The Institute of Science & Technology

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Reverse of cover page.

The **Journal**

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Editorial

Ian Gray

The Institute now has a new name and the opportunity to enlarge its membership with other like-minded professionals.

This reminds me of a recent concert I attended by the National Saxophone Choir of Great Britain, where musicians came from all over the country to demonstrate their skills and provide a delightful balance over a range of nine different saxophones, from the lowly contrabass (and tubax) to the ultra high Soprillo. They were able to play individual musical pieces relevant to their instrument, or combine with one or more of the others to provide a different focus of their interpretation of the musical score or they could combine all together to produce a very effective and powerful sound, which demanded attention from even the deafest of ears! I have to admit I did not expect too much from the evening but this group of players, who did not have much practice time because of their different addresses, made me feel that even a relatively small group of dedicated people can produce a strong message.

The Institute follows a similar pattern with dedicated volunteers steering a progressive ship, hopefully with the full support of its membership, as these volunteers apply their different skills to a common cause. I am sure you can appreciate that with some extra involvement from you, the membership, then even more can be achieved in a relatively short time when you all come together from your various addresses with the UK. The formula for success works either in small groups or in sharing views of others within committees so will you provide your knowledge base to help further the Institute's cause?

It only needs a phone call or email to set the wheels in motion and you can gain the same satisfaction from reaching a worthy IST goal that the National Saxophone Choir of Great Britain feels when one of their concerts is over!

Orbituary

Simon Fairnie FIScT

Ron Dow

Past Chairman IST

It is my sad duty to write this tribute to Ron Dow who died suddenly and unexpectedly after a short illness on 30th August 2007 at the age of 68. I knew Ron for 52 years as a friend, colleague and as a long standing Institute member. We shared a lot in common having been born within two days of each other and both starting in 1955 as junior technicians in Edinburgh University; he in the Medical and I in the Science faculty. During our training period our careers took different paths with Ron working until 1958 under the direction of Professor Sir John Gaddum (Chair of Materia Medica) then with Professor Walter Perry (who later became Lord Perry of Walton the first Principal and Vice Chancellor of the Open University and of course one of our most recent past Presidents) in the Department of Pharmacology where Ron was to spend all of his 45 years working life progressing from junior technician to senior technician to chief technician. After retiring in 1999 he worked in Queen Margaret University College (now University) as a part time consultant.

Following a period of national service in the Royal Army Medical Corps, Ron returned to the department to work with some of the most distinguished scientists and all-time great figures in Pharmacology. On the setting up of a new sub-department, the Medical Research Council Brain Metabolism Unit, it was logical that Ron, now with his specialized expertise, be transferred there to work with its first director, George Ashcroft. There he was not only responsible for the day to day management of the Unit but contributed much to its research work which in the early years was concerned with the metabolism of serotonin the chemical messenger to the brain that is considered to play an important role in depression. The research work of the Unit expanded and focused on central neurotransmission with special reference to mental disorders. Psychopharmacology was now pointing towards dysfunction of the central monoamines, dopamine, noradrenaline and serotonin, as a possible cause of mental disorders such as schizophrenia, manic-depression and major depressive disorder with Ron now becoming a supremely competent and skilled experimenter. He developed a method by which the release from the brain of hormones called 'releasing factors' that control the pituitary gland could be measured such that he was ever called upon to train others in these fine techniques. There are many eminent scientists from all over the globe who, over the years, have learnt some of their skills from him and will testify to his being a great colleague and collaborator as well as an expert manager, much of the latter however due more to his charm and ability to have others run around to help him especially when a pressing deadline had to be met. Ron was the author and a co-author of many important scientific papers having some 50 in all to his name and in 1977 he submitted a thesis in support of Fellowship which was duly awarded after which his research work was further recognized by Edinburgh University when in 1978 he graduated as an M.Phil.

As juniors we both worked under chief technicians, Nelson Condon and Ron Fox, who were active in promoting the Science Technologists Association which became the Institute of Science Technology and, as our mentors, they encouraged us, and many others, to join the Institute and undertake tuition to gain the necessary qualifications to become Members and so progress our careers.

For Ron joining as a student member in 1955 was the beginning of a long association with the Institute which continued right up to a few days before he died when we were working on the drafting of a motion for the Executive. The Edinburgh Branch was one of the first to be formed and was, outside London, the biggest and most successful of all the branches and it was not long before some of the trainees, including Ron, now a Member, became active in the running of the branch which in those days was an undertaking considered as a necessary precursor to becoming an elected member of the Institute Council. As branch Chairman it was apparent how much he was able to give to his office and to the education of others so it was no surprise when he was elected to Council. There he joined a group of like minded men and women from universities and colleges around the country and from the outset his contribution to the affairs of the Institute was apparent. At that time, one third of the 24 Council members were from Scotland who would travel together overnight by train to London rarely missing a meeting of Council or a sub committee. Ron enjoyed those meetings as much for the social aspect as he was a joyful, genial companion and host of many a post meeting get together to share a 'wee dram' he'd specially have imported over the border for the occasion. Through his involvement in the Institute, both as a Council member and as Chairman of Council - a post which he held for 16 years becoming the longest serving in the history of the Institute - Ron played a significant role in promoting practical technology and facilitating the careers of technicians. His post as Chairman (1984 onwards) was held during some very difficult times for the Institute but his vision of the future and ability to pull things together and keep them going, all in a quiet, unassuming way helped the storm to be weathered such that the Institute is in the strong position it is today. For his long and very special service to the Institute he was awarded the Perry Medal of which he was especially proud and delighted to receive as the award was founded by his friend and mentor Lord Perry.

Away from work Ron was a man of many interests, a good singer with a wonderful bass voice; an exponent of Rabbie Burns, of which his knowledge was encyclopedic; a connoisseur of good whisky; a raconteur; a keen and effective fly fisherman; passionate about the highlands, small alpine wild flowers, wild-fowl and gardening. He had an astonishing circle of friends, including actors, writers, journalists, broadcasters, advocates and poets, who met regularly and shared an extraordinary relish for life, conversation, madness and whisky. He has been described as being "a poacher, gamekeeper, loyal friend, steadfast comrade-in-arms, jovial rascal, wild and helpful critic, skilled technician, a true and wonderful big-hearted and quick-witted Scot and a man for whom "a thing of beauty was a joy for ever"'.

He will be sorely missed by all who knew him and perhaps will be thanked by many who did not.

Good bye Ron old friend.

Chairman’s Annual Report

John Robinson
May 2008

A few weeks ago, whilst at a technical staff meeting in an ornate and panelled hall just half a mile from this very computer I was asked a question which stopped me in my tracks. I had been talking about the Institute and how it could help technical staff with their career development and had explained that the IST Executive were all honorary positions, but that I made no bones about what my “day job” motivation was; a salary!

Other speakers had been discussing their motivation for career progression and a few had said they had made career decisions for reasons other than money; interest, satisfaction, personal development, need for a change and so on. So while I am perfectly clear in my own mind that the day the salary doesn’t hit my bank account at the end of the month is the day that I down tools and walk out, the killer question was why do I do what I do for IST?

I hadn’t really stopped to think about it before. And what’s the difference? Why am I prepared to do extra, and not very different, work for nothing, for IST? A lot of it is hassle; it creates tensions which affect my personal life and my working life (though I must say that those in both give me full support) and it constantly makes demands that are often very difficult and sometimes impossible to deliver. And just in case it crosses anyone’s mind; no, I don’t have masochistic tendencies! The bare truth, I suspect, is that I keep on doing it because overall I enjoy it[1] and because I passionately believe that recognised professional skills allied to a proper career structure for which developmental support is available is essential for the profession. Unfortunately, that has not been available for about thirty years and that is bad for the profession and bad for all the very broad spectrum of other professionals who depend on our skills.

So what has all this preamble got to do with the Annual Report? The answer is that I sat down to write it and these were the thoughts that came to mind. You may think they are irrelevant, but they are a starting point and they will, if I take a large leap, lead to reminding me where we are up to and what has been happening for the last year. And if others find it a leap too far it at least reminds us all of what we are trying to do together.

The usual routine of any review is a standard “look back, take stock, evaluate and look forward” process. It applies to all sorts; professional development reviews, appraisals, strategic planning and Chairperson’s reports so I see no need to deviate this year. So what have we been doing

[1] *There may be other reasons related to old age and altruism so let’s not go too deep. Self analysis can lead to nasty surprises if one is not careful, but I do get a vague feeling that I have had an enjoyable career and I would like others who enjoy working at benches and doing risky things (appropriately risk assessed, of course) to be able to enjoy it too. And unless we look after those things we care about there is a risk that it might just disappear at the hands of those who don’t care and then the world will be a poorer place.*

since last year – apart from changing our name ever so slightly?

Well, we had a stand at the ASE Lab Technicians' Conference in July at the University of Hertfordshire, Hatfield. We partook in SEMTA's review of NVQ for Clinical Laboratory Support Level 2 and are maintaining ongoing contact with SEMTA. We represented our members on the Steering Group for the Gatsby-funded ASE/DATA project, the Technicians' National Assessment Centre Techcen and we are looking forward to contributing to Scientific and Chemical's programme of training events for school technicians. We gave talks on our role as a professional body to technical, managerial and specialist staff from Life Sciences and Medicine at the University of Manchester and exhibited and spoke at the UBMA annual conference (also in Manchester). We will also be represented and or speaking at the forthcoming UCLAS and ATSiP conferences and we continue to be involved in the HEATED steering group and the development of the CPD, VLE and TSDP. Apologies for the acronyms; I'm sure that most of you will be familiar with them. And if you are not – here's another; we are delighted that the new UCISA (www.ucisa.ac.uk) award for IS managers is now operational with several individuals from the first intake already having completed.

In addition to that the forthcoming joint conference with HEATED will reveal all about CPD, VLE and TSDP – make sure you are there on 10 June to find out what's going on! On the inside, our drive to increase the number of fellows is gathering pace so please think about your own membership; have you published or contributed to any papers recently, given any seminars, run any workshops or courses, arranged conferences, developed new techniques, undertaken significant CPD, developed a more responsible role, written significant articles? All of these things contribute to your skills and development – why not find out about Fellowship? And if you're not sure or nervous about it, talk to a Fellow; the office will be more than willing to put you in touch with someone who has the experience to give you the support you need.

Our finances remain more or less in steady state – ideally we would like to see greater income so that we can build resources to start new developments and fund new initiatives, but we are not here to make a profit; if we are successful in our endeavours financial issues will look after themselves. In the meantime, we need to be prudent.

So what of the future? We have a small number of eggs in our basket and one or two acorns planted alongside. These remain critical to our long term success and in many ways we are dependent on a few individuals to nurture them and allow them to grow, but all members can play an important part by ensuring that our professional body is presented as such at every possible opportunity. Tell your colleagues and friends what we are doing and try to recruit new members if you can. If our portfolio continues to grow as it is at present we will very soon have something for everyone; the more we benefit our members the more we will recruit and retain.

Finally I will end on the traditional note of giving our thanks to all those whose efforts and very hard work have contributed to the successes of the last year. In particular I would like to thank Wendy, Joan and Louise who have continued to underpin the activities of the Institute by providing an excellent and professional service, often in the background and unseen but nevertheless pivotal to our administrative functions.

The History of Medicine - Medical Effects Make-up

Julia Hyland

As Outreach Officer for the Centre for the History of Medicine at the Medical School, work for me is often 'bloody' awful. I am what is known as a Medical Effects Make-up Artist and my role is unique in that I deliver interactive sessions by recreating trauma, injury and disease. I am quite happy to surround myself with torn flesh, knife wounds, third degree burns and nasty blisters. Funded by the Wellcome Trust I work eighteen hours a week at the Centre, while pursuing film and television freelance work at other times.

I combine my skills with interactive talks and practical sessions. This approach to teaching the history of medicine quite literally animates and demonstrates the characteristics surrounding disease and health while providing participants with a chance to interpret and visualise the effect of a particular ailment. In this way, injuries, wounds and diseases are realistically represented and clinical accuracy is paramount. Thus, I am able to stimulate interest, excitement and debate by reproducing conditions such as plague, smallpox, anthrax and fractures and discuss them in their appropriate medical-historical context. The sessions cover a variety of processes in the application of medical effects make-up and incorporate knowledge in a number of affiliated subjects including anatomy, physiology, chemistry and the history of art. I combine my skills with interactive talks and practical sessions.

My approach fulfils the criteria laid out by the Wellcome Trust, which is to:

- Support formal and informal learning;
- Reach new audiences not normally engaged, as well as targeting existing audiences;
- Examine the social, cultural, historical and ethical impact of trauma, injury and disease;
- Encourage new ways of thinking about health and disease;
- Incorporate new methods of engagement, participation and education;
- Communicate issues of health in society;
- Give a wider understanding of medical history for those with little or no knowledge of the subject.

From prehistory to modern day, in fact all throughout history, the human race has and will always suffer from the effects of disease and trauma. All we can ever hope to do is control and sometimes destroy pathogens, and we have often found ingenious ways of doing so. This leads to interesting discussions on methods and treatments used, which seem so alien to us in the Twenty-first Century. One of my favourite discussions is the use of almanacs and astrology in medieval medicine, where no operation would be performed if the planets were not correctly aligned. It was believed that each part of the body related to a particular sign of the zodiac, which in turn related to the heavens, the moon having a special part to play. No operation would ever be performed on a full moon – God forbid! At this time the Christian church preached that the moon was a feminine influence and women were considered evil!

