T H E E L E C T R O N

N E W S L E T T E R O F T H E I N S T I T U T I O N O F E L E C T R O N I C S

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ELECTRONIC APPLICATIONS IN HEALTHCARE

The healthcare industry contains an extremely broad range of electronic applications that is possibly the most diverse of all industry sectors. These topics range from computer applications in administrative areas, through to complex database management, hardware architectures and highly specialised scientific and research developments.

In this issue of *The Electron* a broad coverage of developments will be presented, beginning with an overview of EHI Live, the UK's leading digital health show, which took place at the NEC, Birmingham, on 1st. and 2nd. November.

This exhibition and conference featured around 130 exhibitors and 115 presentations. Topics included:

* Mental Health and Digital Transformation (Norman Lamb, MP for North Norfolk)

* The New NHS Digital (Beverley Bryant, Director of Digital Transformation for NHS Digital)

* Building a Digital ready Workforce (various presenters)

* Improving Patient Experience through Digitisation (David Walliker, Chief Information Officer, Liverpool Royal and Liverpool Womens' NHS Foundation Trust)

* IT Systems used to deliver Quality Healthcare: The UHB Approach (Mike Garrick, Director of Medical Directors' Services for the University Hospitals Birmingham NHS Trust)

* Making Clinical Software Usability count - Results to date and Preview of the cSUS Next Gen Ratings (Jon Hocksma, CEO and Editor of Digital Health Intelligence, and Dr. Marcus Baw, Locum General Practitioner, Emergency Physician and Healthcare IT Adviser)

* My Ward: Using Electronic Visual Display Boards to improve Quality on Mental Health Inpatient Wards (Nick Hopkinson, Chief Information Officer, Devon Partnership NHS Trust)

* Enabling Global Digital Excellence (Leesa Ewing, Commercial Director for IMS MAXIMS UK)

* Data Science for Health and Care (Daniel Ray, Director of Data Science for NHS Digital)

* Clinical Analytics Platform: 100K Genomics Project (Dr. James Teo, Consultant Neurologist for the King's College Hospital NHS Foundation Trust and Clive Stringer, Deputy IT Director for the Trust)

UNDERSTANDING THE ICT OPPORTUNITY IN THE HEALTHCARE INDUSTRY

In the paper 'Healthcare in 2025: Prepare for a Defining Decade', published by Ovum (5th. November 2015) Charlotte Davies notes the propensity of the healthcare sector generally to lag behind when it comes to ICT adoption, pointing particularly to the availability of accurate and contextual patient information.

The author states:

'Although many information systems have been digitised, information is poorly shared and the overall software landscape is highly fragmented, despite the advent of electronic health record (EHR) systems that act as a hub for individual organisations to share information and coordinate activity. Here, healthcare also lags behind other verticals, in terms of both standardising and implementing effective interoperability mechanisms to share information between organisations and with patients, and in terms of focusing on usability.'

It is therefore anticipated that healthcare enterprises will be investing heavily in the following four areas:

(i) Digitisation, sharing, and optimisation of structured, unstructured, machine and image data.

This will entail investment in more integrated information platforms, with analytics and BPM as key mechanisms for extracting value from information and ensuring it results in action. Enterprises will also seek to rationalise information systems where possible.

(ii) Patient Relationship Management

This is highlighted as a 'hugely neglected and fragmented domain' and it is forecast that providers and payers will seek to deploy joined-up multichannel strategies for managing patient relationships from both an administrative and a clinical perspective. A major challenge identified is that of avoiding platform and portal proliferation.

(iii) Legacy Modernisation

The author highlights the fact that many healthcare systems are not yet exploiting the benefits of cloud and managed services/outsourcing. It is therefore expected that there will be greater adoption of virtualisation and use made of IT service companies as more providers experience critical incidents and struggle with demands on IT.

(iv) Security and Privacy Management

Many providers are seen to be 'underestimating' the threats that exist as more patient data is shared, and the industry as a whole is expected to face challenges in managing the ethical use of patient data.

The report forms part of a wider research series by EHI exhibitors Ovum, entitled 'Digital Economy 2025: Industry Context', which is itself part of Ovum's Digital Economy 2025 series.

For more information contact Chris Pennell, Ovum, Christchurch Court, 10-15 Newgate Street, London EC1A 7HD. Telephone: 020 7017 5239 or Email: charlotte.davies@ovum.com

PAPERLESS HEALTHCARE

In February 2016 Health Secretary Jeremy Hunt announced a plan to invest £4.2 billion in modern technologies and techniques with the aim of making the NHS paperless by 2020. Within this is the objective of implementing digitisation and the elimination of paper from healthcare interactions.

