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# Déjà Vu – The Recycling of Penicillin in Post-Liberation Paris

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## Introduction

Alexander Fleming's article published in 1929 describing the antibacterial properties of penicillin<sup>1</sup> attracted little interest in the decade or so following its publication. What has been referred to as the 'silent years'<sup>2</sup> ended with a resounding rapport when in 1940 an article appeared reporting the chemotherapeutic effects of penicillin and heralding what was to become the birth of the antibiotic age.<sup>3</sup> The research had been conducted by Howard Florey and his co-workers at Oxford University. The intervening years had not in fact been totally silent but had been punctuated by a handful of studies,<sup>4,5</sup> or rather 'whispers', in both Britain and the United States, but none of these was to lead to significant advances.

Florey's work, then, had immediate impact and was to attract interest from unexpected quarters. In the spring of 1941 the Swiss pharmaceutical company Ciba, wrote directly to him requesting a culture of Fleming's strain of *Penicillium notatum*. Florey refused its request, seeing it as a means by which German scientists might gain access to the culture - something he was intent on preventing. He might also possibly have felt some frustration as he had himself at the time been trying to interest British pharmaceutical companies in taking up penicillin production but had not achieved any success. He later refused the Red Cross a culture of the mould on the same grounds.<sup>6</sup>

## Franco-German Co-operation in the Pharmaceutical Industry

Switzerland's status as a neutral country not only enabled its own scientists to access foreign publications throughout the war with relative ease, but was also to serve as a source of foreign literature to the principal belligerents.<sup>7</sup> In addition to this there were in operation at the time informal networks among continental pharmaceutical companies in which information on drug developments circulated freely.<sup>8</sup>

If Florey's suspicions about Ciba were correct, the probable time at which German scientists received concrete information about penicillin was either in the spring of 1941 or soon thereafter. This almost certainly would have been the first of Florey's *Lancet* articles mentioned above, but it bore no information about culturing the mould or extracting and purifying the penicillin, however, it cited Fleming's 1929 article which did contain more information on cultivation. Having been published before the commencement of hostilities it would readily have been available.

An absolute requirement for penicillin production is of course a penicillin-producing mould. In 1941 the most certain way of manufacturing penicillin was to obtain a culture of Fleming's strain of *P. notatum*. Enquiries would almost certainly have been made at all laboratories in Germany which might conceivably have possessed this particular strain. Dr Hans Schmidt at the IG Farben Behring works had obtained a culture directly from Alexander Fleming through the normal procedure of writing to him and requesting it. Indeed, Fleming later claimed that he had sent out 'a very large number' of cultures all over the world.<sup>9</sup> The date at which Schmidt contacted Fleming for the strain is unknown but he evidently did not attempt to culture it nor did he store it under conditions necessary for the maintenance of viability, as when

he finally did attempt to do so, it became clear that the culture had become non-viable.<sup>10</sup>

The National Collection of Type Cultures (NCTC) had in its possession a culture of the Fleming strain. However, when, as mentioned above, Florey was approached by Ciba for the strain he immediately wrote both to the Director of the NCTC and to Alexander Fleming to alert them to the fact that German scientists might try and obtain it from them and pointing out the undesirability of allowing them to do so. Direct application to the NCTC from Germany would obviously not have been an option, but there was the possibility of applications being made from neutral countries. An embargo was therefore imposed on all overseas requests for the Fleming strain.<sup>11</sup> German scientists might conceivably have attempted to acquire a culture from the small handful of researchers active during the 'silent years' but whether they did so remains unknown.

With the NCTC not open to them, German scientists' attention turned to what was arguably the finest mould culture collection at the time and which was located in Baarn in the Netherlands. Its catalogue of mould species did not list the Fleming strain, but did include a related strain, *Penicillium notatum* (Westling) and access to its collections by German scientists presented no impediments after the Netherlands had become occupied. The archive at Baarn contains letters from a number of German organizations, both commercial and academic, requesting cultures of *P. notatum* (Westling) starting in early 1942 and continuing well into 1944. Those applying for this particular strain did so in the belief that it too produced penicillin, whereas in fact it does not. These letters do nonetheless serve to indicate the entry of German scientists into penicillin research.

