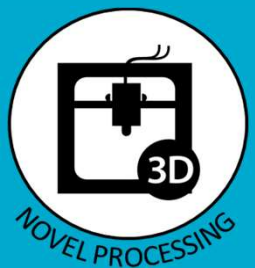


The Future of Personalised Nutrition

CSIRO calls for a personalised food revolution!

Dr Amy Logan, AIM Future Science Platform Testbed Leader

AGRICULTURE AND FOOD
www.csiro.au

CSIRO

The National Olive Industry Conference and Trade Exhibition, Wagga Wagga NSW, 18th -20th October 2018

Personalised nutrition

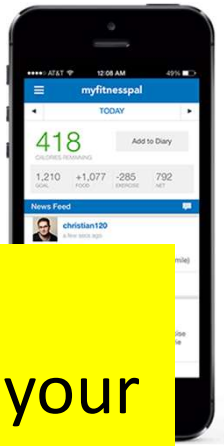
- Interactive advice on what foods should and shouldn't be eaten
  - Targeted to meet the specific needs of an individual
- Real-time data collection
- Revolutionising the consumer experience and how we interact with technology

How do we keep up?

- Increased demands on foods to meet nutritional requirements
- Increased demands for intelligent technologies to manufacture foods of a defined nutrient loading on demand
- Increased demands for foods to delivery nutrition to the body in the most bioavailable form by design → microstructure

Self tracking for diet and exercise

How do we know what a person's individual needs are?



apps

Research in CSIRO involving the integration of:

- Hardware and devises that are informed with your genetic information
- Taste preferences, age, lifestyle data
- Day-to-day nutritional needs → sensor technology

- A kitchen based machine that prepares a structured food on demand to meet your nutritional needs for optimum wellbeing

Biosensor technologies – what is currently out there?

- The market is dev
- Invasive → body w
- Measure bio-signa
  hand held devise.
- Output can be mo
  - Temperature
  - ECG
  - Blood pressure
  - Pulse oximeter
  - Potassium, sodium ions
  - Weight
  - GPS location

Consumer acceptance increasing

- Need to consider privacy issues associated with mass data collection

program to use similar
tor the elderly,
measuring their weight, blood glucose levels and blood pressure.

Herald Sun, April 16th 2017

Current status of 3D technology

Additive manufacturing
- fused layering or extruded through nozzles
- e.g. 3D printing

Image from:
https://3dprintingindustry.com/news/3d-printed-food-growing-market-83916/

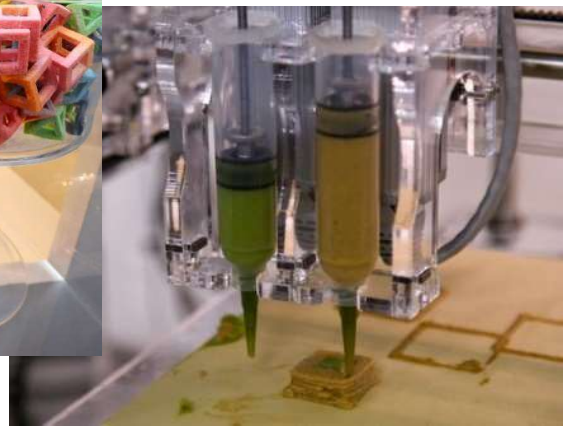
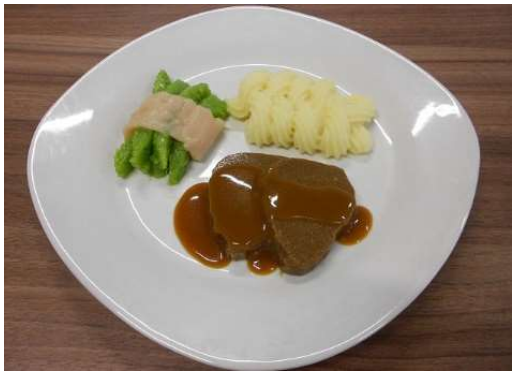


Image from:
http://inhabitat.com/3d-printers-could-some-day-feed-astronauts-in-space/

3D Printed moulds for soft eating foods

Image from:
http://www.toxel.com/inspiration/2018/02/18/modern-cakes/

Image from:
http://www.dailymail.co.uk/sciencetech/article-2611143/Scientists-develop-3D-jellified-smoothfood-looks-just-like-everyday-meals.html



Improved visual appeal to increase consumption however it needs to taste good too!

