportion to the degree of pressure set up. The *middle lobe of the right lung* was placed in the oncometer in all the experiments. Blood-pressure was always recorded from the right femoral artery, and drugs were injected into the right femoral vein. The observations were made entirely upon cats.

We have employed two methods of producing anæsthesia; the first consisted in complete destruction of the brain and sometimes the medulla; the second in the production of a preliminary general anæsthesia with A.C.E. mixture followed by the injection of urethane into the peritoneal cavity to the extent of about 1½ grams per kilo body weight. We have found that the necessary half-hour interval between the administration of the volatile anæsthetic and the commencement of the observations, a period during which the animal is receiving artificial respiration, is sufficient to get rid of any volatile anæsthetic, at all events in so far as it affects the peripheral nerves in the bronchioles. It is well to remember that urethane has a depressant effect on all forms of plain muscle, and an excessive dose may easily invalidate an experiment.

In order to exaggerate the effects of vagal stimulation and to produce a small degree of bronchial tonus we have employed physostigmine. It is well recognised that physostigmine in small doses, such as 1 or 2 mgr., increases the excitability of the cranial and sacral autonomic nerves, and slightly increases the tonus in plain muscle. This amount of the alkaloid injected into the cat produces salivation and sweating, and causes dilatation of the pupils followed in a few minutes by well-marked constriction. Irregular twitchings of voluntary muscle are usually to be seen but they are never severe and in the course of a minute or two pass off. The bronchial tonus which the physostigmine induces passes off in about an hour and a further dose of physostigmine may be required if the experiment is not completed. We were led to adopt this method for artificially increasing tonus as the result of some experiments which we were conducting on physostigmine in which we learnt that death from this alkaloid is invariably

caused by prolonged and most violent broncho-constriction: incidentally we found that the life of the animal could be prolonged indefinitely by continually injecting small doses of adrenalin, not through any action of this substance on the vascular system but, as we show in this paper, by its action on the sympathetic system in causing broncho-dilatation. Dixon and Brodie and other investigators failed to find bronchial nervous tone normally existing; but it must be remembered that the experiments were made upon decerebrate or anæsthetised animals and in either case the central nervous system would no doubt have lost most of its activity so that such experiments afford no evidence that tone does not exist in the normal condition.

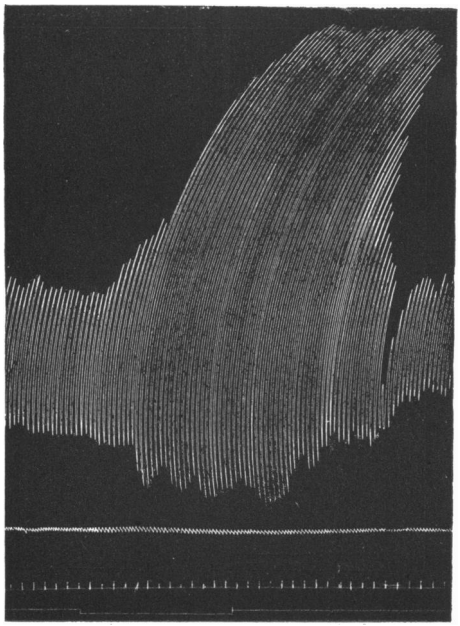


Fig. 1.

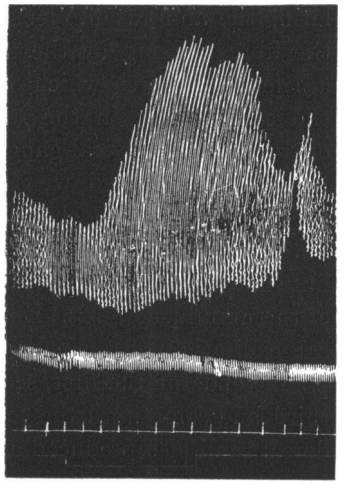


Fig. 2.

Fig. 1. Urethane. Lung vol. and B.-P. Shows the effect of exciting the post-ganglionic fibres from the ganglion stellatum to the lung C=5 cms. Time=5 secs.

Fig. 2. Decerebrate. Lung vol. and B.-P. Shows the effect of exciting all the fibres passing over the annulus of Vieussens. Coil at 6 cms. Time=5 secs.

Broncho-dilator fibres. All previous observers in referring to the vagus are, we believe, speaking of the vago-sympathetic nerve, and no mention is made, so far as we can discover, of attempts to separate the one nerve from the other. Of course in the rabbit separation is not

necessary, but we find no reference to the broncho-dilators in the rabbit's vagus. Definite evidence of broncho-dilatation is confined to the cat and dog. In the present experiments we have determined the action of the vagus and of the cervical sympathetic nerves separately.