For the most part scientists working in Occupied Europe had no or only very limited access to foreign publications particularly in the early stages of the war. This led to a state of affairs in which many scientists in occupied countries were to remain largely ignorant of developments in their field with relatively few exceptions. However, the situation in France was different from that of other occupied countries in that two organisations came into being for accessing, cataloguing and distributing foreign publications to French scientists. The more official of these two bodies was that run by Jean Gérard of the Maison de la Chimie, and the somewhat more clandestine operation was run by Jean Wyart at the Centre National de Recherche Scientifique (CNRS). Because of its official status the first-mentioned of these two organisations tended to specialise in German articles whereas the CNRS tended to concentrate more on British and American publications.<sup>12</sup>

Notwithstanding the existence of these two organisations, it seems unlikely that French scientists learned about penicillin from either of them as they had not fully become operational at that time in the war. The more probable source was Germany. The informal networks that existed among continental pharmaceutical companies and mentioned above in relation to Ciba and German firms, such as IG Farben, also extended to France. In fact Hans Horlein, leader of pharmaceutical research at IG Farben, wrote to his opposite number at the French pharmaceutical company Rhône-Poulenc, offering them information on penicillin.<sup>13</sup> This contact probably took place in late 1941 or early 1942 when it had become clear that IG Farben would be unable to go it alone as they did not have access to the Fleming strain of *P. notatum*. What could the French have had to offer? The answer to this almost certainly lies in previous successes achieved by Rhône-Poulenc in the field of antibacterial chemotherapy. In the mid-1930s Gerhard Domagk had discovered that the synthetic

azo dye, Prontosil rubrum, possessed useful antibacterial properties. However, it was scientists at the Pasteur Institute, Federico Nitti and René Martin, who established that the active part of the molecule was in fact a sulphonamide (*p*-aminophenylsulphonamide) and this enabled the synthesis of a great number of molecular variants, many having antibacterial properties superior to the original parent compound, Prontosil.<sup>14</sup> Collaborations came to be established between the Pasteur Institute and Rhône-Poulenc who essentially mass-produced new sulphonamides that researchers at the Institute synthesised. This association was widely known about and at that particular stage of the war IG Farben may have reckoned that approaches to the Institute coming from a French organisation might be looked upon more favourably.

Evidence has been unearthed of a note from Raymond Paul, Director of Research at Rhône-Poulenc, to Nitti urging him on in 'the race for penicillin'.<sup>15</sup> The same source reveals that Nitti delivered two batches of mould juice to the Vitry works of Rhône-Poulenc on 1<sup>st</sup> October, 1943 and that researchers at the company started their own production in the latter half of the same month. This constitutes direct evidence that the Institute Pasteur was beginning to engage in penicillin research. In order to do so they must have possessed a penicillin-producing strain of *P. notatum*. In fact Alexander Fleming had personally presented André Lwoff of the Institute with his strain when Lwoff paid him a visit in London in 1936.<sup>16</sup> It is an interesting reflection that even if researchers at the Pasteur Institute had not given Rhône-Poulenc a culture, they would have been able to isolate it themselves from spores of the fungus which would have been present in the mould juice.

## The Pasteur Institute at the Liberation of Paris

The full extent and range of the contacts and arrangements mentioned above were to remain largely unknown to the Allies until after the war. However, odd fragments of correspondence between various German agencies with those in the countries of Occupied Europe were intercepted by Allied intelligence services,<sup>17</sup> and therefore it became known that German scientists were working on penicillin which confirmed the suspicions that Florey had had in 1941.