But there are challenges…..

If 3D printing is to be used for the delivery of personalised nutrition:

- Physical and food stability of the stored “ink” ?
  - Powder
  - Liquid
  - Paste
- Will the foods maintaining shape after printing, reheating & cooking?
  - Taste may be affected, e.g. warmed over flavour in cooked meat
  - Food safety once prepared
- Printing nozzle and setting mechanism – dependent on the ink
- Time to print is long
- Cooking after may be required

Image from: http://edition.cnn.com/2014/11/06/tech/innovation/foodini-machine-print-food/index.html

Image from: http://blogthinkbig.com/3d-printing-food/

CSIRO printed foods!

Focus on highly nutritious foods:
- High protein
- High fibre
- maximise nutrient loading per serve
- Smaller serves

Fun shapes for kids

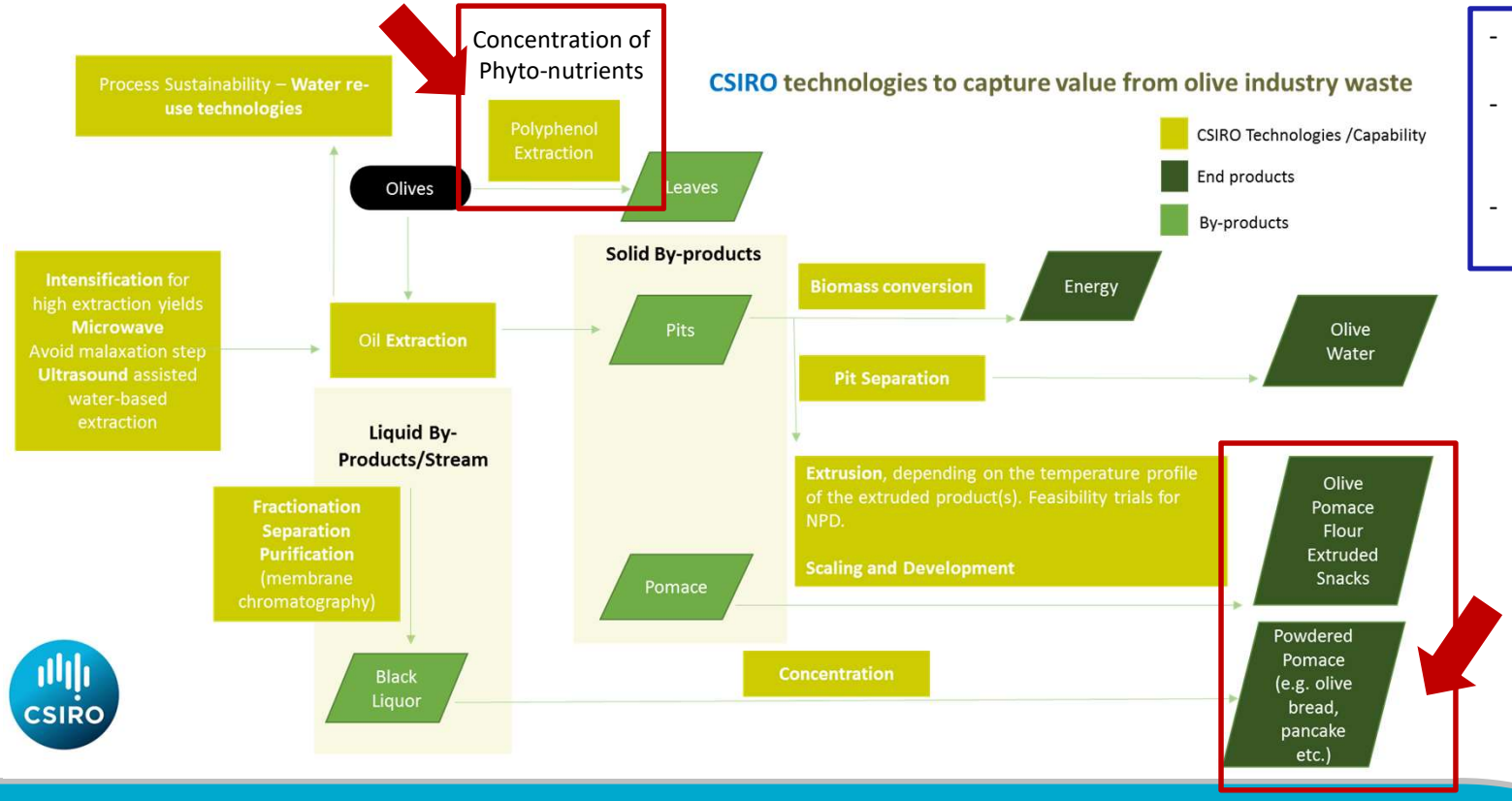