These medical simulations help to capture the imagination of a wide audience of all ages. Sessions are delivered formally or informally to large (>400) groups or small (<5) in a series of lectures, talks and practical demonstrations. These can take place in schools, FE and sixth form colleges, museums, universities or at other special events.

People can and do react emotionally to my work, one girl fainted and another has actually vomited - this is when I know my work is good! The girl who fainted still wanted to be made up with a gory injury when she came to. One model quoted *'it's odd to see something so realistic on yourself and feel no pain'*. Others have actually begun to feel pain after a while. This is because when we are faced with an injury we think it should hurt and our mind gets confused as to what is happening.

I've studied programmes such as *Casualty* where you rarely get an extreme close up of an injury and any trauma is usually only on screen for a few seconds. When the viewer sees what they think is blood they usually turn away and the imagination fills in the gaps, which is far more powerful than any film script.

So what do I use? There are plenty of specialist products on the market, I use theatrical suppliers such as Charles Fox and ScreenFace in London, some I get from the USA, others from France and Germany. They all have interesting names such as *'bruise gel, 'raw flesh', fresh scratch', 'congealed blood', 'dry lip', 'death colours' and 'severe exposure'* to name a few. My favourite is a modelling wax which states on the tin *'a compound for restoring destroyed features'* – a product used in the mortuary which I use for making skin effects. None of the make-up has been tested on animals and all are considered safe to use on the skin after undergoing stringent dermatological controls. Other products include household ingredients, tea, for example, and coconut - great for texture. Rice crispies, porridge and cornflakes make excellent scabs, salt for ice crystals and coffee to colour blood. I use a lot of liquid latex and silicone that I pour into moulds to create pre-sculpted wounds. If I have to create broken bones, I would use spare ribs as these are the closest in nature to human bones. This is where my friends think I am really strange as I have to bleach the bones, dry them and then smash them into pieces with a hammer. It's surprising how difficult it is to break bones and it disturbs me every time! I find I'm not immune to being shocked. I recently researched dog bites for a presentation and talk on Rabies; some of the images I had to look at were very disturbing.

If I need to recreate a burn for example, I would begin by applying liquid latex to my willing volunteer (or myself). Once dry I then add coloured gels to create bruising and scarring before layering on fake blisters and skin, then with tweezers I pull and tear at the latex to produce rumpled charred flesh to give texture which is just as important as colour. I then finish off the 'burn' by adding ash powder and fake sweat. The overall result is a mess of split, blackened skin that looks agonisingly painful and in need of medical treatment.

Example of septicaemic plague

Top two images are real plague, bottom two the make-up simulation

The issue based work I do can demonstrate the effects of gun and drug misuse as well as the effects of drink driving, giving an understanding of the effects of violence and crime. I have recently worked for six weeks with maximum-security young offenders. My workshops were designed to make them reflect on their crimes. To physically wear the injuries helped them to see the long-term consequences of violence.

I also collaborate with other universities and societies, I recently did the make-up for *'Death and the City'* - a roleplay about an outbreak of plague in the city of York in 1632, where the audience were asked to decide the fate of the victim, whether by being boarded in their home, made to leave the city or left to fend for themselves. I am currently working on *'The Business of Bodies'* with the British Society for the History of Science, another roleplay activity where the audience will be asked to judge a case of body snatching, which was rife in the eighteenth and nineteenth centuries. Of course I am a fan of CSI (Vegas) and the old Hammer Horror films and am currently studying for an MPhil degree in Ancient Cosmetic Toxicology, discussing the deleterious effects of lead, arsenic and mercury based skin products used throughout the ages and up to modern day.

Real

Simulated

Over the years I have made anti-bullying films and trained first-aiders. Freelance TV work has included Channel four productions *'Ancient Plastic Surgery'* and *'Helen of Troy'*. Other work has appeared on the Horror Channel, MTV and National Geographic. I had the opportunity to work with Michael Jackson, creating his zombies for *'Thriller'* at the World Music Awards in 2006.

My work is always well received; I find the WOW factor such a thrill.

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The Evolution of Eukaryotic Cells

Stephen J Gamble

ABSTRACT

Higher life forms on Earth are multi-cellular organisms composed of eukaryotic cells. Eukaryotic cells are complex and are unlikely to have been the primary inhabitants of the planet. Evidence is examined to support the theory that eukaryotic cells evolved from simpler organisms by multiple endosymbiotic events.

INTRODUCTION

My interest is in the discovery of life on other planets. Although for many centuries people on Earth have wondered about life elsewhere in the Universe the only place where we definitely know life exists is on Earth. Understanding how life arose and then further developed on Earth provides valuable indications on the possible nature of life elsewhere. The current discussion is restricted to the evolution of one aspect of life on Earth. Similar processes may, or may not, operate in other parts of the Universe.

The events described in this paper occurred thousands of millions of years ago. In scientific literature the term billion is often used. In American usage billion is used to represent one thousand million whilst in UK usage billion is one million million. To avoid confusion the term billion will not be used and two alternative terms will be introduced. The term Giga Year (GY) will be used to represent a period of one thousand million years. Secondly, the term GYA will be used to represent Giga Year Ago, a period of one thousand million years before the present.

Life on Earth can be divided into three domains – the Bacteria, the Archea and the Eukaryotes. All higher organisms on Earth are complex multi-cellular Eukaryote organisms. Eukaryotic cells are primarily characterised by holding the majority of their genetic material separate from the general cell cytoplasm in a defined nucleus. They have a number of other membrane bound sub-cellular organelles not seen in simpler organisms.

As a rough guide, 90% of organisms on Earth are either bacteria or archea. Of the remainder, around 99% are single cell eukaryotes (Walker, 2005). This means that multi-cellular organisms make up only around 0.1% of all life on Earth.

DISCUSSION

Roger (1999) states, "Resolving the order of events that occurred during the transition from prokaryotic to eukaryotic cells remains one of the greatest problems in cell evolution". Compared to bacteria and the archea, eukaryotic cells are considerably more complex.

Given the complexity of eukaryotic cells it is very unlikely that they were the first form of cell to evolve on Earth. This paper will examine evidence describing how eukaryotic cells evolved from earlier simpler organisms. The common perception of evolution is that it is a straight line process with one organism gradually changing into a new organism. In practice evolution is often a series of steps, some small, others large.

The Earth and the rest of the Solar system formed approx. 4.5 GYA. In addition to internal heating the Earth underwent severe meteoritic bombardment and did not form a stable surface until 3.8 GYA. The first evidence of living organisms appears around 3.5 GYA, although organisms may have existed before that date.

The first cellular organisms represent one of the large steps in evolution. Before that three other major steps must have occurred. Firstly, simple bio-chemicals must have formed from simpler chemicals. In a review of the synthesis of amino acids, purines and pyrimidines in primordial conditions, Miller (1998) states that this process occurred soon after the Earth's formation. The second major evolutionary step that must have occurred must have been the linking in someway of these simple bio-chemicals to make more complex molecules such as nucleic acids and peptides.

These first organisms were probably bacteria like and were prokaryotes. Prokaryote is a word derived from ancient Greek made up of pro, meaning before, and karyon, meaning a nut or a kernel. Basically this means that a prokaryote is a cell without a kernel, or nucleus.

The formation of eukaryotic cells is itself another major step in the evolutionary ladder. Eukaryotic cells are much larger than prokaryotes. They have much more efficient ways to generate energy from nutrients using mitochondria whilst some have their own means to trap energy, for example, using chloroplasts. These larger more efficient cells paved the way for the next big evolutionary step, the evolution of multi-cellular organisms containing a number of similar cells. This occurred about 600 million years ago. It is a smaller evolutionary step from multi-cellular organisms to ones in which cells differentiate into specialised functions. The key step is the jump from prokaryotes to eukaryotes. How did it come about?

Giselle Walker (2005) stated that the most likely origin of eukaryotic cells is where one simple cell engulfed another cell. The engulfed cell was not digested but a symbiotic relationship was established. This process is called endosymbiosis. This is a theory that has been around for some time and has gained more support in recent years. Smith and Szathmary (2000) state (page 60) "In the early 1970s Lynn Margulis forcefully revived the idea of the symbiotic origin of plastids and mitochondria", suggesting that the theory had been around before then. Gray (1999) states that the theory has been around for at least 100 years. There is a significant body of evidence to support this theory.

Walker supports the idea that structures such as mitochondria might have once been free living bacteria by pointing out that they have a double membrane. She postulates that the outer membrane could be derived from a vacuole formed by the host cell and the inner membrane could be derived from the cell membrane of the engulfed bacterium. There is further evidence that some early eukaryotes may themselves have been engulfed by other proto-eukaryotes as they have chloroplasts surrounded by a triple membrane. There may be evidence of a residual nucleus, called the nucleomorph, between the outer and middle membranes of the chloroplasts.

By the end of the 1980s it was thought that the general sequence of events was that the earliest organisms were the archea (originally the archea were thought to be a specialised branch of the bacteria called archeobacteria, whilst the true bacteria were termed eu-bacteria) which were followed by the eubacteria. It was thought that the first eukaryote was formed when a eubacterium engulfed either another eubacterium or archeobacterium. However more recent work has shown the cytoplasmic structure and chemistry of archeobacteria to be more similar to that of the eukaryotes suggesting that archeobacteria must have been the original host cells which engulfed other cells. This is supported by the findings of Pisani, Cotton and McInerney (2007) using complex phylogenetic analysis.

Both mitochondria and chloroplasts (plastids) have their own DNA. According to Kimbell (2005) this consists of a single circular molecule of DNA without any associated histone proteins. This is very similar to the prokaryotes and supports the idea that they were once free living organisms. He further states that both mitochondria and chloroplasts have their own protein synthesising machinery. The products of this synthesis all start with formyl methionine (fMet), as do proteins produced by bacteria, rather than methionine, which is the starting amino acid in proteins produced by eukaryotic cells.

Also supporting the endosymbiosis idea are the comments of Margulis and Sagan (2002). They state, "No missing links between eukaryotes and bacteria exist, either in the fossils or in life. The sudden appearance of eukaryotes on the evolutionary stage was genuinely discontinuous and not gradual".

The evidence seems to support the idea that engulfing followed by endosymbiosis has occurred at least twice in historic times to create eukaryotes as they are now observed. These engulfings seem to have occurred around 2.2 GYA and 1.8 GYA. Gray (1999) states that the genomes of mitochondria are sufficiently similar to support the idea that whatever organism mitochondria originated from was only engulfed at one time.

The story is further complicated by the discovery of hydrosomes which appear to be mitochondria like structures which produce hydrogen. Originally they were thought not to contain genetic material, but more recent studies have shown that they do. Gray postulates that hydrosomes, mitochondria and the eukaryotic nucleus may have arisen from a closely related group of eubacteria which invaded proto-eukaryotic cells at about the same time.

Given that chloroplast seem to have the remnants of a nucleus is suggestive that chloroplasts were part of a second wave of endosymbiosis. Therefore, it is likely that hydrosomes, mitochondria and the nucleus were first incorporated into eukaryotes around 2.2 GYA, whilst chloroplasts were incorporated around 1.8 GYA. There is strong evidence (Bell (2001) and Forterre (2005, 2006)) that the eukaryote nucleus originated when a DNA virus invaded an early cell.

Kimbell states that mitochondria are most closely related to aerobic bacteria, most probably the rickettsias, whilst chloroplasts are evolved from cyanobacteria. In support of this he points out that a number of antibiotics such as streptomycin, which block protein synthesis in bacteria, also block protein synthesis in mitochondria and chloroplasts. Antibiotics do not block protein synthesis in the cytoplasm of eukaryotic cells. The antibiotic rifampicin blocks RNA polymerase in both mitochondria and eubacteria, but does not affect RNA polymerase in the nucleus of eukaryotes.

Conversely, Kimbell states that inhibitors of protein synthesis in eukaryotic ribosomes, e.g. diptheria toxin, have no effect on protein synthesis in eubacteria, mitochondria or chloroplasts. This suggests that bacteria, mitochondria and chloroplasts have a common origin.

Following endosymbiosis, the incorporated bacteria have reduced genomes with many of their genes being relocated to the nucleus of the host cell (Gray, 1999). Poole and Penny (2006) present an alternative argument in which the Archea and the proto-eukaryotes arose independently at a similar time. Whilst their evidence supports the idea that the early eukaryote did engulf the mitochondrion they point out that there are no current examples of bacteria living in endosymbiotic relationship with archea.

CONCLUSION

The situation can be summarised by a quote from Roger (1999) "Our current picture of early eukaryotic evolution is in a state of flux".

It is most likely that eukaryotic cells evolved from simpler organisms by incorporation into a host cell of other specialised simple cells by endosymbiosis. This process has occurred on multiple occasions in evolutionary history. The biochemical evidence is supportive of the idea that archeobacteria engulfed on multiple occasions eubacteria which took on the role of subcellular organelles in eukaryotic cells.

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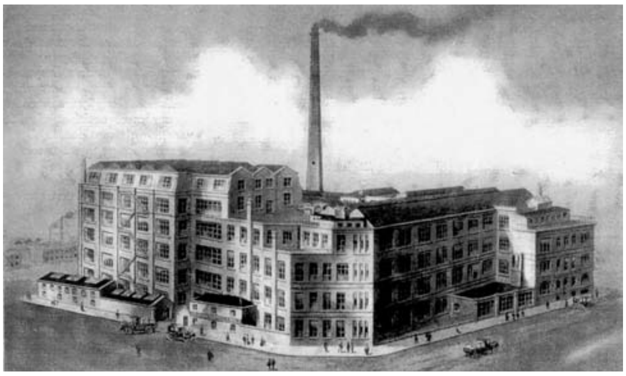
GEC and the Telephone

Bob Estreich and Alan Gall



Peel-Connor factory at Salford (c1890)

'Well-informed people know it is impossible to transmit the voice over wires. Even if it were, it would be of no practical value.' **(Boston Post, 1865)**

The announcement of the telephone's invention by Alexander Graham Bell in 1876 brought forth amazement, delight, and from some, ridicule; while the journal of the Society of Telegraph Engineers was both enthusiastic and cautious:

'… one cannot but be struck at the extreme simplicity of both instruments, [the telephone's transmitter and receiver] so simple indeed that if it were not for the high authority of Sir William Thomson one might be pardoned at entertaining some doubts of their capability of producing such marvellous results.'