One area where a high potential for digitisation has been identified is in the patient case note process, which, according to enterprise software specialists Lexmark Healthcare, 'is teeming with shortcomings and inefficiencies.':

'It requires expensive pre-printed stationery. Manual labour is required to assemble the attendance packs. Paper case note volumes increase with each patient encounter. Expensive onsite and offsite physical storage space is required to house the case notes. Transportation is often required to ship and retrieve historical case notes to and from offsite storage facilities. Paper case notes can only be in one place at a time, can easily be lost or misplaced and are often difficult to read.'

Lexmark recognises, however, that clinician buy-in is essential for successful technology adoption, which requires that existing clinical workflows remain stable and free of disruption.

In response to the challenge Lexmark Healthcare has developed Paperlite eCaseNotes:

'Paperlite eCaseNotes combines Lexmark's MFP (multifunction printer) devices, intelligent data capture and ECM (enterprise content management) technologies to streamline case note assembly, completion and conversion to electronic image without impacting a physician's daily routine.

Rather than requiring personnel to manually assemble attendance packs using pre-printed forms, Paperlite eCaseNotes automatically transmits the patient information to a Lexmark forms server. The

forms server then prompts a Lexmark MFP to print an attendance pack consisting of the appropriate forms, each of which contains an intelligent barcode.

This pack is then passed to the clinician, who fills them out by hand as they always have. The completed forms are then scanned back into a Lexmark MFP and each form is automatically indexed into the ECM system based on the information contained in the intelligent barcode. A digital image of each patient's documents within the case note is then stored in the ECM system, categorised into the relevant section, and the paper used to collect the information is shredded and recycled.

The resulting eCaseNote can now be accessed via the EHR (electronic health record) system, helping to complete the patient record.'

Lexmark Healthcare was an exhibitor at EHI Live and more information may be obtained from Kevin Starling, Lexmark Healthcare, Highfield House, 8 Roxburgh Way, Slough, Berkshire SL6 3UD. Email: mailinfo@lexmark.com

A Programme for Ophthamology

In *Hospital Matters* (November 2016) the article 'Keeping an Eye on Patient Records' highlights an ICM Research Survey for the BBC which draws attention to the alarming statistic that the NHS is currently losing the files of around 2,000 patients every day, combined with some two million serious data breaches that have been logged since 2011.

In this article Christian Martin, Managing Director of Medisoft, a leading provider of Electronic Medical Record (EMR) systems, notes particularly the prevalence of breaches and and loss of data in the field of ophthamology with many hospital eye departments lacking a central repository for recorded patient information.

He says:

"Current paper-based methods of recording patient data in eye departments are out-dated and obsolete, especially when you consider the amount of technology available in hospitals throughout the UK. While hospital-wide systems are available, ophthamology has very specific data requirements that are not always met by these generic systems."

Whilst there is a need for the simple and safe recording of data within ophthamological EMR systems, it is noted that the ability to easily access patient information from any location across several sites within an NHS hospital Trust is also important:

"As the treatment of chronic eye conditions generally requires on-going visits to hospitals over several years, maintaining continuous records and sharing information between a number of NHS sites and hospitals has always proved a challenge for ophthamologists. Given the fact that treatment for ailments such as cataracts and glaucoma can not only span several years, but also require treatment in both hospitals and community optometrists (high-street opticians) during follow-up, the need to measure post -surgical outcomes has also become a key requirement."

Under the present programme for ophthamology NHS hospitals and centres are encouraged to submit assessment and outcome data to The Royal College of Ophthamologists' National Ophthamology Database so as to ensure that the public has visibility of outcomes by surgeon and centre and in this regard Medisoft Ophthamology is noted to have "enhanced the recording of data".

Mr. Martin states:

"As ophthamology uses a wide array of sophisticated diagnostic and monitoring equipment, gathering patient data on a centralised system often proved a challenge for clinicians throughout the care path. Uniquely Medisoft interfaces with these machines to ensure numerical data is accessible to clinicians, meaning clinical outcomes can be improved as well as patient care.

A key example of this in practice is the software's ability to present thousands of visual field assessments in a single novel graph, allowing departments immediate visibility of the number of patients they have with glaucoma and how rapidly they are progressing. It is such data that gives them the ability to 'drill through' to identify patients most at risk, allowing them to prioritise care.

The use of a fully integrated system, deployed across multiple sites, provides substantial benefits to the ophthamology departments of hospitals. It replaces the need for paper notes for assessment and operations, and allows access to records from different sites. Patient records and images are securely stored and backed up and are accessible from any location."