Full of vitamins and fibre

IMAGES: Courtesy of Filip Janakievski, CSIRO Agriculture and Food

(left): a gecko printed from beetroot powder and chickpea combined matrix

(top): carrot powder and starch combined matrix

Source of nutrition for personalised products



- Highly nutritious ingredients
- Source of phytochemicals e.g. antioxidants
- Value adding to waste streams

Developed by: Sharad Menon, Regine Stockmann, and Pablo Juliano.

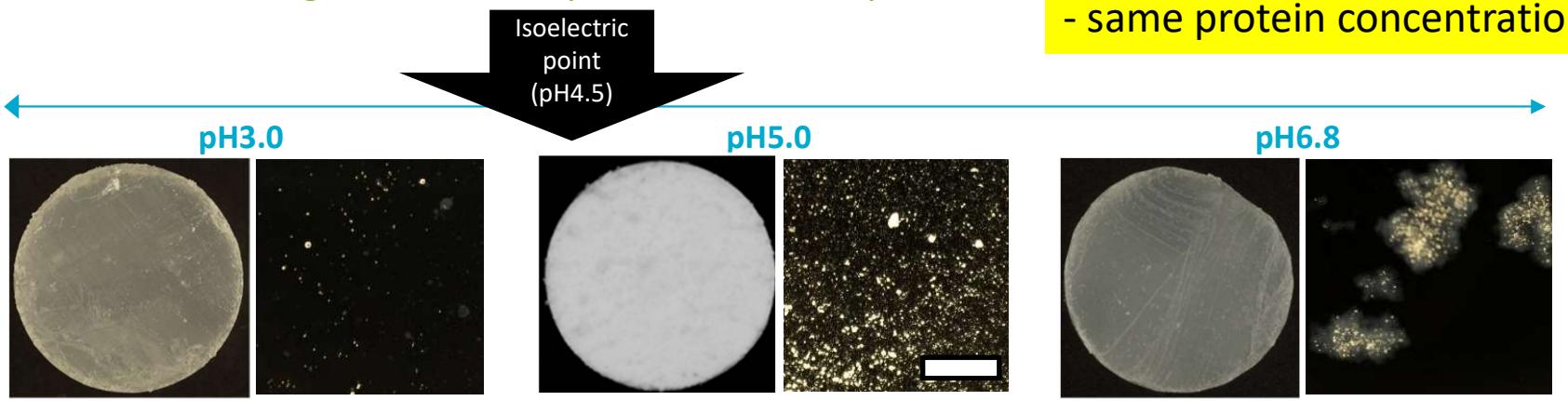
How will structure influence the food materials function for the personalised delivery of nutrition?

- Rate of digestion?
- Nutrient loading, bioaccessibility and bioavailability?

How will structure influence the food materials function for the personalised delivery of nutrition?

- Rate of digestion?
- Nutrient loading, bioaccessibility and bioavailability?