The thoracic sympathetic. If the main accelerator nerves, that is those which leave the sympathetic in the region of the ganglion stellatum, are tied and cut, and the ends connected with the lungs are excited by the faradic current, decided broncho-dilatation invariably ensues, provided that the bronchioles are in a state of some tonus. The dilatation is often maximal; it commences with the stimulation, gradually passes off to the former condition of tonus so soon as the stimulus is removed, and can be repeated an indefinite number of times. A typical record of this nature is shown in Fig. 1. A similar effect may be obtained by stimulating the annulus of Vieussens, the fibres passing by the small accelerator nerves which leave the sympathetic in the region of the inferior cervical ganglion. In one case indeed we found there were no broncho-dilator fibres in the main accelerator, but that they all took the course of the annulus (Fig. 2). Electrical excitation of the cut peripheral ends of the first, second, third and sometimes the fourth dorsal rami also produced a like effect. Broncho-dilatation was not obtained by stimulation of the rami, when the accelerator nerves on the same side had been previously cut.

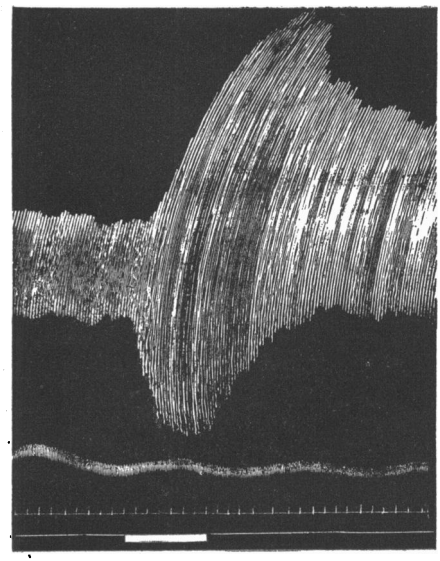


Fig. 3. Decerebrate. Lung vol. and B.-P. Shows the effect of exciting the cardiac end of the cut right sympathetic nerve with the coil at 5 cms. Time = 5 secs.

The cervical sympathetic. It is also easily shown that some of the fibres in the cervical sympathetic are broncho-dilator in nature and pass out by the accelerators. Fig. 3 shows the effect of exciting the thoracic end of the cut cervical sympathetic nerve on the right side. In this instance immediate and profound broncho-dilatation occurs on

the right side, and this condition remains maximal just so long as the stimulation continues, and gradually passes back to its original state of constriction after the stimulation ceases. Sometimes when the initial dose of physostigmine has been larger than that administered in this experiment broncho-constriction recurs immediately the stimulus ceases. In Fig. 4 the effect of two short excitations of the right cut

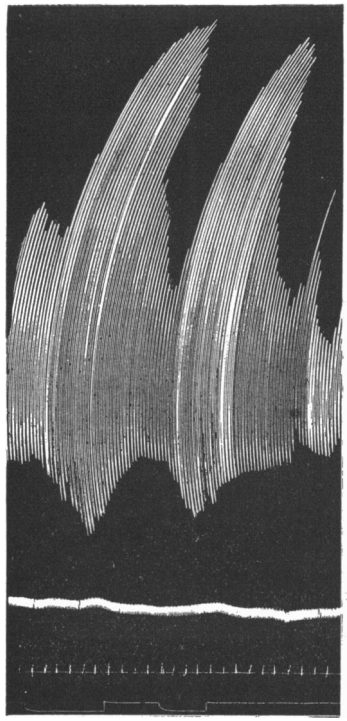


Fig. 4.

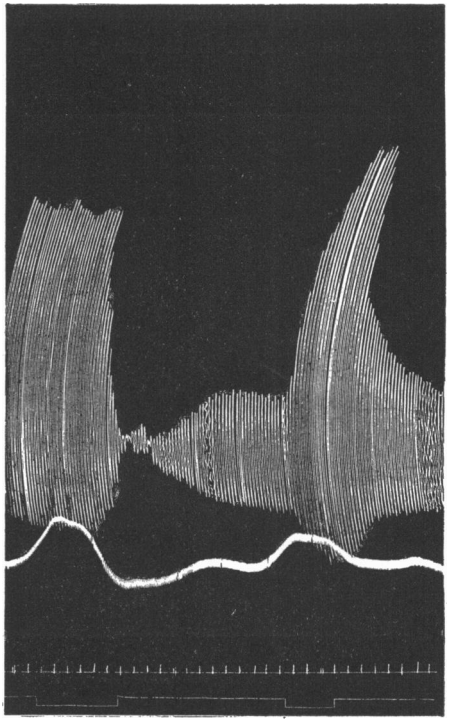


Fig. 5.