The article concludes:

'Prior to the launch of Medisoft Ophthamology, it was almost impossible to gain basic insights from hospital eye departments, such as proportion of cataract operations that resulted in significantly improved patient vision. Medisoft has had such an impact on the industry that good clinical information on the activity of hospital eye departments is steadily becoming expected rather than desired.'

FIRST UK OPEN SOURCE ELECTRONIC PATIENT RECORD SYSTEM DEPLOYED AT TAUNTON AND SOMERSET

Taunton and Somerset NHS Foundation Trust achieved a significant milestone in September 2015 when it deployed the UK's first open source electronic patient record (EPR) system from pioneering clinical technology specialists IMS MAXIMS.

As the largest acute hospital in Somerset the Trust's 4,000 staff serves a population of over 340,000, managing around 700 beds, 30 wards and 15 operating theatres. A need to replace its legacy patient administration system was recognised and new ways of delivering an EPR were investigated. This led to consideration, for the first time, of using openMAXIMS, the open source version of the IMS MAXIMS EPR. One reason for this was the potential that it offered for more local control. Another was the potential future benefit to the NHS of being able to develop and subsequently share changes or improvements to the software with other NHS Trusts with inherent economies of scale.

Eight million records were migrated into the new EPR and Richard Jefferson, Head of Programme Commissioning for NHS England, commented:

"The project represents a landmark moment in the use of open software in the NHS and validates the idea that open source can play a significant role alongside proprietary offerings."

Once the 2,500 staff had been trained the Trust was able to use a full replica of the software on the intranet and work through different scenarios. With every member of staff experiencing the software before it went live there was 'faster and better adoption'.

Other benefits have included improved efficiencies in processes for admission, and the transfer and discharge of patients, assisted through real-time bed management and discharge planning.

The first phase has also led to some new outpatient activity becoming electronic, such as real-time outcoming of patients instead of time-consuming form completion, and clinicians are now triaging letters online rather than printing them out as well as making decisions online for each referral.

It is expected that the cost of moving to openMAXIMS will be recovered within three years and that the EPR will save the Trust £600,000 a year by 2018.

The next stage will involve a move to paperless nursing, e-prescribing and integration with GP and other third party systems.

In June 2014 the source code for MAXIMS was placed on GitHub and to reflect the change from closed source software to open source software the software was renamed openMAXIMS. It is the first fully open source EPR available for use in the NHS.

The openMAXIMS EPR can be downloaded from GitHub and used to run any clinic or hospital of any size. It is best suited to the running of an acute hospital, but is flexible and modular to the extent that it may be used by any healthcare provider in support of patient care.

The software is written in Java and any competent developer should be able to understand how the software operates. It was also developed using the freely available and open source Eclipse development environment such that any developer can make changes, which may then be shared.

IMS MAXIMS were an exhibitor at EHI Live and further information is available from Daniella Catanzaro, Saxon Court Offices, 502 Avebury Boulevard, Milton Keynes MK9 3GD. Telephone: 01203 668 6999. Email: daniella.catanzaro@imsmaxims.com

CASE STUDIES IN DIGITAL DICTATION AND SPEECH RECOGNITION

Aberdeen Royal Infirmary and University Hospital of North Tees

The Pathology Departments of both of these hospitals had a pool of secretarieswho manually typed reports for consultants. Problems would occur when secretaries had to deal with a surge in their workload due to out-of-hours working or irregular shift patterns, which frequently resulted in a backlog of reports waiting to be typed and delays for patients. A solution was therefore required that would speed up the process of turning pathology reports around and avoid the bottlenecks that were occurring during peak working hours.

As both Pathology Departments had existing digital dictation systems supplied by Voice Technologies it was straightforward to convey the advantages that speech recognition could bring to them.

With the aid of Nuance's Dragon Medical, it was possible to demonstrate how pathologists could dictate biopsy reports directly into the laboratory system rather than having to forward their dictations to the secretarial team for transcription.

Many of the pathologists in both hospitals moved quickly from simple biopsy reports to larger and more complex reports. This was partly due to increased familiarity from users over time and partly due to the speech recognition engine as it learned from each individual user. It was not long before there was a significantly positive decrease in the reporting turnaround time at both locations.

The speech recognition solution is noted for its ability to actively reduce pressure on the digital dictation system.

Lynne Doverty, Senior Chief Biomedical Scientist at Aberdeen Royal Infirmary, states:

"On a Friday afternoon we usually have many reports waiting in the digital dictation system. Typically it takes us until the following Tuesday to catch up. Today [Friday] we have six."