Whey protein gels
- same protein concentration

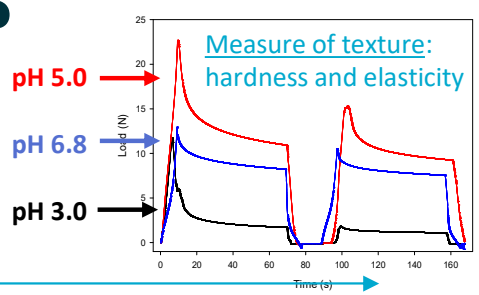


Level of gastric digestion after 2 hours =	100%	100%	50%

Example: whey protein gel

How will structure influence the food materials function for the personalised delivery of nutrition?

- Rate of digestion?
- Nutrient loading, bioaccessibility and bioavailability?

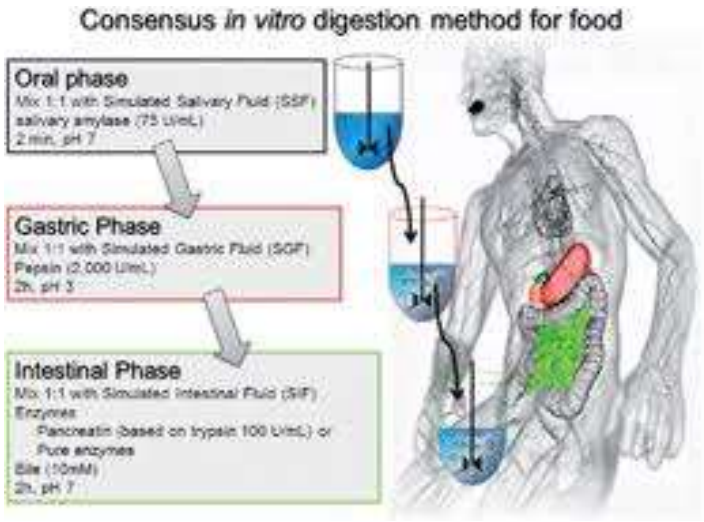


pH3.0 **pH5.0** **pH6.8**

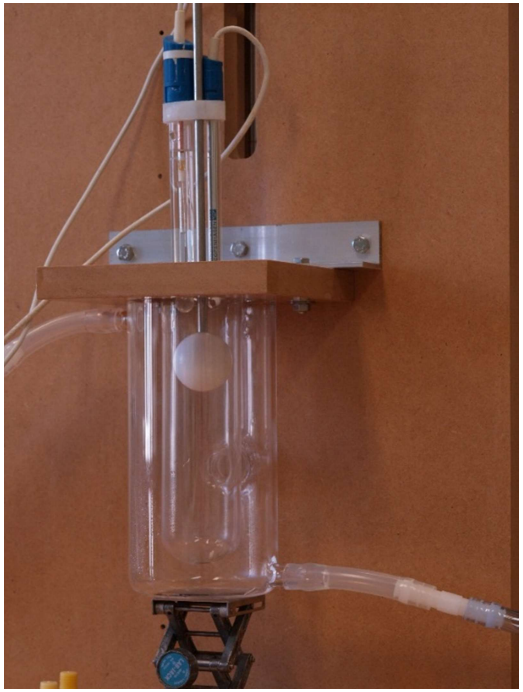
Example: whey protein gel

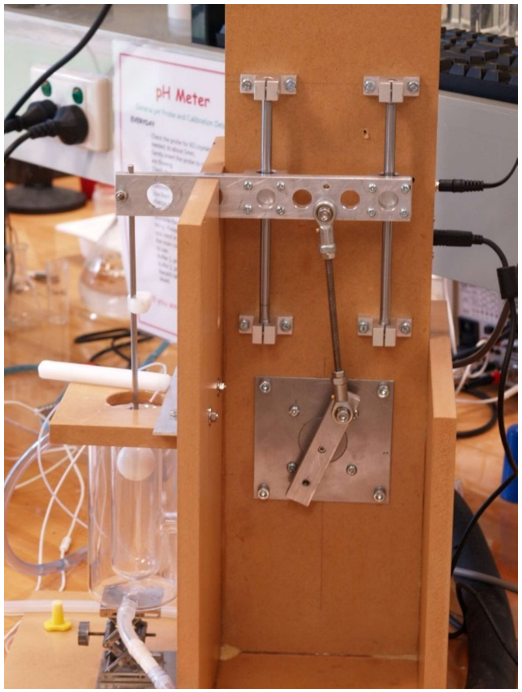
Methods to simulate digestion

Minekus M, Alminger M, Alvito P, Ballance S, Bohn TO, Bourlieu C, Carriere F, Boutrou R, Corredig M, Dupont D, Dufour C. A standardised static in vitro digestion method suitable for food–an international consensus. Food & function. 2014;5(6):1113-24.