Whatever doubts the general public had were soon dispelled. Hot on the heels of invention came commercial exploitation and in Britain the mushrooming empire of the General Electric Company began to embrace the new technology. Keen to make its mark on this industry, as it was in all aspects of applied electrical science, GEC forged ahead to become a major contender in the installation of telephone exchanges. How ironic that the ultimate fate of GEC (renamed Marconi plc) after years of diversification, was to wager its fortune on the telecommunication business – and lose it all.

THE BEGINNINGS

As early as 1861 Johann Philipp Reis demonstrated his invention called the Telephon. It was based on a transmitter where the signal was interrupted rapidly into a series of pulses ('make and break') which could be reconstituted into sound in a receiver. It only worked intermittently and at low levels of sound. Later tests showed that it could have been the first successful telephone, but only with a step-up transformer to boost the signal and keep the circuit open at all times, and with a better receiver. When it worked successfully it was operating as what was afterwards called a 'loose contact' transmitter, rather than a 'make or break'. A Judge in the United States later ruled that it would never have been a workable telephone as invented. On the other hand, there were those who felt that Reis had not received the recognition he deserved. Professor Silvanus P. Thompson stated: 'Nothing shall ever cause me to detract from the merit of this discovery by Bell; only he was not the first…' William Preece, later Sir William, wrote in his 1889 book The Telephone: 'Reis's instrument can and did reproduce articulate speech before Bell ever thought of his telephone' but added '…it is one thing to make a great discovery, and quite another thing to make it commercially useful.'

And so Alexander Graham Bell succeeded where Reis failed. He patented his first telephone in 1876, eventually developing a workable version using a voice-actuated iron diaphragm moving in a magnetic field to generate a signal. His telephone had its weaknesses – it made a reasonable receiver, but it was a poor transmitter. Transmission distance was measured in hundreds of yards. This could be improved with higher voltages, but these caused their own problems. Once Bell proved it could be done, the sudden revival of interest led to a huge number of successful refinements in a very short time. Many of these were invented in parallel in Britain, Europe and the United States. Because of the money to be made in the new industry, most of these inventions were designed to work around the Bell patent.

In 1877 Emile Berliner applied for a patent on a metal-to-metal or metal-to-carbon loose-contact transmitter somewhat like that of Reis, but he also designed an induction coil to wire across it to lift the output signal and maintain the circuit when the contacts were separated by strong voice signals. It worked well, but the American Bell company, who bought the rights to it, delayed the patent for years. They hoped to delay it long enough to get it issued when Bell's patent expired, giving them another 17 years monopoly over the telephone. Bell had meanwhile bought the rights to the Blake transmitter (due to Francis Blake), another loose-contact type. Berliner added an induction coil to this and made other improvements, and the resulting transmitter was put into production for Bell.

From 1877 to the early 1880s Thomas Edison invented a number of transmitter types, but his most successful was one using carbon powder. The American Speaking Telephone Company, owned by the Western Union Telegraph Company, put this into production in opposition to Bell. Legal action followed. In the end, Western Union capitulated and handed over the Edison patent to American Bell, who did nothing with it as they already had the Blake in production.

In the early 1870s Professor David Edward Hughes in Britain designed a 'microphone' using loose contact carbon pencils. He published details in 1878. He never patented the idea, but his notebooks showed that he had developed it some years earlier, based on Reis's work. His carbon pencil microphone became the basis for many practical European transmitters that worked around the Bell patents, such as those by Gower, Crossley and Ader. A thriving telephone construction industry developed in many countries.

In 1878 Henry Hunnings in Britain patented an improved Edison transmitter, which used carbon granules instead of powder. This gave stronger transmission and reduced packing of the carbon in the bottom of the transmitter, a well-known problem that reduced the transmission level. He sold the patent to the United Telephone Company (later the National Telephone Company) who held the Bell patents for Britain. It attracted little interest in the U.S. but the

Bell Telephone Manufacturing Company in Antwerp used the principle to produce a capsule transmitter that could be fitted to a handset.

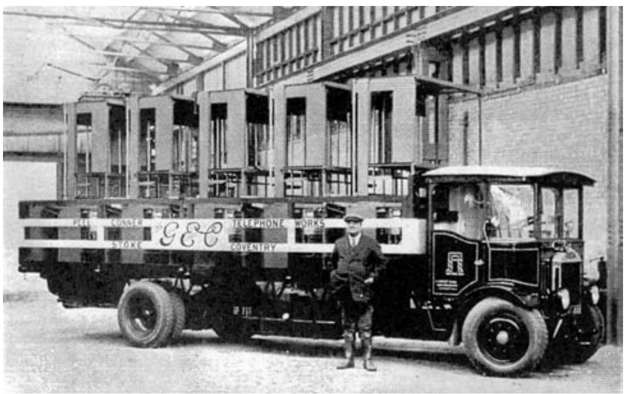
By the 1890s the telephone was accepted technology, if still a little crude, and the industry was thriving. The Bell patents expired during the 1890s and most manufacturers settled on telephones based on a Bell-type electromagnetic receiver and a Hunnings-type carbon granule transmitter. The telephones were still being built for magneto exchanges, where a generator in the phone was used to signal the exchange or other subscribers. A new system called Central Battery was starting to appear, but most development at this time was aimed at larger magneto telephone exchanges and cheaper, more reliable telephone instruments. The parameters of telephone construction had been fairly well sorted out, and precision in manufacture was increasingly important for optimum performance.

THE HISTORY OF GEC

Not so long ago, the name of the General Electric Company would have needed little introduction since its goods pervaded most areas of industrial and domestic life. The early slogan of ‘Everything Electrical’ was certainly no idle boast. Products ranging from light bulbs to kitchen cookers, batteries to power station generators and, of course, telephones, once poured from GEC factories around the country. Rapid expansion began at the turn of the century on the back of lucrative lamp sales, and by the 1930s the company had established 24 works with a total floor area of well over ten million square feet. More was to come under the vigorous leadership of Arnold Weinstock when, in 1967, GEC forced a merger with Associated Electrical Industries, itself encompassing Metropolitan-Vickers, British Thompson Houston, Edison Swan, Siemens Brothers, Hotpoint and W.T.Henley’s Telegraph Works Company. The next year English Electric followed suit, although more amicably, bringing its retinue of acquisitions: Willans & Robinson, Elliott Brothers, The Marconi Company, The Vulcan Foundry, and Dick Kerr.

The official history of GEC gives the birth of the enterprise as 1886 when Gustav Binswanger (later to change his name to Gustav Byng) employed a fellow German immigrant called Hugo Hirst. They had met because Hirst had been lodging at the house of Max Binswanger, Gustav’s brother. The Binswangers’ business operation, based in London, was more complex than the standard history suggests. They did not, as is often stated, set up initially to retail electrical goods but traded in the early 1880s as G.Binswanger & Company, offering a range of merchandise mainly associated with the mechanical engineering of steam generation. In fact, the range of products (asbestos packings, steam & boiler fittings, gauge glasses, lubricators and India Rubber goods) bore a remarkable similarity to those of a Manchester based engineer, inventor and iron merchant called

Delivery vehicle at the Peel-Connor Works, Coventry (c1920)



Charles Leigh Clarke. But the applications of electricity were gathering pace and before long Gustav Binswanger began the procurement and sale of electrical goods. In partnership with James Boyd, he formed the Electric Apparatus Company Ltd in 1884 to continue a business called the Electric Appliance Company that had already been run by Binswanger for a short time at Charing Cross. Separately, and operating from 29 Aldermanbury as G.Binswanger & Co. and The General Electric Apparatus Company, he imported or otherwise acquired electrical items, selling them on to the Electric Apparatus Co. with a 5% mark-up on cost. It was actually in 1884 that Hugo Hirst started working for Binswanger, as a Manager at the EAC. The venture did not make a profit and there was a disagreement between Binswanger and the other directors. On the 8th September 1886 Binswanger ceased to be a director of the EAC, taking Hirst with him, to continue with The General Electric Apparatus Company. The word ‘Apparatus’ was later dropped from the title and the General Electric Company then came into being. Hugo Hirst also started to emerge as the power behind GEC.

With a ‘go-getter’ like Hugo Hirst involved, it was not long before the fledgling GEC started making plans for large-scale manufacturing. Charles Leigh Clarke, previously mentioned and, incidentally, also an investor in the EAC, held a number of patents including one for a successful gas lighter. To exploit these inventions Clarke had helped set up the Patent Electric Gas Igniting Company Ltd at London which changed name to the Electric Portable Battery & Gas Igniting Company Ltd, and then moved to premises at Clegg’s Court, off Chapel Street, Salford. Binswanger had business dealings with the EPBGIC, held some shares, and so when it went broke in 1887 he was well placed to take over the factory and associated patents with the help of a substantial loan from a finance company.

Although it was on the Salford side of the border with neighbouring Manchester, Binswanger & Hirst operated their factory under the name of the ‘Manchester Electric Works Company’. The building stood between a sugar refinery and an engineering works on the banks of the River Irwell, accessed through the entrance to Clegg’s Court. At the three-storey premises there was sufficient space to employ between three hundred and four hundred people. As large as this accommodation was, by the early 1890s it had become a little cramped. However, a move was forced upon the company after a fire swept through the place in 1895, leaving only the offices undamaged.

Not far from Clegg’s Court stood the vacant six-storey Adelphi Mills on Silk Street. This was also near to the Irwell and overlooked Peel Park, a public amenity opened in 1846, named in honour of Robert Peel, founder of the Metropolitan Police Force. There is some evidence to suggest that GEC had acquired this property well before the fire, despite a colourful story later told by Hugo Hirst that the accommodation was found, moved into and operational all within four weeks of the destruction at Clegg’s Court. Peel Works, as the Adelphi Mills was re-christened, remained GEC’s main manufacturing site until large facilities at Birmingham and Coventry were established. As products were moved to new locations, so Peel Works concentrated more on telephone production. In 1905, the Meter Department was moved to a purpose-built factory nearby called Bow Street Works. A planning application of 1904 shows that the intended works could accommodate 140 men but no women. By 1910, when some members of the Salford Technical & Engineering Association organised an outing to Peel Works, the only reported non-telephone related activity there was a small section making stoves, kettles and other heating equipment.

THE FORMATION OF PEEL – CONNER TELEPHONE WORKS

A new chapter in the history of GEC's telephone business started sometime before 1908 with the arrival of American engineer Merritt Scott Conner. There can be no doubt that he was an important figure in subsequent developments. Peel Works became the Peel-Conner Telephone Works and in 1910 M.S.Conner held a sixth of the shares in the newly formed Peel-Conner Telephone Works Ltd, a subsidiary of GEC. In the same year, the meter department at Bow Street Works, at the rear of the main building, was incorporated as Salford Electrical Instruments Ltd. At GEC's annual meeting in July 1910, Gustav Byng reported with satisfaction on the installation of an exchange at Glasgow: '…one of the largest telephone exchanges in the kingdom, every particle, every screw, being made at our Salford Works.'

In spite of this boast, not everything from the Peel-Conner factory originated there.

Their early telephones often used parts imported from other manufacturers, and they then started gradually making their own parts to replace the imported ones. An example is the telephone shown from the 1912 catalogue. It is based on L M Ericsson's famous 'skeletal' model, the first handset phone to go into mass production. It proved very popular, so for some time GEC had been importing complete telephones and rebadging them. Under Conner, they replaced Ericsson's spoked gearwheel with a polished brass one of their own design. The ornate and expensive Ericsson handset was replaced with a simpler version using a Western Electric capsule transmitter that appears to have worked better on the British telephone system. The handset cradle was simplified and the pillar supporting the handset was shortened. The origins of the telephone were still obvious, but it was now a distinctly Peel-Conner version.

Model K88 based on an Ericsson "skeletal" phone, fitted with a GEC handset and cradle by Peel Conner.

GEC continued wholesaling the products of other specialised telephone producers in areas such as marine telephones and the coal mining industry, but it was their mainstream telephone production through Peel-Conner that now showed the greatest growth. Their growing reputation for quality led to many sales in Britain and overseas, with their first full 10,000-line telephone exchange being sold into Glasgow.

The first overseas sales were for 8,000 lines in six new exchanges in the Adelaide area of South Australia.