Dr. Kaushik Dasgupta, Histopathology Consultant for North Tees and Hartlepool NHS Foundation Trust, adds:

"Speech recognition in Pathology has helped tremendously to maintain our report turnaround time even with staff shortfalls. The speech recognition implementation works independently of our current workflow and enables clinicians to generate Microscopy reports there and then with no extra input required from our secretarial support staff."

University Hospitals Coventry and Warwickshire NHS Trust

University Hospitals Coventry and Warwickshire NHS Trust is one of the UK'S largest teaching Trusts, serving over a million people across two major hospitals.

A major problem was the slow, inefficient transcription and generation of letters, which was estimated to take each secretary five hours a day. In order to improve this the Trust needed a system that could streamline letter generation and optimise on resources. The Trust was already efficient in capturing information from clinicians, but wanted to make better use of its Clinical Results Reporting System (CRRS).

For this Trust Voice Technologies developed an end-to-end dictation/document production solution such that a clinician can begin the recording directly from the Trust's pre-existing CRRS and clinic list. The new system then pulls the patient details into the recording before sending it to the secretary for transcription of the body of the letter.

The integration means that typed letters are sent back into the CRRS for electronic review and verification. Status updates are available at all times ensuring that clinicians can see the letters belonging to a specific patient, which letters are currently being typed and which ones are still to be typed.

Barnsley Hospital NHS Foundation Trust

Barnsley Hospital is a leading UK Trust that cares for around 60,000 in-patients, facilitates over 260,000 clinic appointments and provides emergency help for some 80,000 people a year.

Analogue administration systems were under strain with an average turnaround time of 56 days for generating and sending important clinical-related patient correspondence. An efficient digital dictation and automated patient letter production system was required to reduce the time taken to produce patient letters, as well as a new set of digital tools that would help to lift the ever-growing administrative burden on clinical and secretarial staff.

Voice Technologies rolled out Winscribe for effective digital dictation and WinVoicePro for automated letter production across Barnsley Hospital's entire 24 clinical departments. This involved 318 clinical staff and 131 specialist medical secretaries. The customised software platform, which provides letter templates and instant automated links to Barnsley Hospital's Patient Administration System, helped to significantly reduce the time taken to draft and distribute patient correspondence as well as providing higher levels of accuracy in terms of linking with patient demographic information. Average correspondence time was reduced by 55 days.

Voice Technologies are employee-owned and were exhibitors at EHI Live. More information may be obtained from Martyn Rees, 10 Shuttle Street, Paisley PA1 1YD. Telephone: 01142 449 960. Email: martyn@voicetechnologies.co.uk

NEW ANALYTICS CAPABILITY FOR PETERBOROUGH AND STAMFORD HOSPITALS

A new analytics capability has been installed at the Peterborough and Stamford Hospitals NHS Foundation Trust that will, for the first time, provide senior doctors, nurses and managerial staff with the ability to generate instant reports and obtain unprecedented details on clinical activity, patient discharge times, A and E performance and other clinical and business areas so that they can respond immediately to pressures and target resources at priority patients.

The CXAIR system from Connexia allows the creation of a daily A and E dashboard that allows clinicians and managers to view data from a variety of systems at a glance and interrogate the information in the detail required so that they can monitor and respond to the effectiveness and timeliness of care within the department without the need for technical data skills. Discharge rates can also be examined so that staff can tackle any emerging factors that could delay a patient's discharge and reduce lengths of stay across the Trust.

Alec Dearden, Head of Information Services at the Trust, states:

"Staff throughout the hospital will no longer need to request reports from the information team. Self-service analytics, available through CXAIR, will allow people to immediately see where they need to take action. They will be able to look at the root causes of what is happening and understand where they need to focus resources, both in business areas and for patient groups."

Another application area is monitoring of major investments. Senior hospital managers will be able to use the technology to use the technology to closely examine key performance indicators on large projects and this is already being applied to the Trust's electronic document management programme. The analytics platform will help to enhance project governance and allow managers to continually monitor performance rather than relying on manual ad-hoc reports.

Connexia state:

'Reports are created at a much faster pace through CXAIR and in some instances have been developed within an hour instead of the months of development time required by other technologies previously used in the Trust.'

Developers and information service professionals will no longer manually generate reports through Microsoft Excel and SQL tools. Instead they will be focusing on mission critical tasks for the Trust.

