It is expected, however, that laboratories capable of carrying out useful work with organic tracer materials will also be capable of undertaking whatever preliminary preparation of the material may be desirable. It will be some months yet before the full effects of the bringing into operation of the second Harwell pile are evident. In the interval the less powerful "gleep" has performed a useful service in familiarizing an increasing number of workers with the technical problems which arise when employing radioactive isotopes. It is not too much to hope that the larger supplies soon to be available will bring their own demonstration that there is much to be written on the credit side of atomic energy research.

## THE SPHENOID SINUS

The anatomy and comparative anatomy of the accessory sinuses of the nose have been well demonstrated for very much longer than their physiology has been understood. The latter has only come to the fore in relatively recent times, but there is already a much better understanding of sinus reactions and affections, and this has led to improvement in the treatment of these conditions. In this connexion tribute must be paid to the pioneer work of Jonathan Wright and H. Smith[1] and to Dr. Arthur W. Proetz,[2] who has devoted so much time to this work. Appreciation of the importance of the ciliated epithelium, of its action against gravity and around corners, of its survival and continued function in quite advanced pathological conditions, and of the effect on its viability and activity of various drugs and chemicals, have put treatment on a rational basis. It is now recognized that even advanced pathological changes can be reversed, and this, together with the advent of chemotherapy and the antibiotics, has led to increasing conservatism in the surgery of the nasal sinuses.

At the recent Annual Meeting of the British Medical Association in Cambridge the Section of Otorhinolaryngology discussed the sphenoid sinus, and the opening paper read by Dr. Proetz is printed elsewhere in this issue (p. 243). It was generally agreed by the speakers that "the acute sphenoid" was rarely encountered, and that differing as it does from other sinuses, such as the maxillary, in the thickness, blood supply, and glandular structure of its lining, the sphenoid sinus is not often the site of mucus stasis or polypoid change. Of all the accessory sinuses it is easily the best protected from changes of temperature, injury, and direct infection, and it is moreover well situated for the application of decongestive substances. These should be of low concentration and administered in a physiological medium: 0.25% of ephedrine sulphate in normal saline is more effective than a strong solution. Adrenaline is better reserved for haemostasis, and cocaine is poison to the cilia and should only be used for analgesia. Oily solutions are usually inimical to ciliary activity.

Surgery, when required, need not be radical, and obliterative measures should not be attempted. If ciliary activity is preserved, drainage does not have to be "dependent"; in fact, it is impossible to provide for dependent drainage in both erect and recumbent positions. Considering the inaccessibility and the importance of the anatomical structures surrounding the sphenoid—Proetz lists 13—it is fortunate that the weight of experience is in favour of conservative treatment.

[1] *Diseases of the Nose and Throat*, 1914. Lea and Febiger, Philadelphia.
[2] *Essays on the Applied Physiology of the Nose*, 1941. Annals Publishing Co., St. Louis.

## THE LUNGS IN DIPHTHERIA

The cardiac and nervous sequelae of diphtheria are usually regarded more seriously than the pulmonary complications. A bronchopneumonia may of course occur in severe cases of laryngo-tracheal diphtheria either by extension or by superimposed secondary infection. Then again bronchopneumonia after tracheotomy used to be a more serious hazard before chemotherapy reduced the risk. The development of pneumonia in the high proportion of over 10% of 753 cases of diphtheria was reported by Togasaki[1] and his colleagues; one-quarter of these patients died, but the more recent use of sulphonamides has since improved the outlook. Most workers in fever hospitals now use penicillin in the treatment of laryngeal diphtheria as a routine, and with sulphadiazine as a stand-by death from bronchopneumonia is much less common than it was. The only other pulmonary complication which might be looked for at necropsy is the extensive subpleural and interstitial haemorrhage which can occur as part of the general haemorrhagic tendency in severe hypertoxic cases. It is probably true to say that the occasional patient who developed a terminal pulmonary oedema caused little comment, since existing paralyses and cardiac embarrassment probably provided adequate explanation of the condition. The interesting suggestion has now been made by Janbon and Chaptal[2] that toxin may be directly responsible for the pulmonary oedema in such cases.