Fig. 4. Decerebrate. Lung vol. and B.-P. Shows the effect of exciting the cervical sympathetic nerve on two occasions. Time = 5 secs.

Fig. 5. Decerebrate. Lung vol. and B.-P. Shows the effect of exciting first the peripheral right vagus C = 8 and later the right cervical sympathetic C = 6. Time = 5 secs.

cervical sympathetic nerve to the lung is shown: here both the dilatation and subsequent contraction are very rapid, the dilatation occupying very little more time than the duration of the stimulus. Not infrequently the effect can be brought out most clearly by exciting the thoracic end of the cut vagus and sympathetic nerves alternately on the same side

in the neck as in Fig. 5. In this experiment the right vagus was first excited with a moderate current and during the stage of partial recovery the sympathetic nerve was excited and this caused decided dilatation. Alternate constrictions and dilatations can be so produced an indefinite number of times.

The sympathetic fibres in the neck passing to the lungs are not confined to their own side but may cross partly, or in some cases the experiments suggest almost completely, to supply the bronchioles of the opposite lung. Fig. 6 is the record of an experiment in which the

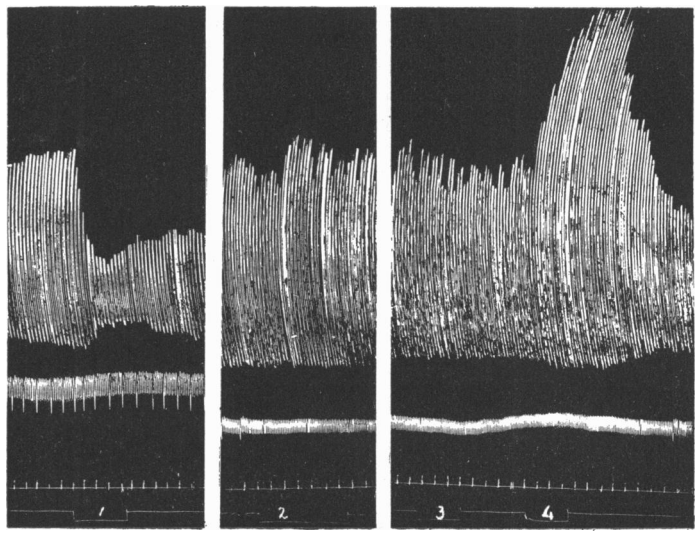


Fig. 6. Urethane. Lung vol. and B.-P. Shows complete crossing of fibres from left to right side. At (1) the left peripheral vagus was excited C=8; at (2) the right peripheral vagus C=8; at (3) the right peripheral sympathetic C=5; at (4) left peripheral sympathetic C=5. Time=5 secs.

crossing from the left to the right side appeared complete: the right cervical sympathetic nerve had no demonstrable broncho-dilator fibres to the right lung, but the left cervical sympathetic had a plentiful supply of broncho-dilators to the right side. It is interesting to note that in this cat the vagal fibres to the bronchioles also appeared to cross completely, so that excitation of the right peripheral vagus was without effect on the bronchioles of the right lung, whilst excitation of the left peripheral vagus caused immediate and profound constriction on the right side. In this experiment we did not determine whether

the broncho-motor nerves in the vagi and sympathetics crossed on both sides, or whether all the broncho-motor nerves were confined to the left side. Partial crossing is certainly the most common feature. But whilst the cervical sympathetic usually has some broncho-dilator effect the action is usually at any rate considerably less than that produced by stimulation of the upper thoracic rami. After the administration of atropine stimulation of the sympathetic nerves was always without effect; this is no doubt because atropine dilates the bronchioles to the maximum as the result of paralysis of the broncho-constrictor fibres, and without some muscular tone it is of course impossible to show inhibition.