Prior to the invasion of France in June of 1944, the Allies assembled teams of specialists to follow in the wake of the fighting forces with the purpose of gathering information on technical and scientific activities that became accessible as the German armed forces were pushed back. The Allies probably reasoned that any work of any significance being undertaken in occupied countries was being done so under German direction, and that knowledge of this would provide early warning of what might be expected as their armies advanced into Germany itself. This was certainly the case regarding nuclear research and explains the alacrity with which Allied specialists made their way to Joliot-Curie's laboratory arriving there three days after Paris had been liberated.<sup>18</sup>

German developments in nuclear research held self-evident intelligence value as did research in other types of weapons, but all aspects of industrial and academic endeavour were also to come within the ambit of the investigatory teams. The information these teams were able to uncover relating to penicillin research in Germany has previously been presented.<sup>19</sup> However, there were a number of so-called 'targets' in Paris and the Pasteur Institute was included amongst them. Interestingly the specialists who arrived at the Pasteur Institute did so at the same

time as those who descended on Joliot-Curie's laboratory. This may have reflected concern by the Allies that biological weapons research may have been undertaken at the Pasteur Institute

The specialists bound for the Pasteur Institute included Hamilton Southworth, a representative of the United States Office of Scientific Research and Development and based at its London Mission. He recorded his observations in a series of newsletters.<sup>20</sup> A second visit by representatives of the Combined Intelligence Objectives Sub-Committee (CIOS)<sup>21</sup> followed soon after on 5<sup>th</sup> September. The information contained in both reports is almost identical. Southworth states that his team came away with the impression that medical research had been 'starving for four years.' The researchers at the Institute told him that they had had access to few American journals and only intermittent access to Swiss and German journals. His report goes on to say that he was told that following the fall of France the Germans had conducted a thorough survey of all laboratories at the Institute but had left most of these alone and that the researchers gradually began to return to their former preoccupations but that they 'felt isolated, discouraged and without equipment.' The Germans had apparently asked for 'a few things' such as typhus vaccine and tetanus anti-toxin but that they (the French) refused to collaborate and the breach between the French and Germans grew wider. This failure to co-operate was evidently not total as suspicions began to develop between different French researchers some of whom believed that their neighbours were, to quote the report, 'un peu collaborateur'.

With regards to penicillin, Southworth was informed that production was initially carried out at the Institute but was later transferred to the Rhône-Poulenc works at Vitry who were producing some 400, 000 units per week. The mould was grown by surface culture and the penicillin titre in the crude mould filtrate contained 20 units



per ml but the final product (of which Southworth had obtained a sample for examination in London) was between 60 and 100 units per mg. Nitti claimed to have a small quantity of material that had a potency of some 8, 000 units per mg but the team seemed dubious about his claim. Southworth was also told that the penicillin had primarily been used to treat staphylococcal infections, and that he and his colleagues could find no instances of the use of penicillin for the treatment of syphilis, gonorrhoea or 'more unusual infections.' The researchers at the Institute revealed that they had been visited by German medical specialists some 8 months previously (i.e. approximately January 1944) for a culture of the Fleming strain of penicillin and that they had duped them by giving them a 'false culture'. They also stated that as late as June of that year a second German delegation had turned up at the Institute looking for an 'active strain.'

The first visit was almost certainly prompted by the fact that In January 1944 Federico Nitti published an article on penicillin in which it was obvious from the technical details supplied that he had in his possession the Fleming strain.<sup>22</sup> The state of German penicillin research was categorised in earlier work as lacking in centralised direction and that as a result there was much duplication of effort.<sup>23</sup> Moreover, the failure to adopt a standardised assay throughout the country made it difficult to identify and then exploit the best strains of *P. notatum*. Whilst the constituent companies of IG Farben may have been aware that Rhône-Poulenc had the Fleming strain, other companies and organisations may not have been, and coming across this work of Nitti's may have caused them to actuate attempts to obtain it for themselves.