Connexia was an exhibitor at EHI Live and more information is available from Jennifer Jones, Connexia Limited, Unit D, Dyson Court, Staffordshire Technology Park, Stafford ST18 0LQ. Telephone: 01785 246 777. Email: info@connexia.com

CROSS-ENTERPRISE WORKFLOW ASSISTS RADIOLOGY IN MERGER

University Hospitals of North Midlands is an NHS Trust located in Stoke-on-Trent and Stafford and was formed in November 2014 when the University Hospitals of North Staffordshire merged with the Mid Staffordshire Foundation Trust. It is one of the UK's largest Trusts, providing primary and secondary care to a population of 940,000 and managing some 200,000 accident and emergency cases a year. The Trust also serves three million people as a tertiary referral centre specialising in such areas as trauma, orthopaedics, neurology and neurosurgery. There are 11,500 full-time staff and a medical imaging department with 500 staff, 40 of whom are radiologists.

When the Trust was formed the University Hospitals of North Staffordshire inherited 50 per cent of the workload of the Mid Staffordshire NHS Foundation Trust and radiology staff experienced an increase in study volume from 390,000 to 650,000 per year. With this increase and new staff joining from the dissolved Trust, the Trust became focused on having its various sites operate as a single entity.

For the Trust's Radiology Department it was envisaged that unifying sites was going to be complex because each of the former Trusts had a different Picture Archiving and Communication System (PACS) in place. Merging systems was an option, but there were concerns about how long it would take to migrate all of the data into a single system. This led to consideration of the alternative, which was to install a system that would provide unified access to the existing systems and allow radiologists to read any study from any location.

Divisional IT Lead for the Trust, Phil Williams states:

"Effectively we needed a technological solution that was going to provide us with a single user interface with the ability to report on any case within the Trust. In doing so, the radiologist providing the report would not need to know if they were reporting on a case from County Hospital or Royal Stoke."

The search led to the adoption of Intelerad's cross-enterprise workflow solution, InteleOne™, which provided a clear alternative to replacing or merging the Trust's legacy systems and radiologists with a single unified worklist and viewer.

A smooth deployment was managed across the Trust's sites, essentially unifying the radiology department. Improvements to radiology workflow then resulted as the unified viewer and worklist facilitated clinical pathways and enhanced reporting flexibility across sites.

Mr. Williams adds:

"Originally the intention was to focus on the reporting of scans from County Hospital and Royal Stoke Hospital. Quite quickly we realised an opportunity to actually report our own scans from other locations, which is what we started to do.

InteleOne™ enables our radiologists to report from different locations, which gives us flexibility across the clinical business operation, and also gives the radiologists a good work life balance. It also enables us to employ or contract our output so we can get radiologists working for us from other parts of the UK, which has a huge clinical benefit for us."

Intelerad specialises in distributed radiology and was an exhibitor at EHI Live. More information may be obtained from Roy Kinnear, Catalyst House, 720 Centennial Court, Elstree Centennial Park, Hertfordshire WD6 3SY. Telephone: 01750 8711 335. Email: sales@intelerad.com

UPGRADING ICT AT AVON AND WILTSHIRE

Avon and Wiltshire Mental Health Partnership NHS Trust has 55 branch hospitals spread across Bath, North East Somerset, Wiltshire, South Gloucestershire and Bristol, representing a total of 2,200 square miles.

The Trust planned to introduce an electronic patient record (EPR) system and provide services to other hospitals and businesses in order to increase revenue by 50 per cent. Unfortunately, however, the Trust had a legacy network that impeded this.

The Trust's data centre contained ICT devices from multiple vendors and this poorly performing antiquated equipment was incapable of supporting the service expansion that was required. On top

of this complex management and poor compatibility between multi-vendor devices seriously hampered data centre operations.

The solution to this was the construction of two new data centres from networking and telecommunications specialist Huawei.

The solution involved the construction of two end-to-end private cloud data centres with ultra-high performance ICT infrastructure and unified O and M capability. The Ethernet Virtual Network (EVN) establishes highly reliable Layer 2 connections between the two data centres enabling service systems to work in active-active mode for higher service availability.

The Huawei CloudEngine series data centres are deployed at the core and access layers, and are connected using 40GE links. The high-performance switches and high-speed links ensure non-blocking forwarding of large amounts of data for the EPR system.

The Huawei Cloud Fabric Data Centre Network supports various virtual fabric technologies such as Transparent Interconnection of Lots of Links (TRILL), which is a standard IETF protocol that implements routing on a large Layer 2 network using IS-IS extensions. This can be used to establish a super-large Layer 2 network that has over 500 nodes, connecting many servers and allowing flexible Virtual Machine (VM) deployment across multiple data centres.