The cell connexions of the sympathetic fibres. If the ganglion stellatum and the inferior cervical ganglion are painted with half per cent. solution of nicotine the effect of exciting the dorsal rami as well as the cervical sympathetics is lost, so that we may assume that these fibres are all connected with ganglion cells in the sympathetic chain. It becomes necessary therefore to enquire the way in which efferent fibres to the lungs come to be in the cervical sympathetic nerves, which are generally regarded as composed of fibres going to the head and neck region only. Several explanations exist and must be considered. One possibility is that some of the fibres from the dorsal roots instead of making cell connexions in the inferior cervical ganglion or stellate ganglion pass up to the superior cervical ganglion, form synapses there and return as post-ganglionic fibres to the lungs. But if this were true painting the ganglion stellatum with nicotine should not affect faradic stimulation of the cervical sympathetic nerve. The superior cervical ganglion is connected with the first, second and third cervical nerves by grey fibres only and excitation of these so far as we have been able to determine does not affect the bronchioles: the experiments were not however very satisfactory. This leaves three possibilities, either the pre-ganglionic fibres pass upwards in the cervical sympathetic nerves looping and returning to join their nerve cells in the ganglion stellatum or pre-ganglionic fibres in some way reach the sympathetic through the ganglion nodosum. The first supposition does not seem probable because as great an effect was obtained by exciting the cervical sympathetic high up as low down. The second hypothesis that the broncho-dilator fibres reach the cervical sympathetic nerve high up in the region of the ganglion nodosum seems more likely but we have not been able to trace the fibres. Still another explanation has been suggested to us by Prof. Langley namely that we are exciting an axon reflex: this could be determined by cutting the cervical sympathetic

nerve and after allowing sufficient time for degeneration, stimulating the peripheral end. If the fibres run down the sympathetic the effect should be absent; if it is an axon reflex it should be present. It is proposed to investigate this point later.

The vagus. After numerous experiments specially devised to show broncho-dilator nerve fibres in the vagus, we conclude that there is no constant evidence of the existence of such fibres. Occasionally small degrees of dilatation may be obtained but it is altogether insignificant when compared with the sympathetic effect. Moreover there is a constant source of error in these experiments as when the vagus is excited, broncho-constriction might be produced on the animal's left side which under the conditions of the experiment would increase the force of the air reaching the right or experimental side and produce an effect stimulating broncho-dilatation.

Reflex broncho-dilator effects. Although the vagus nerve contains no direct dilator fibres to the bronchioles, it certainly contains afferent fibres from the thorax and abdomen to the medulla which cause reflex broncho-dilatation. If in a properly prepared cat the two vagi be severed, excitation of either or both central ends causes in many experiments well-marked and unmistakable dilatation. This may be a reflex down the cervical sympathetic nerves, and no doubt it is partly, but certainly not mainly, because after section of these nerves in the neck broncho-dilatation is almost as good as before on exciting the central vagus. This reflex is lost however either on section of the cord in the upper cervical region or by cutting all the so-called cardiac nerves from the ganglion stellatum. The course of the reflex is therefore *via* the medulla and lateral columns of the cord, passing out by the white rami of the first, second and third dorsal nerves.

Fig. 7 is a record from a cat with both vagi and sympathetic nerves cut in the neck. Tone was produced by exciting the vagus nerve, and the figure shows that in this case excitation of the central ends of either vagus nerve causes dilatation. The dilatation here shown is not due to natural recovery. The vagi in this animal were so hyper-irritable, as the result of the physostigmine it had received, that recovery did not result naturally for some minutes after profound constriction had been produced by vagal excitation. The vagus nerve then besides containing efferent motor fibres to the bronchioles, contains also afferent fibres to the medulla, (1) connected with the thoracic sympathetic system, (2) connected with the opposite vagus (see under reflex broncho-constriction).

We have obtained no evidence that excitation of the central end of the cervical sympathetic nerves affects the bronchioles.

Attempts to obtain reflex effects upon the bronchioles were made also by exciting the central end of the thoracic sympathetic. In some of these experiments the accelerator nerves on the right side were tied and cut and the central end was excited by a faradic current. This method of procedure afforded no certain evidence that dilator reflexes were at work on the same side. The first effect was invariable broncho-constriction which closely followed the onset of the stimulation, and this was in a few instances followed by some small degree of broncho-dilatation:

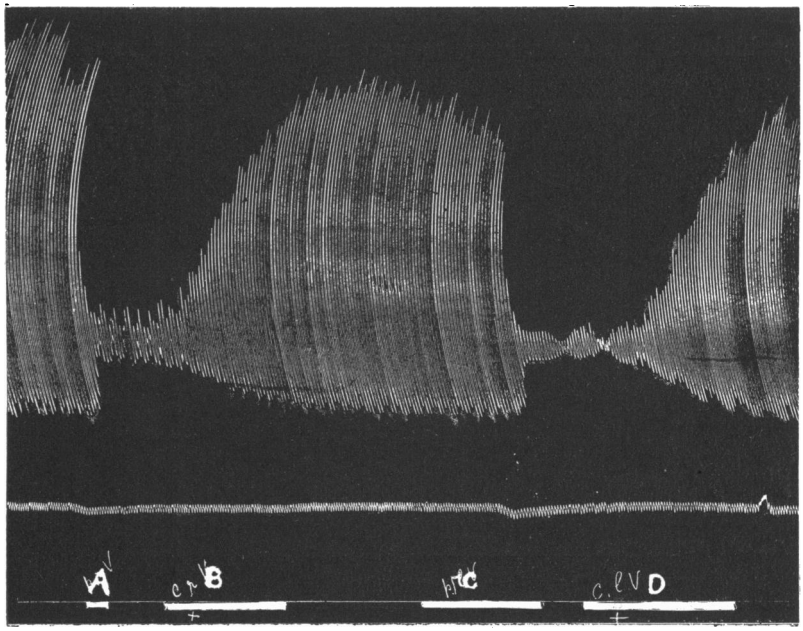


Fig. 7. Urethane. Lung vol. and B.-P. Both sympathetics in neck and vagi cut. Shows the effect of exciting at A peripheral right vagus C=10; at B central right vagus C=6; at C the peripheral right vagus C=10; at D the central left vagus C=6. Time 3 cms. =1 min.

when the stimulation was stopped broncho-constriction immediately became marked and quite often constriction continued until no air passed either in or out of the lung. It is obvious that in these experiments broncho-dilatation could occur only as the result of some crossing of dilator fibres from the left to the right side since the sympathetic fibres on the right side are cut.

Another series of experiments was undertaken in which the middle lobe of the left lung was placed in the oncometer and the central end of the cut sympathetic nerve connected with the ganglion stellatum on the right side was stimulated. Both vagi were severed. This afforded more certain evidence of broncho-dilatation, not it is true very profound but quite clear.

Broncho-constrictor fibres. In the cat the vagal fibres in the neck supplying the bronchioles partly cross to the opposite side; the extent of the crossing varies in each animal. Sometimes all the fibres on one side seem to cross, although this is a rare condition, still in Fig. 6 the record of vagal stimulation in such a cat is shown: in this instance no degree of excitation of the right vagus produced constriction of the bronchioles in the right lung, though moderate excitation of the left

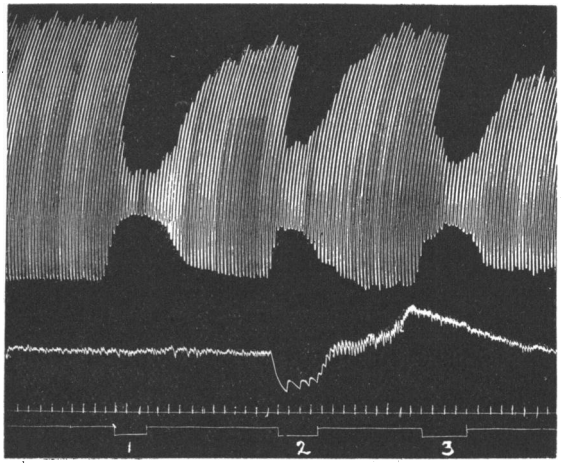
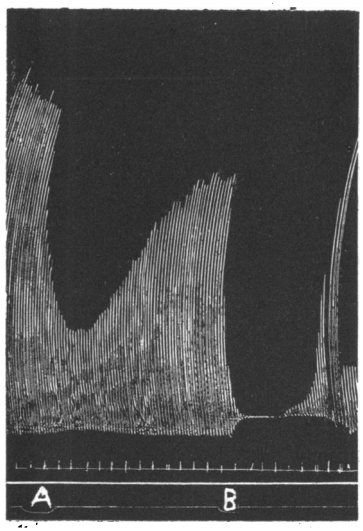


Fig. 8. Urethane. Lung vol. and B.-P. Shows the effect of exciting at (1) right peripheral vagus; at (2) the left peripheral vagus, and at (3) the right peripheral vagus. Coil at 5 cms. in each case. Time = 5 secs.