January 1944 also corresponds to the time when, according to Bernard Sureau, a young physician working at the hospital attached to the Pasteur Institute, the first

patient – a 4½ month old baby suffering from pneumococcal meningitis was treated with penicillin produced in France. Details of this particular case were published in March of 1944.<sup>24</sup>

A survey of the reports produced by the intelligence teams reveals them often to be detailed and to contain much information that would have proved useful to the Allies. The rate at which such reports were received in London must at times been quite high, but there is evidence that the information contained in them was digested and acted upon; Thérèse Tréfouël of the Pasteur Institute was invited and visited London to obtain information about penicillin.<sup>25</sup>

### Recycling Penicillin

Florey's second article on penicillin, which appeared in *The Lancet* in August 1941, was a valuable compendium of technical and medical information on the antibiotic. Details were provided on how to grow the mould, extract and purify the penicillin and also how to assay it. Drawings were provided of special vessels designed by Norman Heatley specifically for growing the mould by surface culture and which enabled efficient collection of the 'mould juice' containing the penicillin. Additionally, the article contained information on toxicity testing of penicillin as well as the results of studies from a limited number of human trials on how it is eliminated from the body. The Oxford researchers found that between 50 and 68 % of the penicillin appeared in the urine quite soon after administration and that this could be recovered with an efficiency of between 30 and 54 %.<sup>26</sup> Finally, accounts of treatment trials of six patients with the antibiotic were included. Given Florey's determination to prevent German scientists from producing penicillin, publication of such details may seem at odds with his views. However, it is clear that Florey did agonise over whether or not to publish and that he wrote to Edward Mellanby, Secretary of the Medical Research

Council for advice. In response Mellanby reassured Florey by telling him that he was 'miles ahead of any possible competition.'<sup>27</sup>

The first of the cases described in Florey's second article on penicillin was that of a police constable who had received an injury to his face that had subsequently become infected with *Staphylococcus aureus* and *Streptococcus pyogenes*. The infection had not responded to large doses of sulphapyridine better known as 'M & B 693', and the patient lay dying after removal of his heavily infected left eye. Here was an opportunity for the Oxford workers to test the penicillin they had laboriously accumulated. The patient showed what was referred to as 'a striking improvement' within 24 hours of the commencement of treatment with penicillin, but it was in very short supply, and it soon became clear that there would be insufficient antibiotic to complete treatment. In desperation resort was made to extracting penicillin from the patient's own urine so that it could be re-injected into him. Initially this enabled treatment to continue but the procedure could obviously not be maintained indefinitely, and the quantity of penicillin available rapidly diminished and just over a month after commencing treatment the patient succumbed again to the infection and died. Notwithstanding the outcome, this 'forlorn case' had dramatically revealed the potent antibacterial properties of penicillin, and encouraged the Oxford workers to continue to evaluate penicillin's therapeutic potential.

Although specific details of how penicillin could be extracted from urine were not included in either of Florey's *Lancet* papers, the principles behind the recovery of penicillin from urine would essentially have been identical to that used to extract the antibiotic from the culture fluid or 'mould juice' in which it is produced by *P. notatum*. This necessitated contacting the aqueous medium with a smaller volume of immiscible organic solvent such as ether or amyl acetate followed by back extraction

into an aqueous medium. Certain changes in pH are necessary in order to effect the transfer of penicillin between the two liquid phases but the details of these are not relevant here other than these necessitate further reagents and indicators. Saving the latter, most of the materials required for the extraction and further purification of penicillin were themselves reusable. This was an important consideration as these would have all been in short supply during the war years and their immediate aftermath. In particular, the organic solvent could itself be purified and recycled. Further purification of the penicillin was necessary, and this was achieved by adsorption onto activated carbon followed by chromatographic separation.

### Penicilline

The quantities of penicillin that were produced jointly by Rhône-Poulenc and the Pasteur Institute were to remain very modest throughout 1943 and 1944.<sup>28</sup> It seems likely therefore that recourse would have been made to extracting the antibiotic from the urine of patients to whom it was administered. Familiarity with drug metabolism of drugs in general and the sulphonamides in particular by the researchers at the Pasteur Institute would most probably have engendered the idea. Aside from this they possessed Florey's article in which it was stated that recovery from urine was undertaken in the treatment of the police constable.