New *In-vitro* stomach model:





Digestion in a dynamic process

Variables can include:

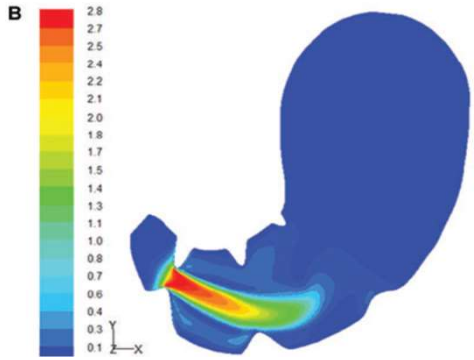
- **Shear field – variation in stomach**

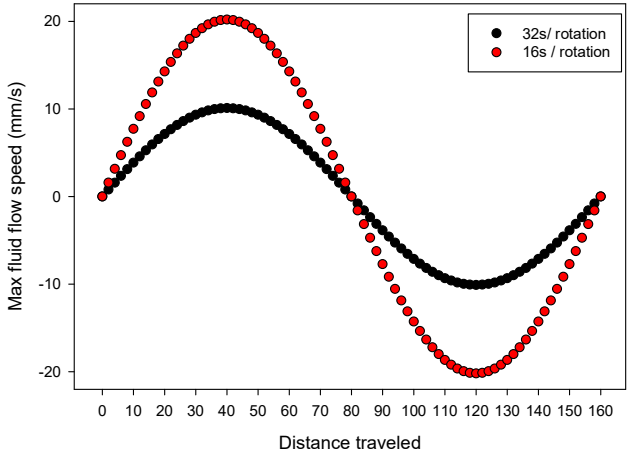
  Maximum flow speed in the gap can be calculated based on the radii of the probe and the cylinder.

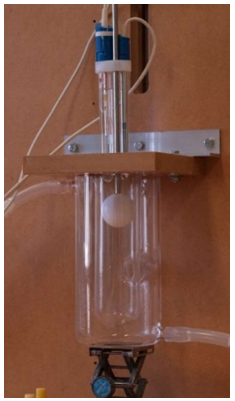
  32 sec per rotation gives a range of 0 – 10.1 mm/s
  16 sec per rotation gives a range of 0 – 20 mm/s

  - Pal et al. (2004) report ~7.5mm/s
  - Ferrua and Singh (2010) report up to 28 mm/s (depending on viscosity)

- **pH (~pH 5 down to ~pH 3)**



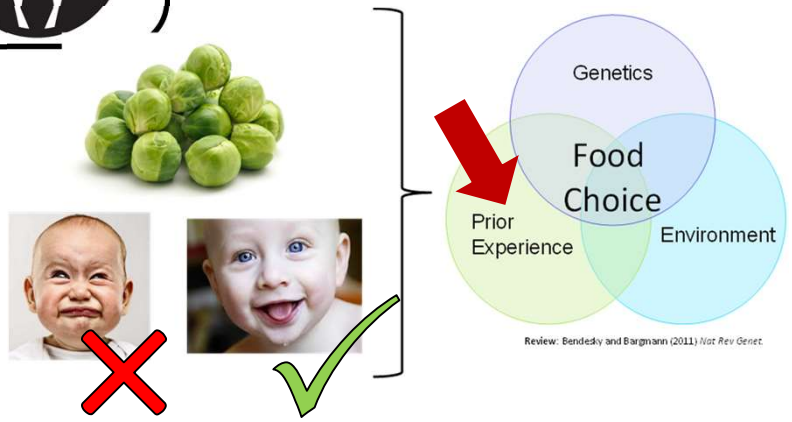




Personalising foods through genetics

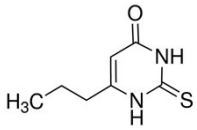
Future: engineer foods specific for a person based on their genetic profile.