A typical early all metal "traction" phone for tramways and collieries, the Model K71

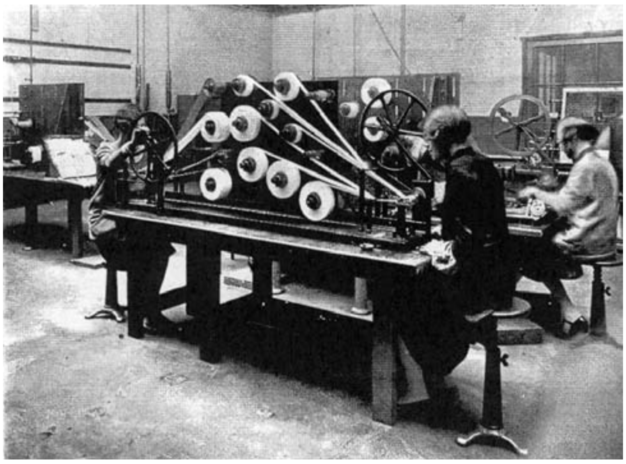
M.S.Conner set to work improving products and processes at the telephone works. A number of patents followed, some twenty applications being made between 1909 and the start of the First World War. Of course, when hostilities broke out it soon became apparent that industry in general had to vastly increase its production capacity and also its ability to respond to new requirements. Telephone production was vital to the war effort – but so were shells for the army's big guns. Apart from turning out trench telephones and trench microphones, Peel Works also developed a method of mass-producing shell casings. According to GEC publicity, the process allowed the production of 20,000 units per week when perfected. Another contribution came from the drawing board of M.S.Conner. Because of the wide use of German magnetos for internal combustion engines, there was naturally a shortage of these devices. Simms Motor Units Ltd, selling magnetos that were made to the design of Robert Bosch of Germany, was the main supplier of British manufactured units to the forces but, presumably, couldn't keep up with demand. Conner designed a suitable magneto, calling on his experience of magnetos for telephones, which fulfilled the requirements of reliability and functionality. The Government subsequently placed an order for 4500 of these. Merritt Conner visited Coventry where he observed that the expansion of the motorcar industry had resulted in a good supply of female workers. On his recommendation, a ten acre plot of land was bought at Stoke, Coventry for the construction of a magneto works to be run as another GEC subsidiary, The Conner Magneto & Ignition Ltd.

Ericsson magneto wall phone, fitted with GEC handset and cradle, GEC Model K8060

The 129,000 square feet at Peel Works was proving insufficient even before the start of the war. To help relieve the situation, cabinet making had been moved to another site, halfway along Adelphi Street, next to the Adelphi Iron Works of Sir James Farmer & Sons Ltd. But once established at Coventry, GEC acquired a further 136 acres at the same location on which to build a new telephone factory. Construction began in 1920 and production moved there in 1921. The Peel Works was now handed over to Salford Electrical Instruments Ltd, the erstwhile GEC meter department that had occupied a small 2-storey building since 1905. Merritt Conner was rewarded for his efforts by a directorship on the main GEC board. He held this position until a fall-out with fellow directors resulted in his departure back to the USA. The Coventry plant continued to be known as the Peel Conner Telephone Works until about 1930 when it changed name to GEC Telephone Works.

K8385, standard British Post Office candlestick

All the magneto business was sold to Simms Motor Units Ltd after Merritt Conner's departure, and the facilities turned over to radio production. Even though Stoke works continued to expand by the addition of numerous extensions, production needs outstripped even these provisions. Eventually, GEC acquired another four sites in Coventry: Helen Street Works, Spon Street Works, Ford Street Works and Queen Victoria Road Works. The combined workforce in Coventry grew to about 10,000 in the early 1950s. At this time, GEC calculated some annual raw material consumption figures for telephone, radio and television production: 2000 ounces of platinum for electrical contacts, 2500 tons of ferrous metals, 1000 tons of non-ferrous metals, 63000 lbs of wool (said to be enough to make 12600 blankets), 44800 lbs of and 17 tons of electroplated zinc. The report also included the fact that 'Enough gas is used to make seven cups of tea for the whole population of the United Kingdom.'



Winding condensers, Peel Conner factory at Coventry 1920s

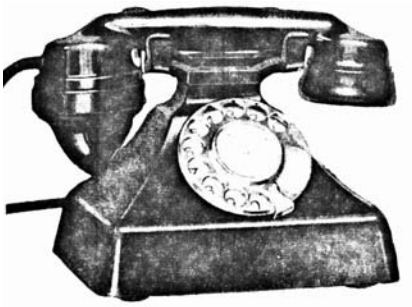
Despite their successes, GEC missed one critical invention – automatic switching of calls. When the British Post Office decided to automate its telephone network after the First World War, they selected the step-by-step system marketed in Britain by British Insulated and Helsby Cables Ltd. Peel-Conner was relegated to producing parts and phones for the BPO system based on telephones designed by Western Electric. As one of Britain's leading manufacturers their share of the contracts was significant, but telephones were no longer a major part of GEC's total output. Production turned to the relays, selectors and switchgear needed for the exchanges. They also began production of dials for the new telephones.

With the introduction of Bakelite moulding in the 1920s, high-pressure presses and Bakelite compounding equipment were installed at the new Coventry factory. Bakelite mouldings were used in so many electrical products that it made sense to put the presses where their output could be fed directly into the production lines. Bakelite telephones became one of GEC's major production lines. In 1921 the Peel-Conner company, now mainly a component producer, was absorbed back into the parent company and its telephone production was rebadged as GEC

THE BAKELITE YEARS

The quality of the GEC telephones remained as high as ever, and they continued as a source of export income for decades to come. In Australia, for instance, the GEC 400-series Bakelite telephones were still being imported in the 1960s before finally being replaced with a locally designed instrument.

The British Post Office standardised on a pyramid-shaped Bakelite telephone, the Tele 162. This had a separate bell set which could be bolted onto the base of the phone or located elsewhere in the house. It was a little clumsy and it was soon redesigned into the Tele 232, a similar looking telephone that overcame some of the 162's problems. GEC's engineers felt that there were still improvements to be made and they designed a telephone they christened the Gecophone. It was more rounded than the angular 232, but featured a one-piece case which included the bell set. It was eventually produced in Black, Chinese Red, Jade Green, Ivory and an attractive mottled 'walnut' finish. The colours were made possible by using a new moulding compound, Urea Formaldehyde, which had a slightly translucent appearance.



Gecophone in black bakelite

Unfortunately the Gecophone was not adopted by the British Post Office or any other large purchasers. It found a market niche on Private Automatic Exchanges sold by the Reliance Telephone Company and with some of the smaller telephone administrations, but was never as successful as it could have been. GEC continued production of the 232 in parallel with the Gecophone.

A weak point in the BPO's 162 and 232 was the 'antler' assembly that held the handset in place at the top of the phone. The antlers were fragile and broke fairly easily under hard treatment. The BPO did not develop a wall equivalent of the 232, preferring to mount a desk phone on a decorative steel wall stand instead. GEC produced a wall equivalent of their Gecophone, called the Muraphone (from the Latin 'mur' for wall). It was a rather shapely design built with rugged use in mind. Again, it was not adopted by the BPO but found a market position in the rental market. It was also used in large numbers by the various railway companies on their own networks, and enjoyed useful export sales.

Muraphone

The British Post Office developed their own phone, the 300 series; the familiar black Bakelite telephone used in thousands between the wars. GEC produced many of these telephones, but once again their engineers felt they could do better. They produced their 1000 series based fairly heavily on an L M Ericsson design. Technically it was similar to the 300, although simpler to build, and its case was softer and more rounded and its handset grip was oval in cross-section rather than the 300's triangular shape. Once again, the BPO stayed with its own design. After World War 2 the Australian Post Office adopted the telephone for their 400 series, but in the end kept the angular 300 case and added the new handset.

POST SECOND WORLD WAR

GEC moved successfully from Bakelite phones through the succession of plastic styles that followed World War 2. Telephone production moved to Aycliffe, Co. Durham in 1963. The BPO 706 telephone once again gave GEC engineers major contracts, and a chance to improve on the design. In 1966 they produced a simpler, more angular version which they called the Sonic 70. Although it had some useful innovations, it was a complete failure in sales. This was effectively GEC's last major product in the telephone area.

Sonic 70 plastic phone.

Advert for BPO 700 Series

Around this time the British electrical industry was going through a series of mergers and rationalisations. GEC's intention was to become large enough to compete against overseas competition, and under new Managing Director Arnold Weinstock this was succeeding. Through the mergers, GEC also found itself the owners of other non-traditional companies such as those involved in shipbuilding and defence.

On Weinstock's retirement in 1996 the company seems to have lost direction. Under the guise of 'focusing on core business strengths', a popular management tool of the time, many of GEC's profitable fringe companies were sold off. It registered a change of name to the Marconi Corporation plc on 2nd March 2000 and concentrated on communications, the Internet and electronics. Then, in a major setback, the company failed to get even a minor share of a huge British Telecom network upgrade contract. Share prices fell and the company was only rescued by bank and shareholder support.

The Internet bubble burst in 2000, and by 2001 the new company's shares had dropped to an all-time low. On Tuesday, October 25, 2005, the company announced that it had sold its business and its name to L M Ericssons.

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Was I a Good Science Teacher or Was I Not?

(Reflecting on my delivery of Earth Science and possible impact of my Teaching to Science Technologists of the Future)

Kevin Fletcher

Background

The selected focus of this article relates to my delivery of Earth Science. By that, I refer to the study of the Weather, the geology of the Earth, and Space. It is a follow up to an earlier article entitled: A CRITICAL APPRAISAL OF MODELS FOR REFLECTING ON SCIENCE TECHNOLOGY TEACHING PRACTICES.

The reflection was prompted by the article Reflecting on practice: some illustrations (Tresman and Edwards 1993) which commented on the positive feedback Earth Science received as a subject by another tutors' students in their reflective diaries. These included the fact that the students appreciated that the geologist who taught them had a far deeper understanding than at the level it was being presented to them and that the success in presenting the material at their level was because of the tutor's much deeper specialist knowledge.

This set me wondering whether the Earth Science I used to deliver was delivered adequately; especially as I am not a specialist and perhaps my students saw that my level of understanding was not much deeper than that at which I was teaching it. Could perhaps my students see right through me and hence the quality of my delivery because it was poorer than it would normally be in my own specialism? (Biology/ Chemistry). Perhaps my "inadequate" teaching put them off science and related subjects and I may have inadvertently contributed to any decline in student numbers.

These are belated thoughts as I am not teaching Earth Sicence at the moment (perhaps some past students are grateful of that fact…) but as a practitioner who still reflects on days gone by, I thought my reflections might be useful to others in a similar field, or those brave souls still engaged in classroom teaching and learning.

My Reflections and Findings

Fensham's (1988) comments about the importance of subject maintenance as an elite field take on new relevance and made me feel even more doubtful of my abilities. I have also become painfully aware of Black's (1992, p3) comments that students' enthusiasm for science declines from a high point of enthusiasm at age 11 to a low level by the end of education (ibid.). Perhaps my abilities, content knowledge and methods contribute something to this decline in the students I had (and to their lack of possible progression to science related subjects) because I did not have a detailed knowledge of the subject, and perhaps it showed! (Although upto now, I have been reasonably content with the status quo!)

Teachers shape the content of science when they teach (Roberts 1988, p27) (and possibly shape the enthusiasm for progression to science related subjects) but it is sometimes difficult to gauge the necessary time for the teaching of the subject because priority is given to the learning of facts and content rather than processes (The Open University, 1994, p 16) so my style of teaching in this topic might well have been termed transmissional and being aware that students "...become better cooks through practise, not reading recipe books..."(ibid.) and that "...successful teaching is a complex activity which requires the teacher to select from the diversity of possible strategies and actions, the ones most appropriate for... existing classroom conditions" (Baird 1988). I feel very doubtful whether I was fully living up to my responsibilities as a teacher in this area, given particularly the process intentions of some science technology courses.

If reflecting on my practice can bring about improvement, then it must be worthwhile exercise, even if it achieves nothing more than reassurance for me. Reflection (self evaluation) may be one way to improve the teaching of science and promote professional development (The Open University 1994, p30). I took comfort in the fact that Soper (1992) recognises that "...reflective practice takes as many forms as those who engage in it" in the hope that "... there is something remaining open to the possibilities afforded by any reasonable new approach to the profession" (Soper 1992). Peers (1993) made me think about the fact that teacher driven approaches (i.e. what I might term transmissional approaches) may conceal, rather than deal, with student's learning problems (ibid.). Mackinnon (1987, p46) recognises that implicit in theories about reflection in practice is that good teaching is an art, that a particular mode of thought will enhance teaching and that this mode of thought depends upon insight. He believes, that a body of scientific knowledge cannot drive practice but what is important is the process of the decision making rather than the decisions themselves (ibid. p47). He also recognises that problems have to be discovered and constructed and that in framing the problem we select the important facets and define the boundaries of what we will consider. Problems need then, first of all, to be framed and then because each problem is unique to the individual considering it, the practitioner must construct personal solutions. Then a period of following through the consequences of the reframed problem occurs and thus the original problem has taken on new, hitherto unconsidered dimensions which themselves require consideration. The whole process moves through "... stages of appreciation, action and re-appreciation..." (ibid.p49).

It may then be worthwhile reflecting on what alternatives were available to me for the teaching of Earth Sciences and whether there were any better techniques. This might have involved visits to other schools or attendance at a training day; although I have already participated in many such events and came away with little gained. It would not seem unreasonable now (although hindsight is a wonderful thing) to have actually asked students to provide feedback so that I would have been able to determine whether they were satisfied with my teaching of Earth Science and what criticisms they had. At the time, that would be a very unsettling exercise, however.

Alternatively the advice of an expert or an independent appraiser may well have given me the feedback I needed but I foresaw some reluctance on my part to undergo appraisal on a topic in which I have little confidence (with any fears of my jobs security that might be raised).

Concluding Comments

In conclusion, having reflected on one particular area of my practice and attempted to reframe the problem areas identified, I may be moving toward, albeit very late, some form of resolve. I am still doubtful whether I have reflected or merely rationalized because there are certainly areas of rationalization within reflection and there are practical problems with some of the solutions and this may be seen as rationalisation for the techniques that I did employ. There is evidence, however, of reframing, a shift to a more student-centred perspective, a change in what should have been attempted (or, in this case, what could have been attempted) and the drawing on personal experience. It certainly feels like I can view these concerns from a number of different perspectives now and see what a possible resolve might have been from each perspective. I can certainly see the cyclic and spiralling nature of the reflective process as it is difficult to find a suitable cut-off point for this review.