With the liberation of Paris the city became the location of a number of Allied military hospitals. Most of these were in established hospitals, but use was also made of other buildings in the city. One example being the Lycée Jean de la Fontaine situated in the SW of Paris near Porte Molitor and which during the Occupation had itself been requisitioned by the German Navy. This building came to house the 198<sup>th</sup> General Hospital (US) which was equipped with 1000 beds.

The realisation was arrived at that such hospitals, housing as they did large numbers of battle casualties receiving penicillin for the treatment of wounds, could potentially serve as sources of penicillin-containing urine in appreciable volumes and at penicillin titres sufficiently high as to make its extraction and purification worthwhile.

The exploitation of urine (chiefly that of animals) as a source of hormones was widely carried out before the war, but the wholesale recovery of a drug from urine for re-administration was something entirely novel. A group with the grand-sounding title of the French Military Penicillin Team was formed and had its base in south west of Paris near Porte de Saint Cloud. Once fully established there were a dozen American military hospitals around Paris participating in the scheme and allowing collection of urine from patients.

The details of the operation are contained in a French publication which appeared shortly after the war had ended.<sup>29</sup> The Penicillin Team comprised a Commanding Officer and a dozen men. It was set up in January 1945 and at first transportation of urine from American hospitals was effected in milk churns placed in a large wooden crate by metro! Soon after however they were to become equipped with vehicles. In addition, they were allocated chemical supplies and other sundries the most significant of which was receptacles necessary for the collection of urine and 20 kg of chloroform per month. The latter were for the purposes of carrying out the primary extraction which was conducted at the Rhône-Poulenc site of Vitry which lay outside Paris near Fontainebleau.

The actual procedure for collection of urine was straightforward. Firstly servicemen receiving penicillin had to be distinguished from other hospital inmates who were not being treated with the antibiotic. This was done by affixing to the foot of the bed a

small placard indicating that its occupant was being treated with penicillin.

Complications would have arisen when such patients became semi-ambulatory as they had to be instructed to urinate into these flasks. Flasks of 5 litres capacity were left at agreed locations on wards to enable easy collection. These had to be clearly labelled – in both French and English to prevent their being disposed of by cleaners. A typical participating hospital might have some 36 flasks in total on its wards. The American medical authorities initially expressed concerns that these urine containers might themselves become sources of contagion and also that the whole process of collection would interfere with the normal operation of the wards. The issue of urine as a source of infective agents was addressed by arranging that the flasks were to be collected by the French penicillin team twice daily. In addition, the collection personnel undertook to wash the 5 litre flasks after they had decanted the contents in order not to impose on the ward staff. Once the team had taken deliveries of its two vehicles, two collection routes were established. The first comprised hospitals in the Northern parts of the city whilst the second comprised those located in Southern Paris. The urine was delivered to a site in Paris owned by Rhône-Poulenc for extraction.

That having to collect and handle urine from a certain category of patient would be adding to the work of the healthcare workers was acknowledged by the military directors of the hospitals. Major A. Fodor based at the 48<sup>th</sup> General Hospital at Lariboisière sought to encourage the full participation of ward personnel by prefacing his written orders on procedures for collecting the urine with the following words: “Seldom indeed does the opportunity occur to give with no material loss to the giver”. However, there must have been occasions when large influxes of battle casualties were received at these hospitals and the collection of urine would have become of

low priority. In the middle of March 1945 the Chief of Medical Services, Lt. Col. R.C. West had to issue a memorandum to personnel of the 191<sup>st</sup> US General Hospital informing them that they had recently been 'very lax' in collecting urine.

