Machine Learning and 3D printing to deliver the goal of Personalised Medicine

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Chronic diseases are now the main cause of death in humans, and incidences of diseases such as stroke, cardiovascular disease, cancer, osteoarthritis etc. are predicted to increase rapidly in line with the ageing demographic of almost all nations. As well as greater effort on preventative strategies, significant improvements are need in therapies to ensure sustainable health care systems and preserve quality of life.

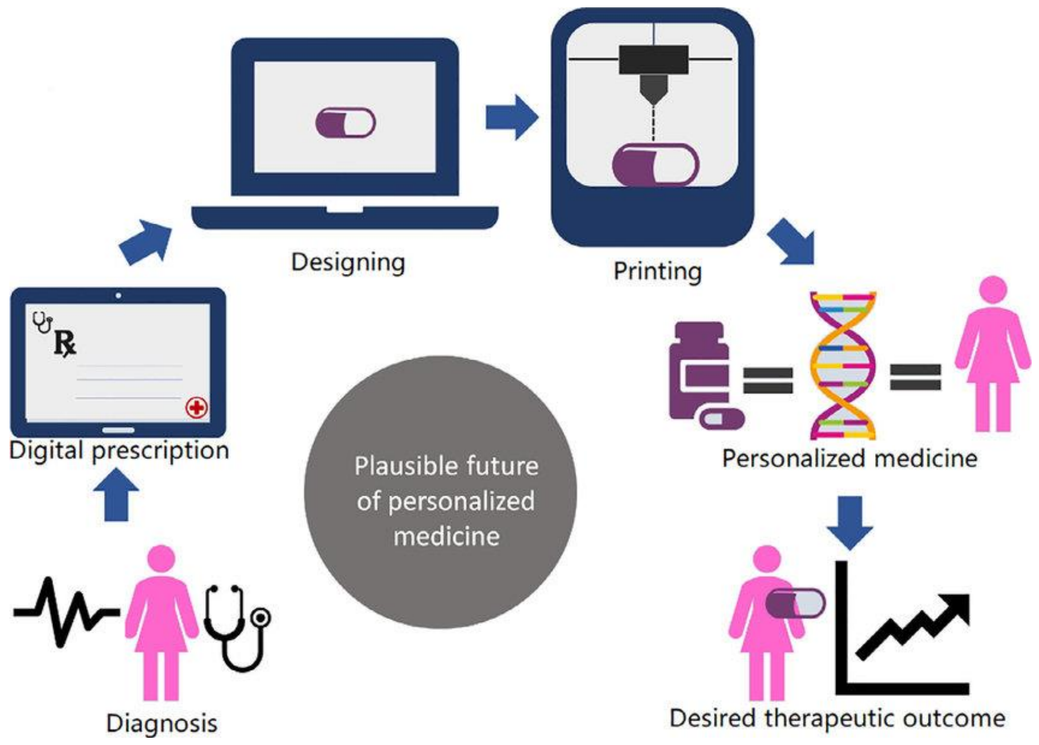


Fig 1. Envisaged 'Pharmacy of the Future', 3D printing is a key enabling technology for the vision of personalised medicine. (Lamichane et al., 2019)

Personalised Medicine involves moving away from a 'one-size-fits-all' approach, towards therapies that are individualised to the specific requirements for the patient. The way an individual responds to a drug treatment can vary widely, depending on their age, body mass, ethnicity, other underlying conditions, and many other factors. 3D printing can enable multiple drugs to be combined in specific concentrations with tailored release profiles to create a unique drug delivery system, bespoke to patient requirements.

A digital prescription can be created based on specific patient data, such as medical history, personal data, data from wearables etc. A specific dosage form can then be designed on the cloud and printed at a local hospital or pharmacy.

CHALLENGES:

- Limited drug/polymer systems which can be 3D printed.
- Difficult to identify workable formulation for printability, stability, desired release profile.
- Challenging to process without degrading or altering the drug.
- **How to ensure the safety of devices printed at the point of care?**