I now realise that my transmissional approach may have concealed rather than dealt with my uncertainties, a little late perhaps but still useful for me to reflect on my practice and share what I have learned with those still out there (and hopefully to have some positive impact on teaching the science technologists of the future).

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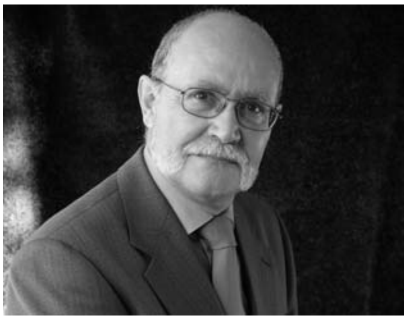
Hand Soldering for Electronics

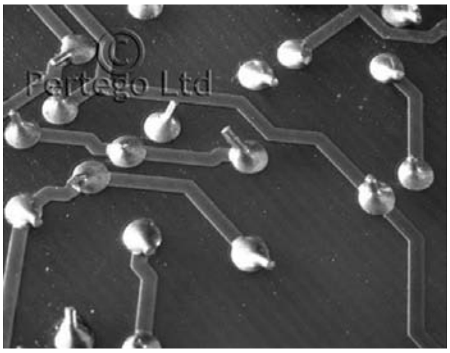
Eric Dawson

With 35 years' experience in the electronics production industry and a degree in Materials Science from Bath University, Eric Dawson set up Pertego Ltd 18 months ago to offer training and consultancy to the industry. His wife and fellow Pertego Director, Elizabeth, offers Management and Life Skills training.

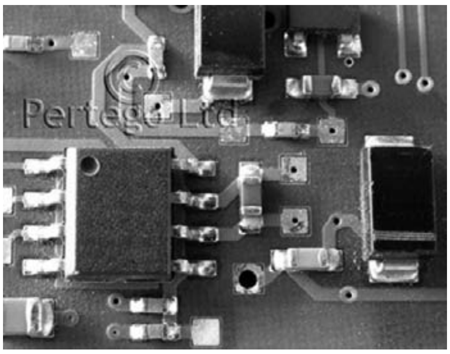


Introduction

The soldering process is used to make a mechanical and electrical joint between two or more conductors. Usually, these are a component wire and a hole in a printed circuit board or a lead or metallised termination of a surface mount device and its associated land on the circuit board. The land is also known as a pad or footprint.



Typical through-hole solder joints



Typical surface mount solder joints

The parts to be soldered -wires, leads, terminations and lands - are made of metals that will bond with the solder alloys used to form acceptable solder joints.

Electronics grade solder melts at temperatures between 179°C and 290°C depending upon the alloy and the application. For the purposes of this instruction we will consider two types of solder:

- Containing lead and melting between 179 and 183°C
- Containing no lead and melting between 216 and 220°C

We also need flux, which is essential to the soldering process to clean the surfaces and help heat transfer. Usually this is contained within the solder wire as continuous cores or pipes, much like the name of a seaside resort in a stick of rock. In fact, they are both made using a similar process.

Photograph supplied by Multicore, a division of Henkel

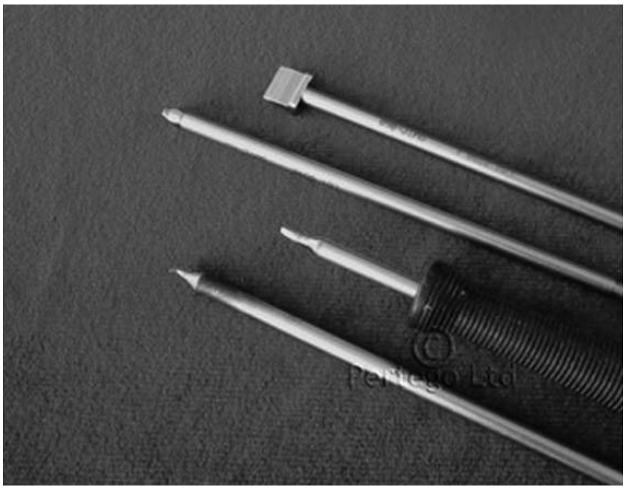
Flux is placed in solder wire by the same process as seaside rock. The process is called "extrusion".

Soldering equipment

A typical good quality soldering iron for the electronics industry consists of:

- Power supply and mains cable
- Handle and lead
- Interchangeable range of tips
- hand-piece stand plus damp sponge

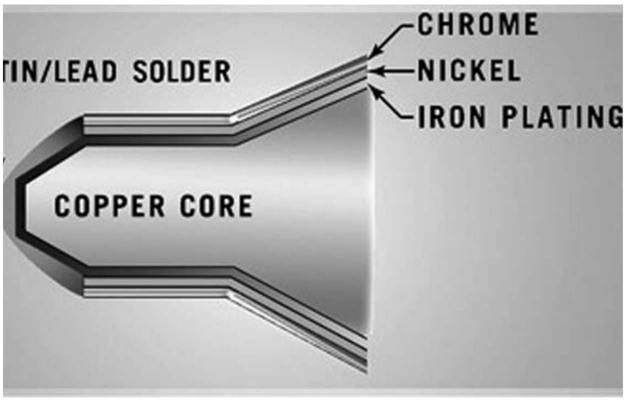
A typical professional soldering system with interchangeable tips



Hook, small chisel, small and large wedge tips

Health and safety issues include checking the condition of the mains power lead so that there is no possibility of coming into contact with mains voltage and being aware that the tip is hot enough to burn human skin. This may not be fatal but is certainly painful. Follow your company's instructions on Health and Safety.

Modern tips are rather sophisticated to provide excellent soldering and long life. A system of tip care is essential to take advantage of the design.



A typical, modern tip construction

Copper is used as the core because is has excellent heat conduction which ensures that heat taken from the end by the cooler work piece is quickly replaced by the heating element. However, if the copper were to be exposed to the solder it would be eroded by the constant dissolving of copper into the molten solder and would soon be worn away. (This easy alloying or dissolving of copper into tin solder is the very action that allows us to make good solder joints on electronic components; however we don't want to destroy our tips).

Iron is easily wetted by solder but doesn't dissolve into it very quickly so it is used as the coating on the end of the tip. Its thermal conduction is not as good as that of copper so it is only present in a thin layer.

The chromium layer is there to limit the flow of molten solder along the tip. Molten solder will tend to travel to the hottest part of the tip. Since this is where the heating element is situated, if there was nothing to stop it, it would all flow away from the end towards the hotter element and not be available to the work piece. Chromium is not wetted by solder and so limits its travel.

Solders

Solders for the electronics industry are generally based on tin. The addition of 37% lead to tin produces an alloy that has a melting point lower than either of the individual metals. This caused by a metallurgical reaction and need not concern us here. Other metals such as silver, copper and nickel may be added to produce alloys with various properties and melting points.

A brief list would include:

Alloy Melting point or range, °C
1. 63% tin, 37% lead 183
2. 60% tin, 40% lead 183 to 187
3. 62% tin, 36% lead, 2% silver 179 to 185
4. 96% tin, 4% silver 221
5. 4% tin, 96% lead 290 to 296
6. 99% tin, 1% copper 222 to 226
7. 96% tin, 3% silver, 1% copper 217 to 220

The first two have been industry standards for over 60 years and are well known and understood.

Number three, with two percent silver, gained popularity in the early days of surface mount technology to reduce the effect of leaching of capacitor and resistor terminations. Leaching is the process whereby metal is dissolved into the molten solder from the substrate material. If too much of this happens on a coated surface of a component, it can go all the way through the coating and leave no termination on the component. With the introduction of nickel barrier terminations the added silver is not really justified any longer but the flow characteristics of the alloy are known and it has a slightly better fatigue resistance than 63:37, so its use has continued.

Alloy 4 has been around for a long time and is used where a stronger solder is needed and the higher melting point is acceptable.

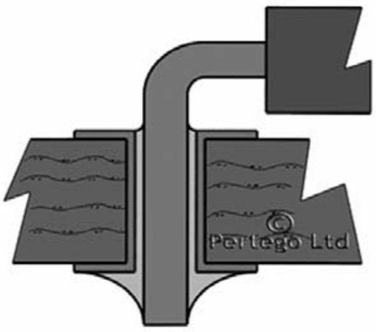
The fifth solder is known as high melting point or HMP alloy. It is used where "cascade" soldering is appropriate. E.g. within a module that will be subsequently soldered at normal assembly temperatures but we don't want the original, internal joints to be disturbed.

To put the temperatures into context, here are a few other significant figures:

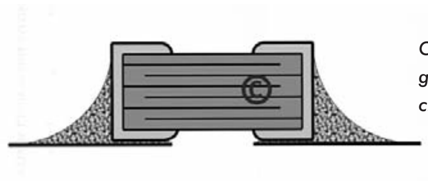
- Pure tin melts at 232°C
- Pure lead melts at 327°C
- Ice melts at 0°C
- Water boils at 100°C
- The human body operates at 37°C
- We are comfortable between 16 and 30°C
- A surface feels uncomfortably hot at 60°C
- Soldering iron tips are run between 315 and 400°C
- Surfaces start to glow red at 600°C
- The Sun's outer atmosphere temperature is about 10,000,000°C

Solder wire is supplied in a range of diameters, usually from 0.3mm to 0.7mm. The choice of which to use will depend upon the size of the joint to be produced.

When soldering a wire-in-hole joint, i.e. conventional leaded devices, the solder diameter should be approximately the same as the lead diameter. This allows a short length of the solder wire to be fed into the joint as it is formed, thus controlling the shape of the joint as it is made. As the solderer, we watch the formation of the joint and should then end up with a joint that looks like:



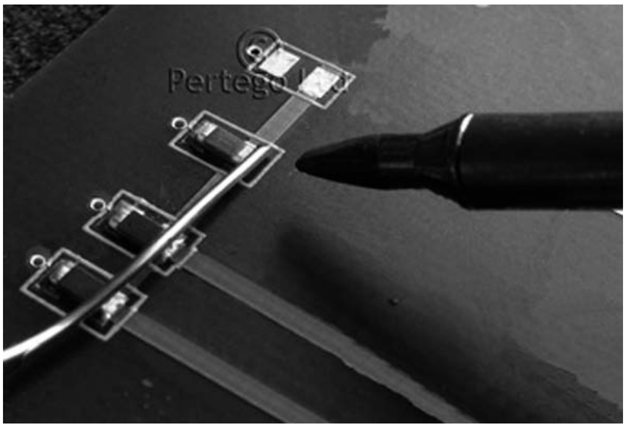
Cross section diagram of a good through-hole plated joint



Cross section through good solder joints on a chip capacitor

Fine surface mount joints are often too small to allow this observation of the progress of the joint, in which case we have to judge the amount to apply, using experience, before we start the process. If we wait to see how much solder is being added we will probably add too much.

One way of doing this is to lay the appropriate diameter wire into the corner formed between the component termination and the board land then place the clean, hot tip onto the solder. As the wire melts we remove it but dwell with the iron tip for another, say, second to allow the joint to be formed. See picture below: The solder wire is placed in the corner between the component and the pad, waiting for the soldering iron to be applied



Flux

An essential part of the process is the use of flux. Without this ingredient we will not make a solder joint.

Flux may be made from natural pine tree rosin or synthesised from basic chemicals. It may be thinned using alcohol or water, depending upon the type concerned. Health and safety aspects of liquid, solid or gel flux involve:

- preventing excess contact with the skin because the skin's natural oils and greases can be removed
- avoiding ingestion
- not breathing the fumes produced during the soldering process itself.

There are various ways of avoiding breathing these fumes and they usually involve some kind of extraction either as a small bore tube mounted on the iron tip/handle or as a larger piece of ducting that can be positioned near to the work-piece. Follow your company's instructions.

All metals used in electronics, with the exception of gold, are covered with a thin layer of oxide. These oxides are very stable compounds made from the atoms of the metal itself and oxygen from the surrounding atmosphere. Solder, itself covered by its own oxide layer, will not form a joint with any metal oxide and therefore these coatings must be removed. Mechanical brushing will remove oxide but it is instantly formed behind the brush/cutter to replace the original coating.

The form of the flux may vary from thick and sticky resins contained within the wire to solutions of the chemical in water or alcohol. They all have the same jobs to do; chemically remove the metal oxides, protect the forming joint from further oxidation and help to transfer heat from the tip to the joint.

Modern, no-clean fluxes are designed to aid wetting of the solder on the wires, terminations, lands etc. and then to be neutralised by the heat. The flux residues are then considered safe enough to leave on most assemblies with no fear of subsequent corrosion. High reliability assemblies or those that are to be conformally coated are usually cleaned after manufacture to remove these residues.

For the majority of new solder joints on clean components and circuit boards the flux cores within the solder wire will be sufficient to form a good fillet. The use of additional flux should be discouraged unless there is a real need. If you are using a no-clean process excess flux residue will appear unsightly and because some of it will not have been heated by the iron it will still be chemically active. This active residue could lead to later corrosion. If your product needs cleaning, it will just be an added burden to remove the pool of flux.

However, there are times when additional flux is necessary, such as reflowing joints during rework or if you are trying to solder an old, degraded component. In this case use additional flux in the form of liquid from a dispenser or gel from a syringe. Make sure you are permitted to use it by your company local instruction and that it is chemically compatible with any other flux present. Clean locally with solvent and lint-free wipes.