Notwithstanding occasional lapses, the amounts collected grew steadily; the peak volume collected between January and February 1945 was about 150 litres per day, by March this had nearly doubled to 270 litres and by April it had increased to some 340 litres. Yields were close to those obtained by Florey's group, and once fully established the recycling operation was producing 10 million units of penicillin per week. The typical total dose being administered to patients was approximately 100,000 units suggesting in theory that 10 patients could be treated weekly.<sup>30</sup>

By its very nature what might be termed the raw material for the process of purification was of variable quality. This was reflected in the potency of the final product which could vary from 138 to 590 units per mg.<sup>31</sup> The most likely cause of such variation was deterioration of the penicillin in the flasks on hospital wards during the time it was awaiting collection. In addition to this a significant number of the patients receiving penicillin would also be receiving treatment with a range of medications for other conditions. A proportion of these, and/or their breakdown products, would be excreted from the body into the urine and would therefore also be extracted along with the penicillin. The separation procedures employed may not have permitted sufficient selectivity, and therefore these other drug residues may possibly have ended up contaminating the final product.

### Épuration

As mentioned above Hamilton Southworth visited the Pasteur Institute immediately after Paris had been liberated and was told that the Institute had supplied 'a few

things' to Germany. The extent of these few things the German authorities had demanded of the Institute was recently revealed by Chevassus-au-Louis. The records he consulted show that following the first dispatch of samples of vaccines to Germany in early 1942 from the Institute, regular deliveries commenced in April of that year. The records show weekly delivery of 10 litres of vaccine were made to the Wehrmacht until 16<sup>th</sup> August 1944 – just days before the liberation of Paris – and that in total some 1,039 litres in all were delivered to them. This constituted some 38 % of total production, the remainder being distributed to French prisoners of war and the French population at large.<sup>32</sup>

There was also the issue of delivery of primarily sera, but also vaccines, to the Behring Works of I G Farben, Chevassus-au-Louis states that the collective 'memoire pastorienne' has sought to create the impression that a series of ruses were employed to delay and ultimately prevent such deliveries. The German authorities got wind of these and decided to make the demand for these products somewhat more urgent and the consequences of failing to meet them more severe. They therefore demanded that deliveries of sera be henceforth made directly to the Wehrmacht. Chevassus-au-Louis came across other documents at the Institute in which it was stated that its Director, Jacques Tréfouël, had claimed after the war that only some 10s of litres had been despatched, when in fact the records show that the delivery for 1943 alone exceeded 1000 litres.<sup>33</sup>

Chevassus-au-Louis quotes a former researcher at the Institute who claimed that typhus vaccine production was transferred to a manufacturing facility in the south of the country and that it was from there that vaccines were supplied to Germany.<sup>34</sup>

Chevassus-au-Louis' judgement of this statement is that it was true but incomplete, and that in fact vaccines were despatched to Germany from the Institute.



During the events related above Bernard Sureau was working as a houseman at the hospital attached to the Pasteur Institute. He was present when their first patient – the 4.5 month old baby - was treated with penicillin. As an old ‘pastorien’ he has left an account of his times and career at the Pasteur Institute. In his papers he claims that the idea to commence work on penicillin occurred when Federico Nitti heard a BBC broadcast in the autumn of 1943 and then burst into the lab with the words ‘Sureau old man, we’re going to make penicillin!’<sup>35</sup> Thus began, as Sureau puts it, the ‘more or less clandestine’ production of penicillin.

The broadcast that Sureau claimed that Nitti had heard was certainly not a figment of his imagination - there was indeed a broadcast on penicillin transmitted by the French Service of the BBC on 29th September 1943.<sup>36</sup> The broadcasts of the foreign services of the BBC that mentioned penicillin were primarily aimed at physicians and other medical professionals. This was in contrast to those of the Home services in which a politically motivated message was relayed in a number of broadcasts. This was one of confirming press reports of the potency of penicillin against life-threatening pathogenic bacteria but pointing out that all supplies were to be prioritised for the armed forces and that the civilian population would have to await its turn. The French Service transmission of 29<sup>th</sup> September was one in a series entitled ‘Medical News’ and it was evidently not the first on this topic, as it began ‘we have already had cause to mention penicillin to you on a number of occasions.’ Apart from mentioning the locations in Britain and the United States where the antibiotic was undergoing clinical evaluation, details were given of the specific pathogens that penicillin was active against – highlighting the fact that these tended to be highly resistant to sulphonamides. This particular broadcast mentioned meningitis and it is perhaps no coincidence that the first case notes published in France of a patient