- Limitations in the numbers of people who can be assessed using sensory descriptive analysis or consumer preference tests
- Potential to assess 100s and 1000s of people using genomic testing as costs ↓



How genetics influence taste, smell and metabolism will influence food preferences – important to consider when designing personalised foods

Genetics influencing taste perception



Bitter taste

PROP

(AVI) **TAS2R38** (PAV)

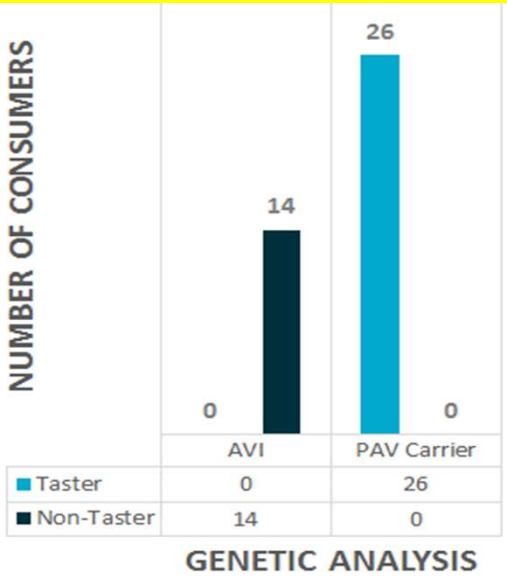
NON-TASTER (INSENSITIVE)

Likely ↑ Green vegetable consumption

TASTER (SENSITIVE)

Likely ↓ Green vegetable consumption

Gene present in those who cannot taste bitter components that is absent in those who can taste bitterness



This information can be used to develop foods that are optimised for particular tastes and preferences.

Welcome to the personalised food revolution!

The concept of personalised nutrition is **transforming the agrifood industry** and how diet recommendations and advice are provided to the consumer.

Where to from here? The future lies in the integration of **intelligent manufacturing** with real-time sensors that capture individual needs on a day-to-day basis,

to develop **structured foods** that are customised for **optimum nutrient delivery** based on the person's genetic information, lifestyle and physiological state.

IMAGE: Courtesy of *Food Australia*

Nicholas Archer, Debra Krause, Amy Logan (2017), "Personalised food revolution". *Food Australia*, 69(4):42-44

Thank you

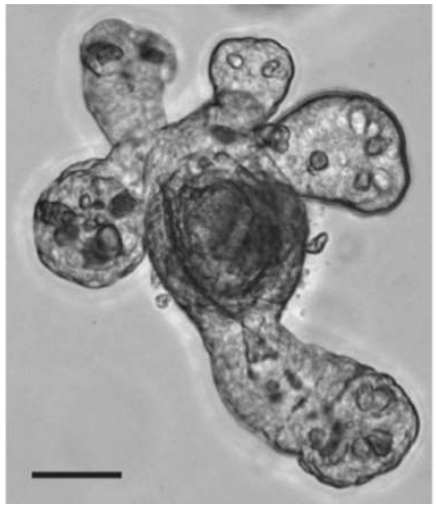
Dr Amy Logan | senior research scientist

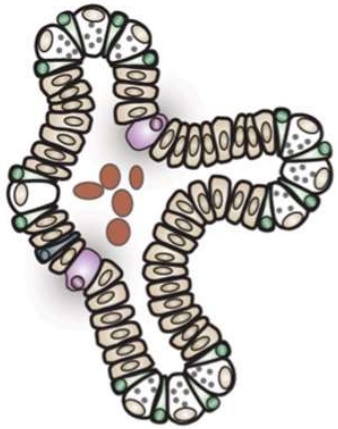
amy.logan@csiro.au

How will structure influence the food materials function for the personalised delivery of nutrition?