Choosing a suitable tip

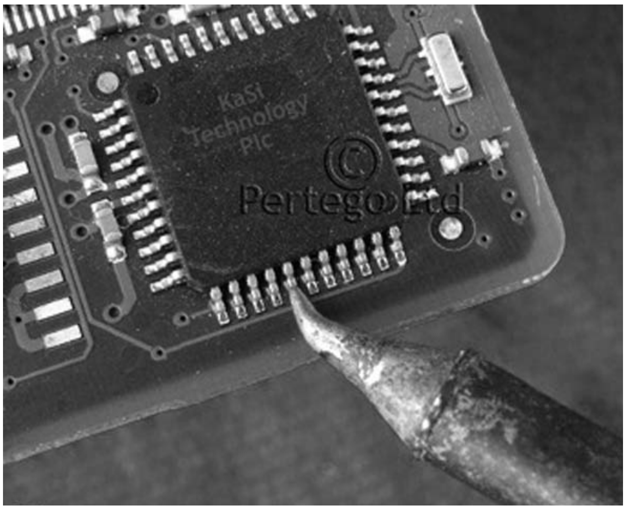
As with the diameter of the solder wire, we need to choose the correct shape and size of the tip for the job.

The shape of the tip will be governed by access to the joint. For most solder joints made on leaded components, the chisel tip could be the first choice.

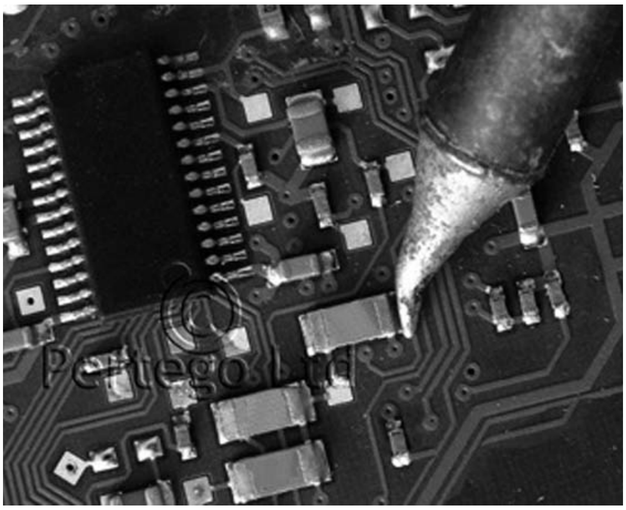
Both sides of a chisel tip are the same so either may be used. The angle of the chisel end allows a natural contact to be made to both component wire and land simultaneously. It has enough mass to provide a suitable amount of heat to the joint.

For discrete surface mount components, either the chisel tip or a hook tip are suitable.

The pointed end of the hook tip may be used to access small joints and its outside curved surface may be used against the side of a termination to transfer more heat than is available from the pointed end.



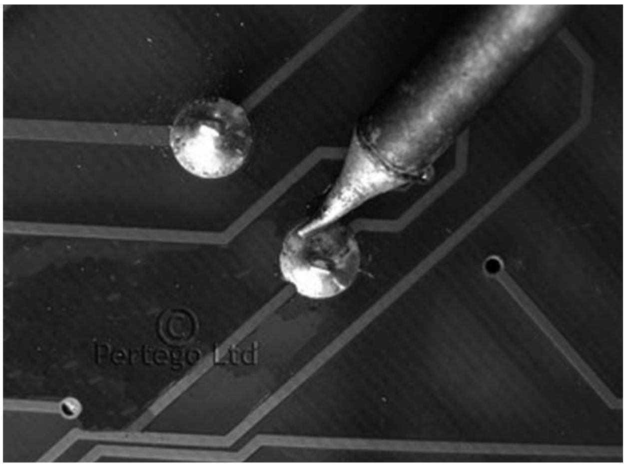
Using the pointed end of a hook tip



The size of the tip will be governed by the size of the wire or land to be soldered. Too small and heat transfer will be poor, leading to excess soldering times and operator frustration. Dwelling too long, even if the soldering temperature has not been attained, can lead to local damage of the board or component.

If the tip is too large there may be a tendency to cause heat and stress damage to adjacent components, tracking or the board surface.

Tip too large and can damage adjacent board surface



Tip too small. Provides insufficient heat transfer to make a good joint

The final choice of tip will also be controlled by the experience and opinion of the operator and the range of tips actually available on the shop floor.

The sponge

On every solder station there should be found a sponge for cleaning the tip. This sponge should be clean, free of metal debris, flux and other contaminants. It must also be kept moist with clean distilled or de-ionised water. It does not need to be soaked. When the hot tip is wiped across the surface of the damp sponge a couple of times old solder, dross and flux deposits are removed leaving the tip ready to be used. The moisture in the sponge will boil instantly because the tip temperature is about 350-400°C, This gives added energy to the tip cleaning process. If the tip is too wet, heat is wasted in boiling off the excess water and the tip will be cooled unnecessarily.

Make sure that the sponge is only used to clean hot soldering iron tips. Other contaminants may damage the tip, reduce the solderability or become a health hazard. A hot tip on a sponge that has been contaminated by super glue will cause particularly unpleasant fumes to be released. These fumes are toxic and must not be breathed by the operator.

The soldering method:

1. Choose tip and solder wire diameter
2. Allow iron to reach soldering temperature
3. Arrange the work piece so that is held securely and you have a comfortable angle to apply the iron and the solder

4. Wipe the hot tip on the damp sponge to clean off old solder etc.
5. Apply fresh solder to the tip to cover it (called "tinning the tip")
6. Contact both surfaces to be soldered together with the tip using a light,controlled pressure.
7. Feed solder onto the interface of the tip and one of the surfaces
8. As the solder melts and flows onto the joint area move the solder wire so that it is being fed into the joint itself, not the soldering iron tip.
9. Observe the formation of the joint and when there is sufficient solder, remove the wire
10. Dwell with the iron for another, say, second to allow full flow of the solder.
11. Remove the tip briskly, making sure that molten solder is not "flicked" outwards.
12. Continue with subsequent joints if appropriate
13. Wipe the tip on the sponge
14. Tin the tip
15. Replace the tip/handle in the appropriate stand

Do:

- clean and tin the tip before putting it back in its stand. This will protect the iron on the tip from oxidation from the atmosphere and prolong its life. The coating of solder acts as a sacrificial protection for the tip; atmospheric oxygen acts on the solder not the tip metal. This solder and its oxide layer is then removed when the tip is next cleaned prior to making a new joint
- switch off the iron when not in use, e.g. at tea breaks. This will save energy and prolong the life of the tip
- keep the sponge clean. Renew it regularly.

Do Not:

- use dirty or contaminated tools or consumables
- use the tip as a screwdriver or chisel. (A chisel tip is so called only because it looks like a chisel. It will not break up concrete!)
- transfer solder. That is, apply solder to the tip then transfer it to the joint. By the time the tip gets to the joint, the flux will be neutralised and will not allow the formation of a reliable solder fillet. (The advanced technique of 'drag soldering" uses transfer of solder from the tip, but under carefully controlled conditions.)
- keep on retouching a joint to reform it. The flux will be ineffective and repeated touching of the joint will make matters worse. If necessary, start again from point 4 of the method
- use a hot iron as a pointer in a conversation
- eat or drink after handling solder until you have washed your hands.

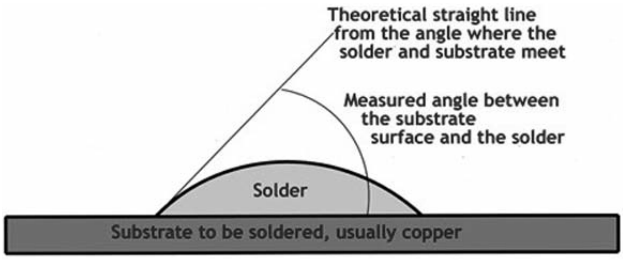
Solder joint requirements

Different joint geometries have their own quality requirements, such as fill of a through plated hole and solder climb up the termination of a chip capacitor. These requirements can be found in the appropriate documents as used by individual companies.

Some required properties are, however, universal and these are:

- low wetting or contact angles, (i.e. less than 90° on all surfaces to be joined. 90o is also known as a right angle).
- complete coverage of the solderable surfaces, including the insides of through plated holes.
- no pin holes or blow holes
- no damage to components or substrates
- no excess solder leading to bridges, spikes etc.

A wetting or contact angle is the angle that is formed between the surface being soldered and the edge of the solder. It can be estimated by imagining a straight line drawn out from the point where the two metals make contact and then estimating the angle that this line makes with the underlying flat surface.



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Note: Since this article was written Eric has now retired and Pertego Ltd no longer exists. Ed.

REACH

REGISTRATION, EVALUATION AND AUTHORISATION OF CHEMICALS

REACH – What is it all about?

It's not often that the introduction of new legislation covering chemicals makes the national press but this is what happened last year! But there has also been misinformation and scare-mongering. So what are the facts and what are the implications?

The REACH Regulation1, which came into force on 1 June 2007, covers Registration, Evaluation and Authorisation of Chemicals. (Interestingly, the REACH acronym is used by all 27 Member States of the European Union although, obviously, the meaning, when translated, doesn't fit.) It is European legislation and applies to all Member States of the EU without having to be incorporated into national legislation. It will ultimately replace 40 pieces of legislation across Europe.

Why was it thought to be necessary?

The majority of chemicals on the European market today are not safety tested. In 1979, the EU adopted legislation that required stringent safety testing of all chemicals that are being brought to the market for the first time – so-called "new" chemicals. All chemicals that were registered up to September 1981 have been exempt from safety testing ever since. These are known as "existing" chemicals, and there are around 70,000 of them on the market today. More than 90% by volume of all chemicals on the market are so-called "existing" chemicals.

Aims of REACH

- To provide a high level of protection of human health and the environment from the use of chemicals.
- To allow the free movement of substances on the EU market.
- To make the people who place chemicals on the market (manufacturers and importers) responsible for understanding and managing the risks associated with their use.
- To promote the use of alternative methods for the assessment of the hazardous properties of substances.
- To enhance innovation in and the competitiveness of the EU chemicals industry

The basic components of the REACH process are:

- A single **pre-registration phase** to enable basic information to be submitted between 1 June 2008 and 30 November 2008.
- **Registration** on a central database of all substances which any individual company manufactures or imports into the EU in quantities greater than 1 tonne per year. There are special arrangements to phase in registration for pre-registered substances currently manufactured or on the market, based on tonnage.

  Manufacturers/Importers will be required to register all substances on 1 June 2008 unless they intend to pre-register them.
- **Evaluation** of substances which may pose a risk to human health or the environment.
- **Authorisation** for substances of high concern. All other non-authorised uses of authorisable chemicals will be prohibited.
- **Restrictions** on marketing and use of substances where the risks to human health and the environment are deemed to be unacceptable.

What is different about REACH?

- Under REACH, the burden of proof for demonstrating the safe use of chemicals is transferred from Member States' authorities to industry to ensure that risks to human health and environment are avoided or adequately controlled.
- Registration will require a Technical Dossier which will include all the uses of the substance that have been communicated to the registrant.
- A new type of environmental hazard classification is introduced. A substance may now be classified as Persistent, Bioaccumulative and Toxic (PBT) or very Persistent and very Bioaccumulative (vPvB). Criteria, based on ecotoxicological data, have been set and some substances have already been assessed and classified.
- A new agency is being set up to manage REACH. The European Chemicals Agency (ECHA)2, based in Helsinki, will start to receive Registrations from 1 June 2008.
- Each Member State is responsible for appointing a 'Competent Authority' to manage the domestic aspects of REACH. In the UK, the Competent Authority is the Health and Safety Executive, working with the Environment Agency and other government departments.
- Each Member State is required to set up a 'help desk' to provide advice and guidance. In the UK, this is provided by the HSE.3
- Lines of communication are to be improved between manufacturers/importers and downstream users (suppliers, distributors, customers and end-point users). Information will also be available for the general public.
- The format for Safety Data Sheets has been amended slightly and, as Registrations are made, more information will be available for inclusion in the Safety Data Sheet. Eventually, for some substances, extended Safety Data Sheets will be provided. Each eSDS will contain an annex which describes Exposure Scenarios for all the registered uses of the material and the Risk Management Measures deemed to be most suitable.

Which chemicals are affected?

REACH covers both "new" and "existing" substances. All chemicals produced or imported into the EU in quantities above 1 tonne per year will be registered in a central database. Chemicals deemed to be of most concern will need authorisation. This will require industry, etc. to gain specific permission for particular uses which have been demonstrated to be safe. Other uses will be prohibited.

Which chemicals/substances are not affected?

Some are specifically excluded:

- Radioactive substances
- Substances under customs supervision
- The transport of substances
- Non-isolated intermediates
- Waste
- Some naturally occurring low-hazard substances

Some, covered by more specific legislation, have tailored provisions, including:

- Human and veterinary medicines
- Food and foodstuff additives
- Plant protection products and biocides
- Isolated intermediates
- Substances used for research and development (i.e. in any scientific experimentation, analysis or chemical research carried out under controlled conditions in a volume less than 1 tonne per year)

Research and development activities under REACH

Product and process oriented research and development (PPORD) is defined as any scientific development related to product development or the further development of a substance, on its own, in preparations or in articles in the course of which pilot plant or production trials are used to develop the production process and/or to test the fields of application of the substance.