In their series of cases the first seven patients developed a transient pleurisy, almost always accompanied by frank effusion. In most of these it was difficult to exclude a co-existent cardiac or renal complication as the cause; and though in one patient the pleurisy appeared in the stage between the end of the early toxic effects on the heart and the later neuropathies it would be unwise to overlook the possibility of a relationship. The division of any acute infection into stages is a valuable convenience for the purposes of clinical description, but it should not obscure the fact that illness must be viewed as a whole, each change being dependent on what has happened before. In a further four patients (three of whom died) acute pulmonary oedema developed. The authors discuss at some length the possibility that the oedema may result from toxic damage to the vagus or sympathetic. They point out that a strongly positive oculo-cardiac reflex is often noted in these hypertoxic patients. In a paper which appeared recently in the *Journal* Cameron[3] emphasized the importance of damage to the central nervous system as a cause of pulmonary oedema. But in severely paralysed patients it must always be difficult to separate such related predisposing factors as pharyngeal paralysis, with its risk of the aspiration of mucus or even of foodstuffs, and diaphragmatic paralysis with consequent anoxia, which Short[4] regards as an important cause of pulmonary oedema. Because in their view the sympathetic–vagus mechanism is involved, the French workers recommend the use of atropine in such cases. They claim good results with 1-mg. doses given five times daily.

The third group in Janbon and Chaptal's series consisted of seven patients who developed acute and progressive pulmonary embarrassment at the time of the late post-diphtheritic palsies. Here they may well be right in arguing that the toxin directly affects the respiratory centre, for in each there was extensive toxic damage in the region of the nucleus ambiguus. Many of their patients seem to have been treated initially at home and to have been admitted to hospital only when the serious complications of

[1] *Amer. J. med. Sci.*, 1942, **204**, 218.
[2] *Sem. Hôp. Paris*, 1947, **23**, 2417.
[3] *British Medical Journal*, 1948, **1**, 965.
[4] *J. Path. Bact.*, 1944, **56**, 355.

the later stages developed. The fact that in this country almost all patients with diphtheria are admitted to hospital at the beginning of the illness may explain why such extensive complications are less frequently seen here.

## HUMAN FACTOR IN AIR ACCIDENTS

Public confidence in the safety of air travel has been shaken by the melancholy succession of disasters to civil air liners, and no flood of statistics about the relatively small number of people killed per million passenger-miles flown can do much to allay the anxiety thus aroused. The investigation of mechanical defects as a cause of flying accidents is pursued openly and effectively, and yet, though the frequency of pilot-error accidents is realized, little is done to disentangle the complex cognitive and emotional basis of the human failure which so often precipitates the catastrophe. The Air Ministry is therefore to be congratulated on its publication of the results of wartime research on this vital subject.[1] What has been learnt about the principles of human behaviour in complex, distracting, and fatiguing situations can be widely applied to accident problems in all hazardous occupations.

At the beginning of the late war the laboratory study of whatever was included by the conventional term "fatigue" was begun in Cambridge under the direction of Sir Frederic Bartlett, and the present monograph by Dr. D. Russell Davis describes the results achieved. He used an experimental apparatus designed like an aircraft cockpit; the controls are attached to a mechanism which records the nature, extent, and duration of the pilot's deviation from a prescribed course. It was called the Cambridge Cockpit, and in it pilots were observed while they performed all the manipulation of controls and instruments required in mock flights of varying durations. The analysis of the resulting records showed that, contrary to expectations based on previous work in industrial psychology, there was no simple relation between the duration of the flight and the numbers of errors made. Indeed, errors increased in the first half-hour of the test, to reach a maximum during the second half-hour, after which they declined.

Russell Davis found that these errors, and thus the individuals who made them, could be divided into two main groups—errors of overactivity, where a tense individual tends to over-correct his initial mistakes, and errors of inertia, where subjects resigned themselves to a lowered standard of performance. Other types of error—specific end deterioration, preoccupation, and perceptual disorganization—were observed, but they were subsidiary to the two main groups, whose importance and significance became clear when the results of these tests were compared with psychiatric assessments of the same individuals. It became obvious that errors of overactivity were an expression of the acute anticipatory anxiety of the neurotically predisposed individual with obsessional trends, while errors of inertia were merely another facet of the withdrawal mechanism of the hysteric. Conclusions based on laboratory experiments do not entirely satisfy the practical flying man, but these were strikingly confirmed by following up the subsequent flying careers of the men tested and by independent studies of operational efficiency. It was found that men in the two "error" groups had an undue number of flying accidents, of failures in training, and perhaps, too, of casualties in action.

The relative unimportance of prolonged activity alone in the causation of accidents was also demonstrated by Bradford Hill and G. O. Williams, who showed that landing accidents were no more frequent after long sorties than after much shorter ones. Similarly Reid's studies of the effects of operational hazard on navigator efficiency in action and the incidence of neurosis re-emphasized the importance of acute anxiety in the determination of behaviour and performance. In future work on the human problems of industry this example of the synthesis of laboratory and field research might well be followed.

[1] *Pilot Error*, 1948. H.M.S.O., London. Price 9d. net.