- Rate of digestion?
- Nutrient loading, bioaccessibility and bioavailability?

Human intestinal organoid models for *ex vivo* analysis





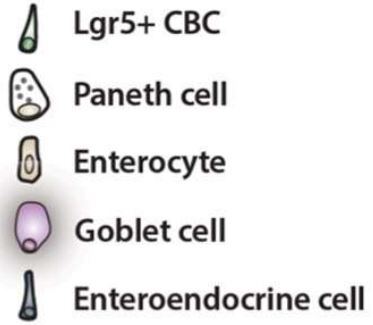
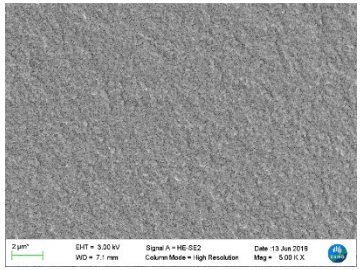
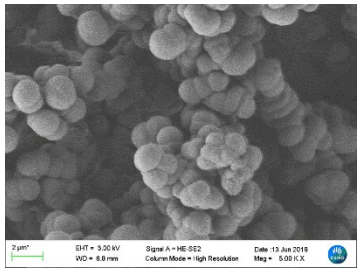
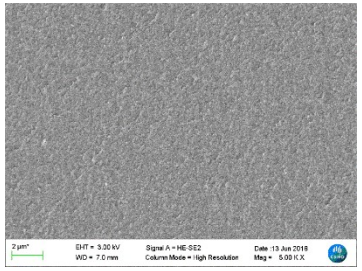
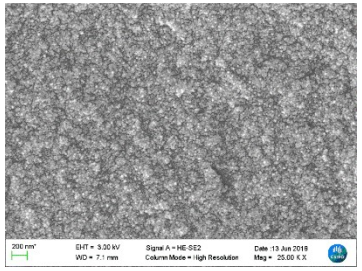
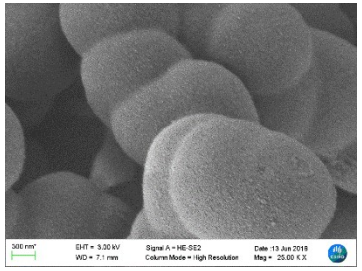
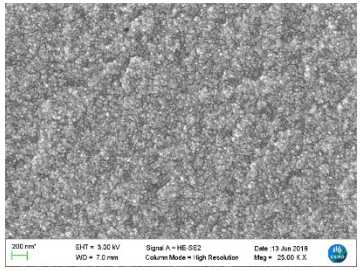
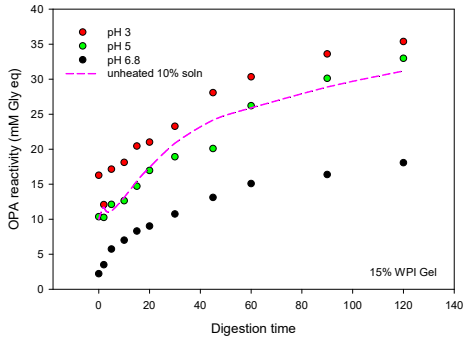


Image from:
O'Rourke, K. P., Dow, L. E. and Lowe, S. W. (2016). Immunofluorescent Staining of Mouse Intestinal Stem Cells. Bio-protocol 6(4): e1732.