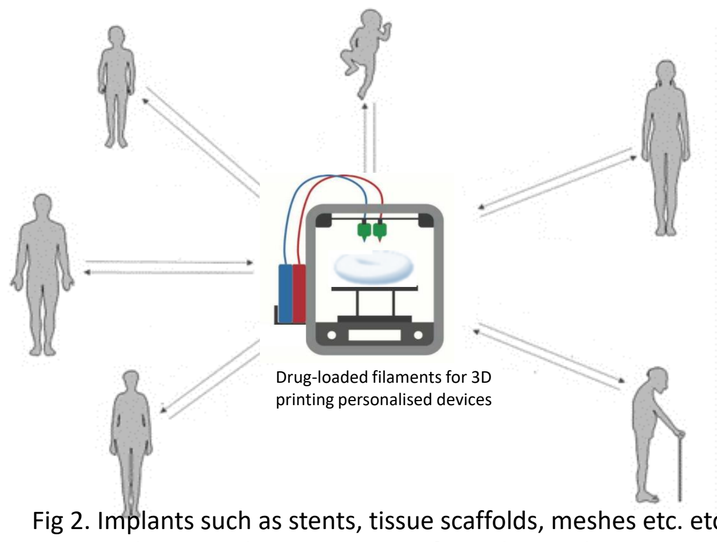
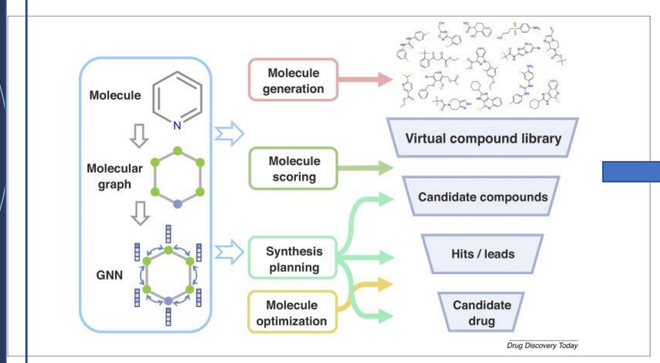
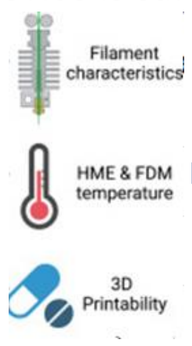


Fig 2. Implants such as stents, tissue scaffolds, meshes etc. etc. can be printed to patient specifics in hospital setting

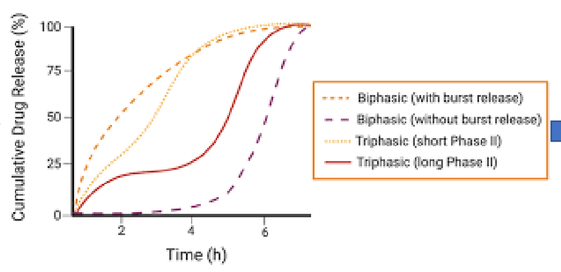
Machine learning, computational modelling and advanced sensor systems can all play a huge role in overcoming the current challenges associated with 3D printing personalised drug delivery devices. This includes discovering new drugs and excipients, predicting suitable formulations without vast expensive material trials, design of personalised devices to deliver required mechanical properties and drug release profiles, and monitoring and control of the production process to ensure the final device is safe and effective for the patient.



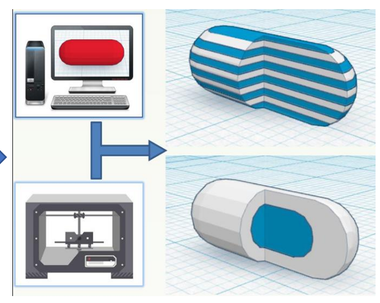
ML in discovery of new drugs/carriers (e.g. Xiong et al.,2021)



ML in screening formulations for 3D printing (www.m3diseen.com)



Robust Prediction of final properties from in-process data (PROCEED 3D Project, ATU)



Computational Models for design of personalised drug delivery devices (ATU)

The PROCEED 3D Project at ATU focuses specifically on modelling, optimisation, and process monitoring and control to deliver on the potential of 3D printing in personalised medicine. We would be delighted to collaborate with EU Green partners in this space. Contact: marion.mcafee@atu.ie

Lamichane S, Bashayal S, Teakwang Keum , Gyubin Noh, Jo Eun Sea, Rakesh Bastola, Jaewoong Choi, Dong Hwan Sohn, Sangkil Lee, *Asian journal of Pharmaceutical Sciences*, 2019;14:465-479. https://doi.org/10.1016/j.ajps.2018.11.008.
Xiong J, Xiong Z, Kaixian Chen, Jiang H, Zheng M, *Drug Discovery Today*, 2021, 26,6, 1382-1393, https://doi.org/10.1016/j.drudis.2021.02.011

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