## PENICILLIN IN EXPERIMENTAL SYPHILIS

Recent investigations in the U.S.A. on rabbits experimentally infected with syphilis have shed light on the differences between the various forms of penicillin. It has been recognized for some time that these forms are not alike, but it has not been possible to make a quantitative comparison by clinical observations. A joint report[1] by five groups of workers now states that penicillin G is the most active, that F has about one-seventh the potency of G, and that K has about two-thirds the potency of F. No figure was given for penicillin X. The experiments were carried out by inoculating the testes of rabbits with a virulent strain of *T. pallidum* and treating the rabbits six weeks later with penicillin given every four hours for four days. The rabbits were then observed for 120 days, and from those showing no signs of syphilis a lymph node was taken for emulsification and injection into a normal animal. These were kept for four months to see if lesions developed in which *T. pallidum* could be detected by dark-ground illumination. By this method it was possible to find what percentage of animals were cured by a given dose of a given penicillin. Different workers agreed reasonably well about penicillins G, F, and K.

The duration of the experiment was a disadvantage, and Turner[2] and his colleagues devised a shorter one. Rabbits were inoculated by intracutaneous injection (on the back) with 0.1 ml. of an emulsion containing *T. pallidum*. Syphilomas appeared in 14–21 days, and on a given day a drop of serum from the middle of the syphiloma was examined by dark-ground illumination and the number of visible motile organisms counted. The penicillin to be investigated was then given by intramuscular injection in three doses at two-hourly intervals. The number of motile organisms in a drop of serum from another syphiloma on the same animal was then determined after 24 hours. Each dose of each kind of penicillin was given to a group of rabbits so that the mean effect could be calculated. The final result was that penicillin G was most active, that F had about one-sixth the activity of G, that X was about equivalent to F, and that K had less than one-fifth the activity of F. These relative values were on the whole similar to those obtained by the longer method.

In other interesting investigations Eagle, Magnuson, and Fleischman[3] compared the action of penicillin in rabbit syphilis with that of a combination of penicillin and heat. They found that when the body temperature of the rabbit was increased by 3° to 4° F. (1.8°–2.4° C.) for a period of about 10 hours during the administration of penicillin the curative dose of penicillin (in 50% of the animals) fell from 30,000 to 3,000 units per kg. body weight. The authors believe that the rise in temperature reinforces the action of the penicillin, because observations on treponemata *in vitro* do not suggest that such a rise of temperature has any lethal action itself. The same authors[4] have also measured the increase in the curative power of penicillin in rabbit syphilis brought about by adding beeswax to a solution of

[1] *Amer. J. Syph.*, 1947, **31**, 469.
[2] Ibid., 1947, **31**, 476.
[3] Ibid., 1947, **31**, 239.
[4] Ibid., 1947, **31**, 246.

calcium penicillin in arachis oil. A required curative dose of 39,000 units per kg., given daily for four days, fell to 8,000 units when 3% beeswax was added, and to 3,500 units with 6% beeswax.

## THE PHANTOM LIMB

A number of our correspondents have discussed recently the problem of pain in "phantom limbs," and there is a further contribution to this discussion at page 267 of this issue. The symptoms which follow amputation of a limb are so incompatible with the ordinary dictates of common sense that it is small wonder that most amputees prefer to keep discreetly silent about them. Even standard textbooks still generally dismiss the subject in a few embarrassed phrases or omit it altogether.

It is now established that phantom sensations are a physiological sequence of all major amputations, the pattern of subjective phenomena being remarkably constant.[1 2 5] Immediately following amputation the patient is aware of the continued presence of the lost member, generally in a comfortable relaxed position, and he usually feels that he is able to "move" the limb normally. During the months of convalescence the phantom progressively "shortens," until it may feel only a few inches long. Sensation from fingers, toes, and joints persists longest and most vividly, so that ultimately a phantom arm may be experienced as only fingers, wrist, and elbow, with no intervening forearm. By this process a relatively intact central nervous system adapts itself to a profound bodily change, and it is an entirely normal physiological occurrence. In W. R. Henderson and G. E. Smyth's recently reported series[2] of over 300 prisoners of war who had undergone major amputations only about 2% "asserted that they had never felt a phantom"; it may be that these men rejected the possibility much in the manner of Craig's[3] patient who, having a painful phantom, did not at first report sick because he "did not expect a doctor to treat a ghost." The painless phantom is of little importance to the patient who is reassured that his experiences are perfectly normal, and their chief interest lies in the light they cast on the functioning of the nervous system.