vagus gave rise immediately to well-defined constriction. It does not, of course, follow from this that the broncho-constrictor fibres for the left lung came from the right side although this may have been the case. Fig. 8 shows the most usual condition: in this animal the innervation was such that excitation of either vagus caused well-defined broncho-constriction in the right lung, the effect being more pronounced when the right vagus was excited. In this figure the effect of stimulating the right vagus is shown at 1 and 3 and the effect of stimulating the left

vagus at 2. As it happens in this instance all the inhibitory fibres to the heart are in the left vagus, but this condition is of course variable and bears no relation to the presence or absence of broncho-constrictor fibres. The same condition is shown in Fig. 9: in this example the animal had been killed some minutes previously by bleeding, and it will be seen that excitation of the left vagus nerve causes moderate broncho-constriction of the right lung, whilst stimulation of the right vagus with a current of equal strength occludes the bronchioles completely, so that air can neither enter nor leave. Just as it is rare for all the fibres to cross over so it is rare to have no crossing; the vagus nerve supplies in



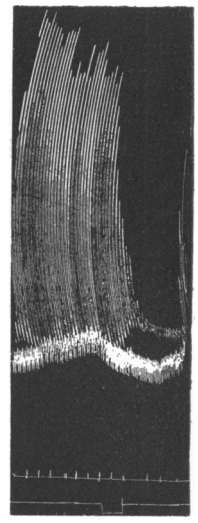


Fig. 9. Fig. 10.

Fig. 9. Dead cat. Lung vol. shows the relative effects of exciting the left vagus at A and the right vagus at B. Coil at 10 cms. Time = 5 secs.

Fig. 10. Urethane. Lung vol. and B.-P. Shows the effect of exciting the left central vagus. Coil at 8 cms. After section of the right vagus no constriction was obtained. Time = 5 secs.

some degree the bronchioles on both sides. This fact is at variance with the views expressed by Dixon and Brodie, but their experiments were largely made on dogs in which the vago-sympathetic was excited and not the separated vagus.

The cervical sympathetic nerve rarely contained broncho-constrictor fibres, but in two instances we have recorded broncho-constriction on powerful excitation, once of a sufficiently decided character to occlude

the bronchioles temporarily. This condition is unusual, just as the presence of broncho-dilator fibres in the vagus is unusual. We regard it as probable that in both these unusual conditions each nerve contained some fibres arising from the other and some such fibres are known[1]: so that dilator fibres may be found on occasion apparently in the vagus and constrictor fibres apparently in the cervical sympathetic.

Reflex broncho-constriction has been described by Sandmann as the result of exciting the mucous membrane of the nose and larynx; by Einthoven by exciting the central cut end of the sciatic nerve in one instance; by Dixon and Brodie by exciting the mucous membrane of the nose; by Prevost and Saloz by exciting the nose, the central end of the crural or vagus nerves. The latter observers also remark that the reflexes are exaggerated by physostigmine. We find that reflex broncho-constriction can be obtained more or less readily by exciting the central cut ends of various afferent nerves. They are obtained very readily by exciting the central end of one vagus nerve, whilst the other remains intact: both Einthoven and Dixon and Brodie were unsuccessful in showing this reflex. It must be remembered that one vagus nerve may contain few or no fibres to the bronchioles, in which case excitation of the central end of the opposite vagus is not likely to exert any decided degree of broncho-constriction. The easiest plan to obtain an effect is to excite the two vagi alternately whilst intact, with a weak current, and if one is found to exert a greater effect than the other to cut the less active nerve and excite its central end. Fig. 10 shows the effect of exciting the central cut end of one vagus nerve: it will be noticed that it causes immediate broncho-constriction of a strength sufficient to occlude the bronchioles completely. When the opposite vagus nerve is also cut, central stimulation of either never causes broncho-constriction, although

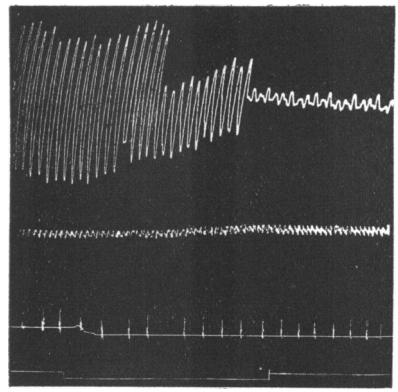


Fig. 11. Urethane. Lung vol. and B.-P. Shows the effect of exciting the central end of the cut accelerators with the secondary coil at 5 cms. Vagi intact. Time = 5 secs.

[1] Langley. This *Journal*, xxv. p. 471. 1900.

broncho-dilatation under these conditions may occur as we have already pointed out.