When performing research with a substance, it is not only important to check whether it is included in REACH Annex XVII (list of substances subject to restriction) or Annex XIV (list of substances subject to authorisation) but also to identify whether the substance might have properties of very high concern (e.g. being persistent, bioaccumulative and toxic) as those substances might be in the future subject to authorisation.

Guidance is available on specific provisions under REACH for substances manufactured, imported or used in Scientific Research and Development (SR&D) and Product and Process Oriented Research and Development (PPORD)4.

Who will be affected?

- Manufacturers of substances within the EU and importers who bring into the EU single substances or products containing single substances in quantities greater than 1 tonne per calendar year. This includes importers of substances from Switzerland and other non-EU European countries.
- Downstream Users who need to
- Identify all substances bought in to the organisation, together with suppliers and countries of origin.
- Inform their European manufacturer/importer/supplier of the use of the substance and the way in which it is used.
- Assist the manufacturer/importer in production of Exposure Scenarios and Risk Management Measures.
- Receive information about recommended uses and methods of use from manufacturer/importer, including Safety Data Sheets, and pass this to other people in the supply chain, e.g. customers, employees.

In addition, users of substances should ascertain their suppliers' intentions about registration and the continued supply or availability of a substance. If a substance is unlikely to be registered, time, effort and resources are required to find an alternative.

How will REACH be enforced?

There are three broad areas for REACH compliance:

- Registration
- Supply chain
- End use

In the UK, bodies that already enforce health and safety in the workplace, environmental protection, consumer protection and environmental health will continue to act within the scope of their existing functions.5

Penalties for breaches of REACH are due to be set by each Member State by 1st December 2008.

What information and guidance is available?

The phase-in procedure for registration means that safety information will gradually become available from June 2008 until the end of 2018. High Production Volume substances and CMRs (carcinogens, mutagens and reprotoxics) will be dealt with first. This means that the information supplied in Safety Data Sheets will continue to evolve and grow. Therefore, it is important to ensure that up-to-date Safety Data Sheets are available for substances and preparations.

Guidance for those involved in registration and the creation of extended Safety Data Sheets, as well as the enforcing authorities, is still being developed through REACH Implementation Projects managed by the European Chemicals Bureau6.

And finally

REACH is said to be the most significant piece of legislation affecting supply and use of chemicals for more than 20 years. It is the most complex Regulation produced by the European Union and the political will is there to ensure that it is a success. During the next three years, there will be another major Regulation concerning chemicals and that will affect us all. It is the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) – but that is another story.

Footnotes

1 REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

2 European Chemicals Agency - http://ec.europa.eu/echa/home_en.html

3 Tel: 0845 408 9575, E-mail: UKREACHCA@hse.gsi.gov.uk
Post: UK REACH CA Helpdesk, 2.3 Redgrave Court, Bootle, Merseyside, L20 7HS

4 Guidance on Scientific Research and Development (SR&D) and Product and Process Oriented Research and Development (PPORD) published by ECHA June 2007. Available at http://reach.jrc.it/docs/guidance_document/ppord_en.pdf

5 The Health and Safety Executive (HSE), in Great Britain
The Health and Safety Executive of Northern Ireland (HSENI)
The Environment Agency (EA) in England and Wales
The Scottish Environment Protection Agency (SEPA)
The Northern Ireland Environment and Heritage Service (EHSNI)
Local Authorities

6 European Chemicals Bureau, http://ecb.jrc.it/reach/rip/

Environmental Science Ltd
www.esldatasheets.com
01354 653222

A method to determine the effect of dehydration on agar plates and microbial recovery

Tim Sandle[1]

Introduction

Monitoring the cleanliness of laboratory laminar airflow cabinets and cleanrooms is an important step for any laboratory which requires a 'clean zone' (that is an area with a low level of microbial contamination). One of the most common, an inexpensive, ways to assess this is the use of settle plates. Settle plates typically consist of Petri dishes filled with a culture medium, such as a general purpose medium like tryptone soya agar (TSA) or nutritive agar. The amount of culture media in different settle plates varies is typically between 20 - 30 ml of culture media per 9cm plate.

Settle plates exposed in clean rooms and clean areas are typically done so for periods of up to four hours. The maximum time of four hours is recommended by the European Medicines Inspectorate. The main source of error arising from the use of settle plates is a failure to understand the effect of weight loss as the plate looses water. Too great a rate of dehydration will reduce the growth promoting properties of the culture media leading to a failure of a plate to grow micro-organisms which will lead to a 'false negative' in that a plate may indicate 'no growth' when in fact the clean area contained unacceptable levels of micro-organisms.

This paper summarises a study that was undertaken to assess the weight loss of settle plates and one which could, potentially, be replicated by other laboratories.

The use of Settle Plates

Settle plates are Petri-dishes, typically of either 9cm or 14cm diameter, containing different fill volumes of agar (normally between 20 and 30 mL). Agar is a polymer made up of subunits of the sugar galactose, and is a component of the cell walls of several species of red algae (Class Rhodophyceae, of which the species Gelidium is the preferred choice of agar manufacturers) that are usually harvested in eastern Asia and California. Laboratory agar has a gelatinous appearance and the gel is maintained at room temperature. Agar is typically used in a final concentration of 1-2% for solidifying culture media, although different agars have different gel strengths. Agar has traditionally been used to grow bacteria rather than gelatine because the majority of bacteria will not degrade the agar as would be the case with gelatine based media. Specifications for bacteriological grade agar include good clarity, controlled gelation temperature, controlled melting temperature, good diffusion characteristics, absence of toxic bacterial inhibitors and relative absence of metabolically useful minerals and compounds. The most common type of agar used in industry is tryptone (or tryptic) soya agar (TSA). TSA is a medium which contains enzymatic digests of casein and soybean meal, which provides amino acids and other nitrogenous substances making it a nutritious medium for a variety of organisms. To this dextrose is added to provide the energy source and sodium chloride to maintain the osmotic equilibrium, whilst dipotassium phosphate acts as buffer to maintain pH. These ingredients are added to agar which acts as the gelling agent.

Settle plates are commonly used to monitor the air quality in cleanrooms and clean zoned. The plates are designed to detect any viable micro-organisms that may directly settle onto a surface (that is micro-organisms that are carried in the air-stream, although a person who leans over a plate can also potentially deposit micro-organisms). At determined monitoring locations (ideally positioned and exposed either side of the main activity in the room or laminar cabinet) the lids of the dishes are removed and the plates are exposed to the air for a defined period of time. In theory, micro-organisms and particles containing micro-organisms settle out of the air under gravity, and are deposited onto horizontally positioned agar plates. This theoretically works better in turbulent or laminar airflows. The efficiency can be described as the 'settling rate'.

The settling rate depends partly on the characteristics of the particles and on the air-flows. Larger particles will tend to settle faster (due to gravitational effects) and settling is facilitated by still air-flows (which should not occur within a correctly designed uni-directional air-flow zone). Smaller particles have a lower tendency to settle due to sir resistance and air currents. The principle behind settle plates is that most micro-organisms in air are in association with particles. Generally the 'complete particle' (micro-organism in association with the 'carrier') is 12mm diameter or larger (see Whyte, 1986). Outside of uni-directional air, such as a cleanroom, the greater the degree of turbulence there is. The amount of air turbulence is proportional to the amount of time that particles remain suspended in the air. Thereby, the greater the amount of air turbulence then the longer the particles will remain suspended in the air. This can influence the reliability of the settle plate and some microbiologists will opt to use active air-samplers to provide additional assurance when assessing the cleanroom cleanliness.

The phenomenon of gravitational settling is, however, a debatable issue. The prevailing view, as discussed above, is that as most micro-organisms are associated with physical particles they will be large enough to settle out of the air due to gravity (refer, again, to Whyte, 1986). The dissenting view is that micro-organism carrying

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particles or any micro-organisms not associated with particles as being light enough to remain in the air-stream for several minutes and possibly be carried out of the air-stream and not settle (see Sykes, 1970). Much of this debate thereby centres on the size of the particles in the air and the airflow.

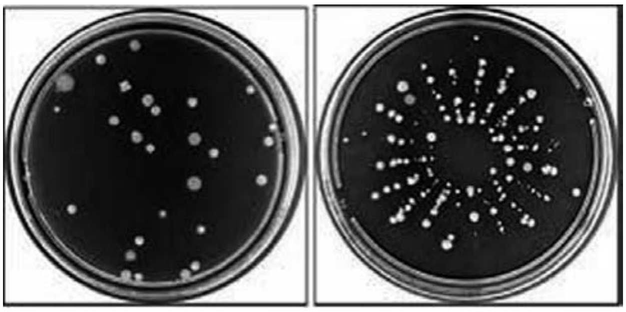
The results from settle plates can either be simply assessed as the number of micro-organisms per plate or in a semi-quantitative way by calculating the number of micro-organisms settling per four hours. For example, guidelines such as EU GMP express alert and action levels as cfu (colony forming unit) per four hours.

Where settle plates provide semi-quantitative data this is not fully quantitative data because the information from the plate does not quantitatively relate to the level of contamination per unit volume of air (unlike the information obtained from an active air-sampler). However, as the surface area of the Petri-dish and the exposure time are known, the number of contaminants likely to settle in the air-stream can be calculated.

A further issue for the interpretation of settle plate data is with the actual 'value' of 1 cfu on a settle plate. The single colony forming unit could be the representation of one micro-organism or several hundred micro-organisms that were carried on a skin unit. Such uncertainty restricts the interpretative value of the settle plate.

Study to examine the effect of weight loss

As settle plates are exposed over time they undergo a loss of weight due to desiccation. The degree of weight loss varies depending upon the environment in which the plate is exposed. The weight loss tends to be greater when plates are exposed under a laminar airflow or uni-directional air-flow cabinet. The process of desiccation can be considered of in terms of total water loss or by reduced access to moisture due to the formation of a 'skin layer' onto the agar surface. The purpose of any validation assessment will be to show that the plates retain the ability to support growth after the maximum exposure time (which, as indicated above, is a four hour exposure).



When designing a validation test protocol to examine the impact of weight loss there are a number of factors to consider. These include:

a) The type of culture media;

b) The use of neutralisers in the culture media may or may not be a factor depending on the application of the plates;

c) The location of the plates (time and space parameters);

d) The hydration state of the media and the impact of this upon the rate of dessication;

e) The metabolic and physical state of any micro-organism that may be deposited onto the plate surface;

f) The length of the exposure time;

g) The environment used (for example, exposure under a uni-directional air-flow unit).

There are also different approaches to take when designing when and how settle plates will be assessed. These are captured in the three options below.

Option 1:

Should plates be exposed first and then inoculated with a micro-organism to demonstrate that a plate retains the ability to support growth?

The disadvantage with this approach is that:

1) Additional moisture could be available from the culture medium which could skew the obtained result;
2) The use of laboratory prepared strains are not representative of the environmental flora. The use of environmental isolates may provide a greater degree of robustness because they will have adapted to have survived in adverse environmental conditions. However, once environmental isolates have been cultured in the laboratory they arguably become laboratory cultures and phenotypically different from environmental flora.

However, it can also be considered that exposing plates and inoculating them after four hours was a greater challenge because a micro-organism was more likely to be deposited onto the surface of a settle plate during exposure rather than at the start of the exposure time. Furthermore, at the end of four hours the plates had undergone maximum weight loss, whereas inoculating the plates at the start of the incubation could have resulted in micro-organisms being carried from the surface with moisture loss (because the microbial population applied would be as a suspension), which would not have been an accurate challenge.

Option 2:

Should settle plates be inoculated with a micro-organism and then exposed?

The disadvantage with this approach is that:

1) This approach does not assess the ability of the plate to recover micro-organism at the end of the exposure time.

Option 3:

Should plates be exposed first, then incubated for the maximum incubation time, and then inoculated with a micro-organism to assess growth?

1) This is a variation of Option 1, and although of interest it has too many variables to give meaningful data. Here, is this an examination of settle plate exposure or of incubation time?

Example study

The paper at this point summarises a study that was taken at the author's own establishment. The approach was based on the first option.. The study was carried out using TSA settle plates with a 25 mL fill.

The micro-organisms used in the study were:

1. Bacillus subtilits (ATCC 6633)
2. Candida albicans (ATCC 10231)
3. Staphylococcus aureus (ATCC 6538)
4. Escherichia coli (ATCC 8739)*
5. Aspergillus niger (ATCC 16404)
6. Pseudomonas aeruginosa (ATCC 9027)
7. Environmental isolate – Staphylococcus epidermidis.
8. Environmental isolate – Ralstonia pickettii.

The ATCC reference refers to micro-organisms which were taken from the American Type Culture Collection, which is an internationally recognised depository for micro-organisms. The environmental isolates were isolated from cleanrooms in a manufacturing facility. They were added to the study to show that exposed plates could also recover micro-organisms exposed to the environmental conditions.

The first part of the experiment was to measure the weight loss. Under a laminar airflow cabinet four plates were exposed in the following approximate locations:

A		B
	UDAF	
C		D

The exposure time from one such plate was:

i. Exposed: 07:40

ii. Collected: 11:40

The calculated means in the table have been rounded down to two decimal places.