treated with penicillin was suffering from this condition. Therefore, although this and similar BBC broadcasts were undoubtedly useful to French researchers, they were almost certainly not the factor that initiated their research on penicillin.

The overwhelming balance of evidence presented above indicates that penicillin was already in production in the autumn of 1943 as a result of the collaborative venture between Rhône-Poulenc and the Pasteur Institute. Also, Sureau's use of the words "more or less clandestine" do not bear scrutiny. The researchers at the Institute published accounts of the first clinical applications of the penicillin they had produced in open journals. They cannot have been in any doubt that these publications would have been scrutinised by the German authorities. Indeed, one their first articles on penicillin was cited in a review on contemporary production of penicillin published in the German serial *Chemiker Zeitung* in October 1944.<sup>37</sup>

To some extent the decision to publish may have had more to do with these researchers striving to maintain their professionalism and enabling them to give free rein to their instincts as academics. The phrase 'publish or perish' has come to pervade the academic establishments of our times. For the scientists at the Pasteur Institute working under conditions of privations of all kinds and feeling cut off from the international scientific community, their inspiration for continuing with their research is more likely to have been 'perish or publish'.

In his deposition in the archives at the Pasteur Institute Sureau comes across as seeking to sanitise the precise circumstances in which penicillin production had taken place in France. The very manner in which he claims that penicillin production was initiated – listening to BBC broadcasts in contravention of German regulations – is itself made to seem an act of defiance against the Occupiers.

Similarly, although as its Director Jacques Tréfouël had no option but to accede to German demands for sera and vaccines, he is seen later as massively under-reporting the quantities of these products actually supplied to various German organisations including the Wehrmacht.

There can be no doubting that the idea of extracting penicillin from hospitals treating servicemen receiving penicillin was an inspired one. That the penicillin obtained by these procedures seems to have been for the treatment of sexually transmitted diseases (STDs)<sup>38</sup> was no more than keeping with a precedent set by Winston Churchill who approved the release of penicillin to soldiers of the 8th Army who had contracted STDs, advising the directors of medical services to put it to 'best military advantage'.<sup>39</sup> Notwithstanding, the evidence is that in nearly all cases cures were effected.<sup>40</sup> Presumably French resisters wounded in action would have been eligible for penicillin obtained from Allied military supplies.

There should be no reason for assuming that the Pasteur Institute was any different from any other French organisation that had had to make accommodations with the German occupiers. At the same time it must also be stated that estimates have been made suggesting that some 11 % of the workers at the Institute were members of various resistance movements or networks, and that a secret supply of pharmaceutical products was maintained in the cellars at the Institute for the Forces Françaises de l'Intérieur (FFI).<sup>41</sup>

Apart from the strictly literal purifications, or 'épurations,' of penicillin from urine, épurations, albeit of a very different kind, were being conducted on the streets as the Germans started withdrawing from Paris and those accused of collaboration were called to account. This species of épurations could often be summary and bloody

affairs. In time these gave way to more searching and measured investigations of Franco-German relations during the Occupation.

That the researchers at the Institute should feel unease over the contact they had had with the occupiers is understandable, and it is perhaps against this background that the whole endeavour to extract penicillin from urine should be viewed. Contact with various German agencies, unavoidable as it was, left a taint at both the Pasteur Institute and Rhône-Poulenc. An opportunity presented itself both to re-purify the standing of both organisations and to demonstrate open engagement with the Liberators at the most basic level by, to borrow the words of James Joyce, 'carry[ing] off their filthy streams'.

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