Reflex broncho-constriction can also be obtained by cutting and exciting the central end of the thoracic sympathetics. Fig. 11 shows the effect of exciting the central stump of the cut accelerator fibres connected with the ganglion stellatum, a gradually increasing broncho-constriction is produced. We have also observed broncho-constriction whilst exciting the central end of the second and third rami. In no case have we observed any sign of broncho-constriction after section of the vagus nerves.

The action of adrenalin and atropine. Dixon and Brodie[1] believed that crude suprarenal extract exerted little effect on the bronchioles. de Gaınrat[2] using adrenalin obtained variable results but twice noticed broncho-dilatation after an intravenous injection; and Prevost and Saloz[3] obtained negative results only after the intravenous injection of adrenalin. It is quite certain from what we know of the action of adrenalin that if the broncho-dilator nerves belong to the sympathetic system then adrenalin should cause profound broncho-dilatation. Kaplan[4] and Jagic[5] and later numerous other clinical observers have noted that the injection of adrenalin relieves the spasm in patients suffering from bronchial asthma. Januschke and Pollock[6] using the Dixon and Brodie method showed on decerebrate and ether anæsthetised cats that adrenalin slightly dilates the bronchioles; but if the bronchioles were first thrown into a condition of tonus by some drug such as muscarine, then adrenalin caused profound dilatation. Trendelenburg[7] using an isolated ring of ox bronchus suspended and fixed to a writing lever in the usual way found that adrenalin caused marked relaxation.

In these experiments on cats we have always found that when the bronchioles are not fully relaxed adrenalin causes a maximal broncho-dilatation. Fig. 12 shows the result of an experiment on a cat anæsthetised with urethane. The sympathetic nerves as they come off from the ganglion stellatum were first excited and it will be seen how little is the effect (A) on the bronchioles, the reason being that urethane and indeed most anæsthetics cause maximal broncho-dilatation. In this condition we have always found that neither sympathetic stimulation,

[1] *Op. cit.* p. 171.
[2] *Thèse de Genève.* 1909.
[3] *Ibid.* p. 341.
[4] *Medical News.* LXXXVI. p. 871. 1905.
[5] *Berlin. klin. Woch.* p. 583. 1909.
[6] *Ibid.*
[7] *Arch. f. exp. Path. u. Pharm.* LXIX. p. 79. 1912.

adrenalin nor atropine cause any significant increase in the lung-volume at any fixed air pressure. In this experiment the vagus nerve was then excited with the secondary coil at 10 cms. which produced some broncho-constriction shown at (B) and when the muscle tone in the bronchioles was constant an injection of adrenalin was made into a vein (C). The adrenalin caused a fairly rapid broncho-dilatation, but it will be noticed that the degree of dilatation does not exceed that which was present during the sympathetic stimulation at (B) before the vagus nerve was excited. Later in this experiment the injection of a large dose of atropine, enough to abolish completely any vagal action or any effect which muscarine or physostigmine produces, caused no further dilatation.

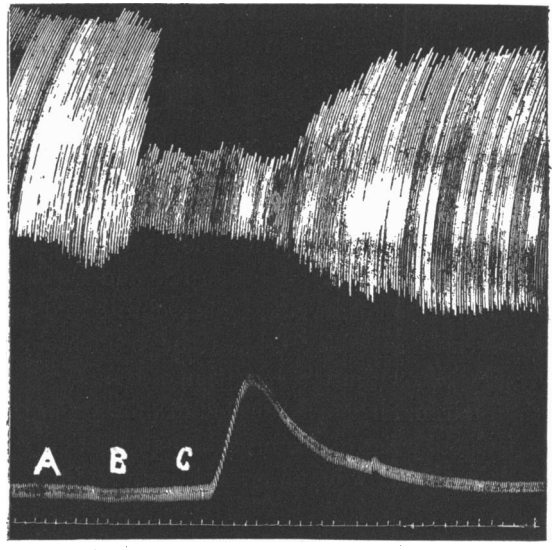


Fig. 12. Urethane. Lung vol. and B.-P. At A the right accelerator bundle was excited with the coil at 5 cms. At B the right vagus was excited with the coil at 10 cms. and at C 1 c.c. of 1 in 10,000 adrenalin was injected. Time=5 secs.