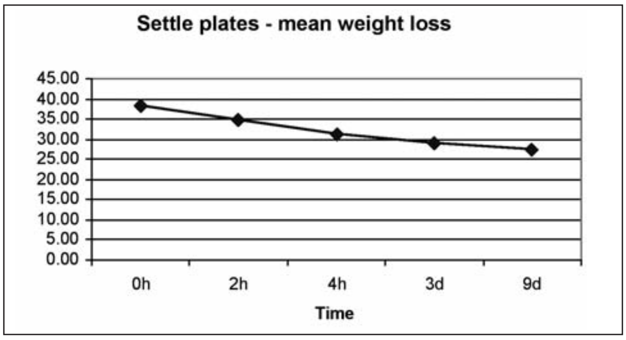
Weight of plates

Plates were weighed pre-exposure at time zero; after two and four hours exposure and then at the end of the incubation. The weight of the test plates was compared with unexposed, but incubated, control plates. The data is summarised in the table below:

Test	Plate Reference	Weight (g)				Percentage weight loss*
		Zero	Two	Four	Post-incubation	
Control Plates	A	40.8648			40.3368	1.3%
	B	41.4935			40.9675	1.3%
	C	40.2479			39.6236	1.6%
	Mean	40.87			40.31	1.4%
Test 1	A	40.8656	37.6864	33.0955	32.7016	19.98%
	B	41.7061	38.4254	34.6685	34.1966	18.01%
	C	41.2053	39.3663	36.4186	35.9480	12.76%
	D	40.3667	38.8215	36.0909	35.6763	11.62%
	Mean	41.04	38.57	35.07	34.63	15.61%
Test 2	A	40.6046	39.5601	34.4747	34.1558	15.88%
	B	40.2326	35.9606	34.2161	33.7754	16.05%
	C	41.8610	38.5509	37.6134	37.2118	11.11%
	D	42.7275	39.8943	36.4376	36.008	15.73%
	Mean	41.36	38.49	35.69	35.29	14.67%
Test 3	A	42.1058	39.2699	36.9409	36.4876	13.34%
	B	41.0372	38.1036	34.8957	34.4577	16.03%
	C	41.0017	38.1627	35.4506	35.0046	14.63%
	D	40.9041	38.9069	37.3340	36.9195	9.74%
	Mean	41.26	38.61	36.16	35.72	13.44%

$$* \text{ Calculated from: } \frac{\text{Post-incubation}}{\text{Zero Hours}} \times 100 - 100$$

The mean weight loss was represented graphically:



The graph demonstrates an initial rapid weight loss and then a steady reduction.

Microbial challenge

The plates were then tested for growth promotion at the end of the incubation. The data below relates to a challenge using the micro-organism Escherichia coli.

Control Plates

The test data from the control plates indicated:

Control Plate	Count (cfu per plate)	Mean cfu
A	65	
B	44	
C	49	53

Where cfu is 'colony forming unit'.

Standard deviation = 10.96

Test Plates

The data from the exposed test plates indicated:

Test Group 1

Test	9. 10. Count (cfu per plate)	11. 12. Mean cfu
A	51	
B	34	
C	46	
D	46	44

Standard deviation = 7.23

Test Group 2

Test	Count (cfu per plate)	Mean cfu
A	58	
B	40	
C	36	
D	44	44

Standard deviation = 9.57

Test Group 3

Test	Count (cfu per plate)	Mean cfu
A	41	
B	48	
C	39	
D	55	46

Standard deviation = 7.27

Mean recovery assessment

Control Count Mean (A)	Test Group Mean (B)	Productivity ratio (B / A)	Pass / Fail
53	44	0.83	Pass
53	44	0.83	Pass
53	46	0.87	Pass

Summary of experimental findings:

The data indicated that the typical weight loss was approximately 12g (on average) from initial exposure to the end of the incubation. The minimum and maximum values and the standard deviations indicate that the values to do not vary greatly and that most plates under go the same level of weight loss. In subtracting the highest recorded weight from the lowest (42.15g – 25.16g), the maximum weight loss shown was 16.99g (or approximately 40% of the agar). With the successful recovery of the micro-organisms it was demonstrated that settle plates can lose approximately 12g (or 29%) of their weight and retain their ability to support growth.

Conclusion

This paper has described a method which can be used to assess the weight loss from settle plates. Such a study is an important one for microbiologists who use settle plates to assess the cleanliness of a room or laminar airflow environment, in that a high weight loss can lead to the failure to grow micro-organisms. Should a study indicate that microbial growth is not obtained then either the environmental conditions should be examined (such as rate of air velocity or the temperature and humidity of the environment, or the volume of agar added should be reviewed).

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Tim Sandle is the company Microbiologist at Bio Products Laboratory (BPL). BPL is the manufacturing unit of the UK National Health Service Blood and Transplant.

Prior to his current role Tim has worked on a number of different microbiological projects within the pharmaceutical industry including developments in the testing of endotoxins and pyrogens for protein based products; establishing the environmental monitoring regime for a network of over two hundred clean rooms and validating a sterility testing isolator system.

Tim has written more than sixty articles relating to microbiology and pharmaceutical operations, including endotoxin testing; operation of isolators; clean rooms and environmental monitoring.

The Deadly Doctor Freud - A Tale from the Archive

Alan Gall

Unlike such august bodies as the Institute of Physics and the Royal Society of Chemistry, the IST can only look back on 54 years of its own history. During that time it has evolved from the Science Technologists Association to the present body that embraces not only the laboratory worker but also many others in managerial and specialist rolls. As Archivist, committed to making a regular historical contribution to the Institute's journal, the broad subject base of the Institute provides me with the chance to roam freely through a wide range of topics within the boundaries of physical and biological sciences, and also explore the many facets of technology. Along the way, I am frequently surprised at what turns up.

An article written jointly for the IST and the British Society of Scientific Glassblowers concerned a German glassblower called Fritz Hartwig. Fritz had arrived in this country around 1908 to work for Otto Baumbach, a fellow German who was already installed as the official glassblower to the University of Manchester. Otto, incidentally, is notable for constructing the delicate apparatus that Ernest Rutherford used to prove the identity of alpha particles as ionised helium (or helium nuclei as we would now say). When World War One began, Otto was interned after making some rather unwise comments about the superiority of the Kaiser's army. Somehow, Fritz escaped the same fate and seized the opportunity to acquire Otto's customers by forming the Scientific Glassblowing Company in partnership with a British subject, Alfred Edwards. It was whilst looking into the history of the SSG (still trading today) that I was told of the connection between Fritz and Sigmund Freud.

A branch of the Freud family, headed by Sigmund's two half-brothers Emanuel and Philipp, had arrived in Broughton, near Manchester, between mid-1859 and the beginning of 1860. Pauline Maria Freud was born to Matilda and Philipp in 1873 but did not marry until 1921, just before reaching the age of 48. Her husband was Fritz Franz Oswald Hartwig and the circumstances of their meeting have yet to be uncovered. They had at least one thing in common, both ran their own businesses: Pauline with a wholesale milliners under the name Miss Freud Ltd in the centre of Manchester, operated in partnership with a spinster called Mable Sirett.

Leslie Adams, a doctor from New York, decided to write a book about Sigmund Freud and at the beginning of the 1950s wrote to libraries in London and Manchester for information. An item of particular interest to Dr. Adams was the death of Emanuel Freud, uncle to Pauline Hartwig. Emanuel had died under mysterious circumstances and just about the only report of the incident appeared in the Southport Guardian:

> On Saturday afternoon [17th October 1914] just as an express passenger train passed Parbold Station, it was noticed that one of the carriage doors had opened, and an elderly man lay on the line. He had apparently fallen out of the compartment in which he had been travelling alone. The body was identified as Emanuel Freud, aged 82, and residing at 21 Albert Road, Southport.

A recent paper in Psychoanalysis and History by Michael Molnar proposes that Emanuel's fall from the train may have been an age-related accident and asks: 'What pressure of bladder or fantasy impelled Emanuel out of the moving compartment?' Although a possible suicide is discussed by the author, an alternative explanation, that of murder, is not suggested. Now, I have called this article 'The Deadly Doctor Freud', borrowing the title from a book by American clinical psychologist Paul Scagnelli. Not only does Dr. Scagnelli believe that Emanuel met his end by means most foul but that the perpetrator was none other than Sigmund Freud.

Did Sigmund really have the desire and capacity to arrange a murder? Yes, according to Doctor Scagnelli whose diagnosis is that Freud was as mad as the psychotics that he treated. According to the book, the train incident was not the only death to be blamed on Sigmund. Apart from a number of patients subjected to drug overdoses, Emanuel's son John vanished without trace - abducted, it is suggested, by order of uncle Sigmund. Paul Scagnelli presents an interesting case, discussing evidence for the Freud family's involvement with counterfeiting, Sigmund's sexual abuse by his nanny and other incidents that are claimed to have nurtured a psychotic personality that became capable of murderous action. However, much of the book is a psychological profile of Sigmund with little or no firm proof apart from circumstantial evidence.

Considering the disappearance of John Freud, there are a number of contradictory dates given for when this event took place. A seemingly thorough genealogical tree of the Freud family compiled by Hanns-Walter Lange says 'disappeared from Manchester after 1875'. A book by Eric Miller, quoted by Paul Scagnelli, asserts that John was never seen again after about 1873 and that support for this is provided in a note that Fritz Hartwig wrote. Miller also states that the 1881 census lists all of Emanuel Freud's family – 'Only John is missing'. Another biography, Freud and his father by M.Krull (1986), is said to give the dates as after 1875 or 1918 (others say 1919). Michael Molnar gives John's age as 54 'from the last known records'. So John vanished either in his late teens/early twenties, at age 64 or sometime between.

Regarding the note that Fritz Hartwig wrote, this does support the earlier dates without being specific: '…he [John] left his parents at an early age and nobody has heard or seen anything of him since.' Contrary to Miller's statement that John is absent from the 1881 census, the record reveals that John was living in lodgings on the same street as his uncle Philipp, a short distance away from his father's house. Why would he move from the family home? One possibility is a row with his parents. Ten years later, in the 1891 census, there is a John Freud living in lodgings at an address in London. The age and job description are feasible matches - the only discordant note is that the place of birth is given as Manchester, not Austria. Another check, on births in Manchester, indicates that there were no male births under the name of Freud anywhere near the time period in question. So, it seems possible that this is our man and that he gave his birthplace falsely as Manchester, the city were he lived for more than 20 years. If John did fall out with his family and move away then the abduction theory is harder to support. A scan of the 1901 census, however, has failed to give any positive sightings and there is no record of John's death in England and Wales.

So did Emanuel Freud slip or was he pushed? The train incident does not seem to have been investigated, perhaps because of the distraction caused by the start of World War One. In the absence of any concrete proof that can be put forward, interested readers might like to form their own opinion of Dr Scagnelli's book – that is, if you can actually get hold of one. The British Library and main UK university libraries do not seem to hold copies. My own copy was bought from the USA via the Internet, having been withdrawn from the California State University, San Bernardino Library.

In a letter dated 10th February 1952, sent to Sidney Horrocks at Manchester Central Reference Library, Leslie Adams wrote: '…the Freud family are morbidly reticent about their family history… any work which may be done in this direction must be in spite of their non-cooperation. This indicates that behind this history there is some desperately disillusioning truth.'

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Acknowledgments

Thanks are due to James Peters, Archivist at John Rylands Library, University of Manchester for access to the Freud papers in the Special Collections section. The photograph of Sigmund Freud is reproduced by courtesy of the University Librarian and Director, John Rylands Library, The University of Manchester.

Manchester's Central Reference Library holds the correspondence between Leslie Adams and Sidney Horrocks.

Thanks also to Robert Stuart of the Scientific Glassblowing Company Ltd who first drew my attention to the connection between Fritz Hartwig and the Freuds.

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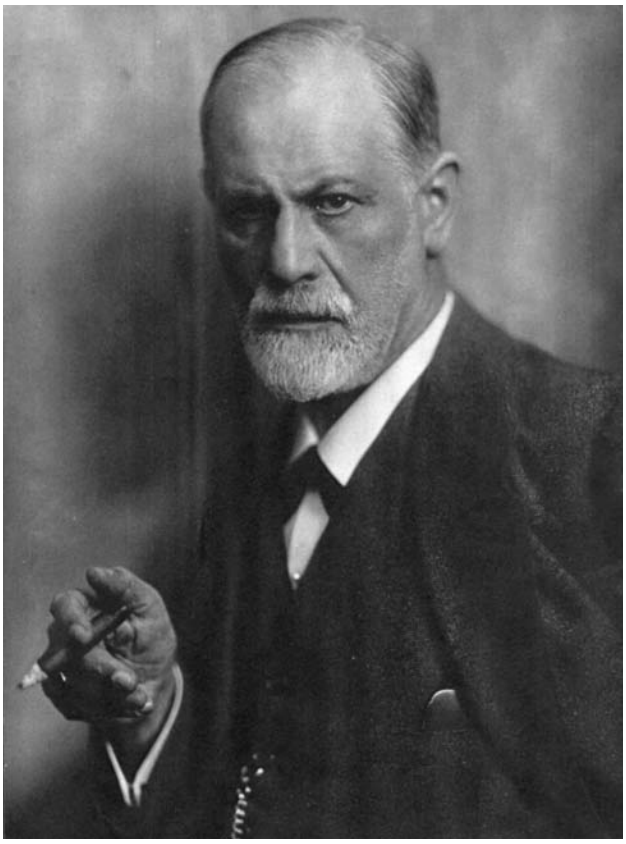

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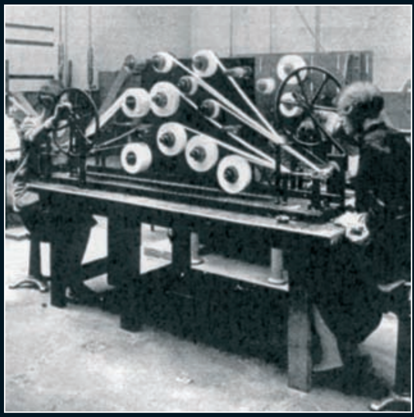
The Journal

Spring 2008



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