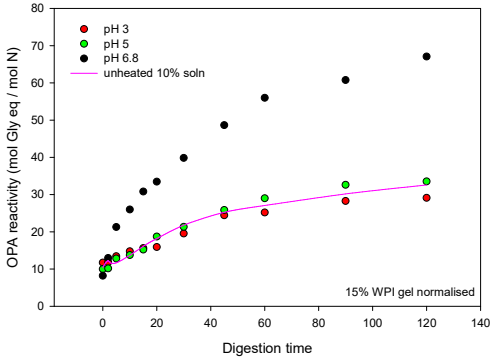
Structure - SEM

	pH 3	pH 5	pH 6.9
5kx			
25kx			

Intestinal digestion 15% WPI gels



'Raw data' - a measure of total peptides



Normalised against total nitrogen
- a measure of the degree of polymerisation

Coupling biosensors with humanised models

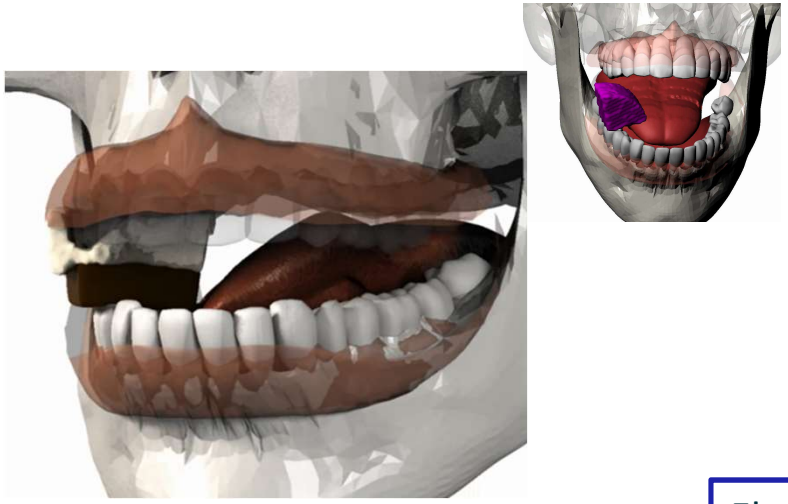
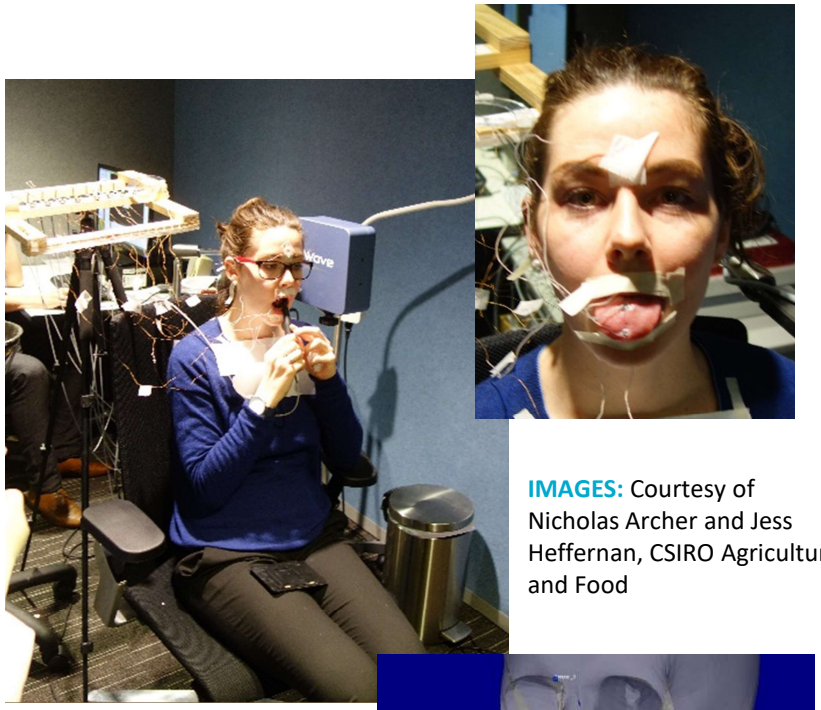
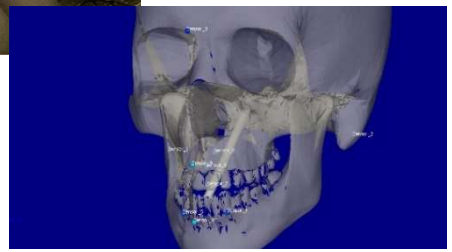


IMAGE: Courtesy of Simon Harrison and Paul Cleary, CSIRO DATA-61





IMAGES: Courtesy of Nicholas Archer and Jess Heffernan, CSIRO Agriculture and Food

Electromagnetic Articulograph **(EMA)**, in collaboration with Macquarie University

Our research vision...