The contrast between the action of adrenalin and atropine is better seen in Fig. 13, in which the animal was decerebrate. In this instance the vagus nerve was very active on account of a previous injection of physostigmine. Adrenalin was administered at (A) and almost at once the bronchioles commenced to dilate, slowly at first, but much more rapidly later until maximal dilatation was reached. As the adrenalin effect passed off the bronchioles commenced to constrict again and in two and a half minutes from the time of injection the constriction was such

that almost no air was entering or leaving the lobe under observation. At (B) a dose of atropine was injected into the circulation and the bronchioles once again rapidly dilated to their maximal extent, but now the dilatation was permanent and by no means that we tried (adrenalin, nitrites, sympathetic stimulation) have we been able to obtain any further degree of dilatation.

Adrenalin then causes an active dilatation that is transient and atropine a passive dilatation that is permanent.

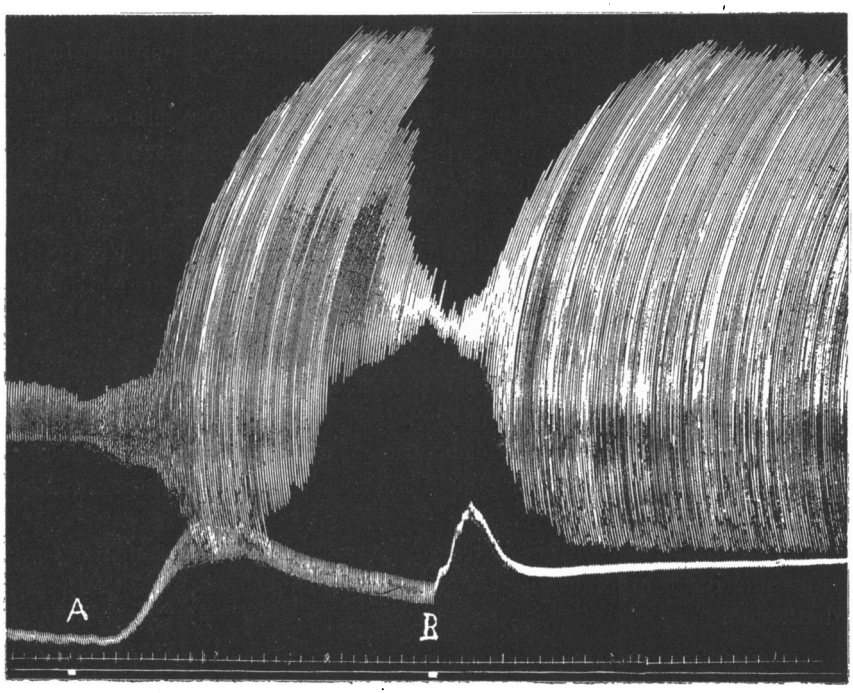


Fig. 13. Decerebrate. Lung vol. and B.-P. Physostigmine had been given earlier in the experiment. Shows the effect of injecting at A 1 c.c. 1 in 10,000 adrenalin, and at B 1 c.c. 1 in 1000 atropine sulphate. Time = 5 secs.

Fig. 13 also shows the effect of adrenalin and atropine upon the heart-rate under these conditions. Adrenalin has very little effect on the rate of the heart but atropine causes decided acceleration and a rise in blood-pressure largely due to this factor. From this we conclude that the antagonism between the two nerves supplying bronchial muscle is more nearly equal than the antagonism between the two nerves supplying the heart: in the latter instance the vagal effect far overshadows the sympathetic.

Conclusions.

1. The bronchial muscles are supplied by powerful broncho-dilator nerves which are sympathetic in origin.

2. The fibres proceed mainly through the rami of the first, second and third dorsal nerves, are connected with nerve ganglia in the ganglion stellatum and proceed to the lungs with the cardiac accelerators. A variable number of fibres pass down the cervical sympathetic and these too have their cells in the ganglion stellatum.

3. Some crossing of fibres to the bronchioles of the opposite lung is the rule.

4. Very occasionally we have found evidence of broncho-constrictor fibres in the sympathetic of the neck and of broncho-dilator fibres in the vagus. The effects are always insignificant and we believe are due to each nerve containing some fibres arising from the other.

5. Reflex broncho-dilatation was obtained by exciting the central end of the vagus nerves after section of both, and of the cut central end of the accelerator nerves, also after section of the vagi, this being a crossed reflex.

6. The broncho-constrictor fibres in the vagus cross to a variable extent but some crossing in the rule.

7. Reflex broncho-constriction was obtained by exciting the central end of one vagus, the central end of the accelerators and the central end of the anterior crural nerve.

8. Adrenalin administered to an animal showing bronchial tonus causes active temporary dilatation; atropine causes passive permanent dilatation.