Amplifying the body-image concept of Head and Holmes,[4] Riddoch[5] suggested that there are normally three integrated "body images" in the sensorium—visual, motor, and sensory—in terms of which all movements are initiated and all sensations interpreted. The loss of a limb does not at first impair the sensory or motor patterns which help to constitute the compound body image. The limb still persists in the sensorium; it is still remembered, and so it can be felt and "moved" as though still present. With passage of time the cortical elements formerly concerned with the lost limb cease to play a role no longer useful, and they probably take over other functions. Accordingly the phantom becomes "telescoped." The fingers, joints, and toes, having the largest cortical representation, persist longest and most clearly.

The phantom limb which is painful presents a much more difficult problem of immediate practical importance. Reports differ about the frequency with which such pain occurs, and probably the criteria adopted by the authors and their patients in assessing actual pain have not been the same. The very low incidence—about 4%—reported by Henderson and Smyth may be due to the distinctive type and age group with which they dealt. Riddoch believed that phantom pain followed about 50% of amputations; Sliosberg[6] puts the figure at about 70%, while Craig considers that some pain is almost invariable, generally diminishing in intensity and frequency spontaneously, so that only a small proportion of patients overcome their natural reluctance and seek medical advice.

Formerly the pain was believed to arise in neuromata growing in the stump, but it is now known that such growth is normal and that the amount of pain experienced bears no constant relation to the state of the stump. It is probable that these cases are examples of causalgia similar to that which may follow any nerve injury.[3 7 8 9] Pain so produced is felt in the phantom, just as deep pain, skeletal or visceral, may be projected to a phantom arm or leg.[10-12] The pain of angina pectoris may, for example, spread to a phantom left arm.

Unless there are obvious defects in the stump, or pressure of the prosthesis on a superficial neuroma is producing troublesome pins and needles, remodelling operations are generally of little benefit. Persistent severe pain can frequently be relieved by procaine sympathetic block, and it may not return for weeks or months, when the procedure can easily be repeated. The duration of the period of relief tends to increase, so that complete cure may follow three or four injections. Not until all such simple methods have been tried should more drastic treatment be considered. It is important at all times that the patient should see that his strange symptoms are accepted as being real, as indeed they are.

1 Livingston, W. K., *Pain Mechanisms*, 1943, p. 150. New York: Macmillan.
2 *J. Neurol. Neurosurg. Psychiat.*, 1948, **11**, 88.
3 *British Medical Journal*, 1948, **1**, 904.
4 *Brain*, 1911, **34**, 102.
5 Ibid., 1941, **64**, 197.
6 *British Medical Journal*, 1948, **1**, 1108.
7 Doupe, J., Cullen, C. H., and Chance, G. Q., *J. Neurol. Neurosurg. Psychiat.*, 1944, **7**, 33.
8 Nathan, P. W., *Brain*, 1947, **70**, 145.
9 Bingham, J. A. W., *British Medical Journal*, 1948, **2**, 51.
10 Cohen, H., *Lancet*, 1947, **2**, 933.
11 Harman, J. B., *British Medical Journal*, 1948, **1**, 188.
12 Craig, J. D., *Lancet*, 1948, **1**, 497.

## INTERNATIONAL STUDENTS' CONFERENCE

The British Medical Students' Association is to be congratulated on its enterprise in holding recently what is believed to be the first international congress of medical students, a report of which appears on page 265. Over 100 delegates from 24 countries, including 30 from Britain, met successively in London, Oxford, and Birmingham from July 6 to 22 to study many aspects of British medicine—clinical, laboratory, industrial, and public health. When books and journals are difficult to obtain and currency restrictions in many countries impede the traveller, conferences such as this assume an added importance in promoting the free exchange of medical knowledge. There is no better way of broadening a young man's education than by giving him the opportunity of meeting colleagues from abroad and studying their methods. The mere fact that he is in strange surroundings stimulates him to examine them carefully, and the high prestige enjoyed by British medical science in the post-war world invites the closest scrutiny of its achievements.

When the B.M.S.A. was founded in 1941 to promote the interests of students it was recognized that clinical conferences, both national and international, would be one important means of fulfilling this aim, and students in this country accordingly hold several conferences every year in London and the provinces. A teaching centre invites students from one or more other regions and takes considerable trouble over displaying its wares attractively and helping to mitigate the over-specialization deplored in Professor Ryle's address read at Oxford. We should not let the occasion pass without complimenting those many teachers and authorities on special subjects who enthusiastically contribute to the success of these meetings. Their time is well spent, for as one student said[1] at the congress held in 1943, "We are still young enough and daft enough to work for a future that will be better than the present."

1 *British Medical Journal*, 1943, **2**, 309.