The EVN solution uses MAC over IP technology to establish Layer 2 network connections over IP WAN networks, allowing servers in different data centres to establish a cluster. Cross-DC server clusters enable the Trust to deploy active-active service systems in the two data centres. EVN also provides end-to-end load balancing capability to improve service availability.

Huawei state:

'With EVN technology a super-large Layer 2 network can be established between the two data centres allowing free VM migrations across data centres. This cross-DC network virtualisation capability enables flexible VM deployment and scheduling.

VS technology virtualises one physical device into multiple logical or virtual systems. Each VS is configured, managed, maintained and runs like an independent device on the physical device. Network services in different VSs are isolated.'

The Trust deploys different services in different VSs on the core switches, enhancing network reliability and security. This 1:N virtualisation technology is noted to 'reduce the cost of hardware equipment and greatly improve utilisation of network resources'.

The Huawei E9000 and RH 2288 10G servers are noted to 'significantly improve' computing performance relative to the original Gigabit servers and Huawei highlight SPEC test reports showing that these Huawei servers have a 15 per cent lower failure rate than similar server products.

Mark Osborne, Chief Information Officer for the Trust, states:

"By choosing the Huawei ICT Infrastructure portfolio products we were able to rapidly evaluate, select and implement our new ICT infrastructure, delivering new services to our clinicians and in turn our patients and new partners far sooner than we previously anticipated and made considerable savings that we never expected at the start of our strategy planning and budgeting."

Huawei was an exhibitor at EHI Live. More information may be obtained from Kevin Cheng, Huawei, 300 South Oak Way, Green Park, Reading, Berkshire RG2 6UF. Telephone: 01189 208 000. Email: kevin.cheng@huawei.com

3D-PRINTING TRANSFORMS PHARMACEUTICAL PROVISION

3D-printing takes a computer-generated design and transforms it into a three-dimensional object using a special printing machine that deposits successive layers of material e.g. plastic or metal, onto each other.

In 2015 the US Food and Drug Administration approved the epilepsy drug Spritam (levetiracetam), the world's first 3D-printed pill. This development is described by Katrina Meggett (ref. 'Tailor-made Tablets set to transform prescriptions', *The Future of Healthcare*, 30th. August 2016) as ' a milestone moment' that 'paves the way for a future of 3D-printed medicines'.

One reason why this is such an important breakthrough is the fact that differently shaped drugs, which can only be made through 3D-printing, have different rates of drug release. Another is the ability to use one pill for the administering of up to five different drugs. The article highlights, notably, research at Nottingham University where one such drug has been successfully 3D-printed.

The article states:

'These innovations would change how patients take their medications in future, with doses tailored to individuals and one pill a day or week replacing the multitudes of tablets that might normally have to be taken. Drugs would be easier to take, work better and have fewer side effects.'

Reference is then made to pioneering work at Glasgow University where a 3D-printed chemical reactor is being developed that will use chemical reactions to produce new molecules. Through the use of digital code, changing the shape of 3D-printed vessels and altering a mix of 3D-printed base ingredients chemical reactions can potentially be used to produce different drugs, and a '3D-printer-like robot' will be created to 'accelerate the discovery and manufacture of novel drugs'.

The article also highlights the potential for 3D-printing to improve access to drugs, with 3D-printing pills at home being described as 'a possibility', although the concept of pharmacies becoming '3D-printing medicine hubs' is reckoned to be more likely:

'Pharmacists would be handed a prescription, download a recipe from a pharmaceutical company, then 3D-print the drug from basic ingredients while the patient waits.

Printing drugs on demand would cut storage and shipping costs, and improve access to medicines. For developing countries this alone would be monumental.'

Personal information would be entered into the pharmacist's computer where an algorithm would adjust the recipe so as to produce a drug that was tailored to that particular patient rather than conforming to mass-production standards. Braille bumps could be added, for example, for patients with poor eyesight.

ADVANCES IN MICROSCOPY

Flourescence microscopy has recently come to prominence for its ability to reveal hitherto unseen cellular structures at nanoscale resolutions.

Now, scientists in America have developed an infrared microscope that can take images of living cells in 3D as well as probing deeper into cells so as to track the movement of individual proteins and drug molecules.

A 'pump-probe method' overcomes problems previously associated with the ability of IR microscopy to capture 3D images. As water strongly absorbs IR radiation such microscopes could only resolve dead, dried tissues, and typical IR wavelengths are greater than a single cell causing limitations.

The new technique by-passes the IR diffraction limit enabling capture of the motion of proteins and drugs within cells.

The article 'IR Microscope exposes Proteins in living Cells' (*Chemistry World*, Vol.13, Issue 11, November 2016) states:

'Scientists first fire a mid-IR laser at the sample, the pump, which is subsequently absorbed. This excites the molecules and leads to changes in both the temperature and refractive index within the cell or tissue. If the team were to simply look at this excited sample, however, they would encounter the same problem countless others have had with IR imaging. The trick is to then expose the sample to an optical light probe beam.'

The article then quotes Ji-XinCheng of Purdue University as follows:

"Using another visible beam [we can] measure the local changes in the refractive index of the sample induced by the IR laser. In this case we can [image] living cells because the visible beam can go through the cells....and also the resolution is now determined by the visible probe beam, which is ten times better than the IR imaging."

This approach allows the team to probe the sample at different depths and build up a 3D image.

The improvement in resolution allowed the team to capture the movement of lipids and drugs in cells all in the IR domain, and the power of the microscope was such that lipid and protein transport in a live roundworm were observed without the need to tag or label molecules.

Ji-Xin Cheng concludes:

"We hope this can be used to see single bacteria with IR, which was not possible before. This could enable early detection of an infection."

SMART NANOPARTICLE PROVIDES CANCER BREAKTHROUGH

A 'smart' biodegradable nanoparticle that can target and treat tumours has been developed at the University of Toronto.

The particle can absorb light, generate heat and kill tumours. It uses heat and light to locate the tumour and is envisaged to greatly enhance the effectiveness of photothermal therapy, which involves the injection of nanoparticles into the body with the objective of attaching themselves to cancer cells and subsequently destroying them. Electromagnetic radiation in the form of light is applied to the affected area so as to excite the nanoparticles and effect disintegration of the tumour.

The nanoparticles have been collectively named Photothermal Enhancing Auto-Regulating Liposomes or PEARLS and overcome the present problems of overheating of tissue and the inability to ablate larger tumour volumes due to the cessation of the travelling of light after it has been absorbed.

The article 'Nanoparticle offers hope for future Cancer Treatment' [Ref. *Laboratory News*, August 2016] quotes Senior Scientist and Lead Researcher Dr. Zheng, who says:

"It [the nanoparticle] is a thermal sensor and once it reaches the desired ablation temperature of 55 degrees Centigrade it becomes invisible allowing the light to move deeper into more tumour-rich areas and repeat the treatment process.

The result is a promising new way to heat and ablate larger volumes of tumour with minimal damage to surrounding tissues in a controlled and precise way. The next step is to conduct pre-clinical studies to test the concept further."

ULTRASOUND IMPROVES DIAGNOSIS OF ELEVATED CRANIAL PRESSURE

Elevated cranial pressure from head traumas and brain tumours is potentially fatal. Conventional diagnosis, however, relies on time-consuming, invasive surgery that also places patients' lives at risk.

Now, scientists at Kaunas University of Technology in Lithuania have developed a new technique, utilising ultrasound, which uses the Doppler Effect, to provide precise and instant pressure measurements through a probe that is applied to the patient's eye. This then enables doctors to make informed decisions on the type of action needed, with potentially life-saving consequences.

The article 'Brain Trauma: Ultrasound eases the Pressure' by Andy Pye in *Environmental Engineering*, Vol. 29, No. 4, August 2016, describes the technology as follows:

'Similar to the principle of the inflated armband used to measure blood pressure, the ultrasound scanners measure brain pressure by applying a small amount of pressure to the eye to match that of the central retinal artery just behind it, which leads directly to the brain.

The technology then arrives at the measurement by comparing the applied external pressure to the autonomous intracranial pressure. For perspective, intracranial pressure is usually in the range of 0 to 10 mmHg in healthy adults - roughly 10 per cent of the pressure created by the human heart to circulate blood - while pressure greater than 20 mmHg is considered abnormal.'

Precise and accurate measurements of this type are important because relatively small increments in pressure can have devastating effects on pressure-sensitive brain tissue. Levels above 40mmHG are almost always associated with neurological dysfunction (impairment of consciousness and problems with breathing), whilst pressures above 60mmHg tend to be fatal.

The technology is marketed as the non-invasive intracranial pressure meter Vittamed 205, and the non-invasive cerebral auto-regulation monitor Vittamed 505 and has received the CE Mark of approval.

The architect of the technology, Arminas Ragauskas, was named by the European Patent Office as one of three finalists for the European Inventor Award 2016 SME Category.

NEW BIOSENSOR IMPROVES BLOOD TESTING

Blood tests used to detect infection or disease require a sample of blood to be taken from a patient for analysis to confirm or otherwise the presence of certain proteins that are hallmarks of disease. With present techniques, however, only one type of protein can be identified per sample, meaning that if multiple tests are required delivery of results can be prolonged and the testing more expensive.

Now, a biosensor has been developed at the Department of Electronics at York University that combines light and electricity in silicon sensors in a completely new way so as to detect multiple disease biomarkers in a single small sample.

The sensor consists of nanometre devices that resonate at a specific optical frequency. Since the devices are optical, they are sensitive to changes in the speed at which light propagates locally.

The article 'Some good Sense for testing Blood' by Jason Ford in *The Engineer*, October 2016, quotes PhD student Jose Juan Carlos, who was behind the innovation, as follows:

"When the environment around these devices changes, the local speed of light varies and thus the resonant frequency is altered. For instance, the surface of the device can be modified so it is also sensitive to a certain protein. In this way, when the protein sticks to the surface, it leads to a change in the resonant frequency.

The novelty of our sensor is that, by exploiting its electrical properties, we have been able to modify the surface of each of these devices so that each of them can be sensitive to, for example, a different protein."

The resulting new technique enables testing to be performed in areas of just a few square micrometres, considerably reducing the amount of blood required from a patient.

The researchers plan to pilot the new technology in urine samples for urinary tract infections, which have a high resistance to antibiotics.

CLOUD-BASED MODELLING AND SIMULATION TOOL AIDS UNDERSTANDING OF CANCER

A new cloud-based modelling and simulation tool, known as BioModel Analyzer, has been developed by AstroZeneca in order to better understand the millions of potential changes in cell signalling that can cause cancer cells to multiply out of control.

In the absence of computer modelling, drug discovery researchers have had to rely on an incomplete understanding of the stages in cell signalling pathways and their own intuition in deciding which steps to block.

In the article 'Has Microsoft made an Oncological Smart Bomb' Jonathan Dry in *Laboratory News*, November 2016, explains:

'There may be tens to hundreds of different possible points to choose from in a single pathway. Even with the latest high throughput screening methods currently available it may take weeks of effort to identify promising candidates. With computer simulations all that work can be done in minutes.

Faced with an impossible number of different choices, scientists currently tend to choose their favourites to investigate and may therefore miss better options. The beauty of computerised modelling is that you remove the current limitation on the number of hypotheses you can investigate and the potential for human bias.'

The computer screen serves as a 'blank canvas' on which the essential components of the biological processes of cancer, such as cells, genes and proteins, are 'dragged and dropped'. The basic signalling pathways that can go wrong in cancer cells are then added and the computer algorithms perform the many calculations that are required to fill the gaps in the signalling pathways and predict what would happen if different steps are blocked with drugs. The likely effects of different types of drug are effectively tested at different points on a pathway so as to ascertain the best places to intervene:

'In a signalling pathway that has become resistant to a cancer drug already in use, new opportunities are highlighted where we can add novel compounds with the potential to restore treatment sensitivity.'

The new tool was piloted using signalling pathways in acute myeloid leukaemia (AML):

'In the laboratory we used a range of techniques, including DNA and RNA sequencing and protein arrays, to collect genomic, transcriptomic and proteonic data from AML cell lines ready for processing.

Microsoft computer scientists used this information to develop highly sophisticated algorithms to model all the possible variations in a key signalling pathway in AML cells and the likely outcomes.'

The next stage was to simulate experiments that would normally have to be performed in the laboratory, with the objective of predicting how drug combinations may be used to overcome individual drugs that target specific steps in cell pathways in AML, as well as how this may vary between cell lines.

The two sets of results were compared and an 'excellent match' was observed that indicated which drug combination would make a cell sensitive to treatment and the protein changes that led to that cell becoming sensitive.

The article concludes:

'Using computer modelling to capture the great variability inherent in signalling pathways in cancer cells, and then simulating the effects of drug combinations at key points for individual patients has the potential to push back the current boundaries of personalised medicine.

At present cancer treatments are targeted at single points in signalling pathways, based on genetic mutations in a patient's tumour. Future personalised therapy is likely to be able to spread its effects to multiple points in a pathway identified by computer simulations and then confirmed in the laboratory. Ultimately such simulations could even take account of interactions between the tumour and its broader environment, including host immunity and DNA damage response mechanisms.

We're moving away from hitting a pathway just because we know it's active. Instead, we're identifying the best place to hit the pathway in order to get the best possible response for that patient.'