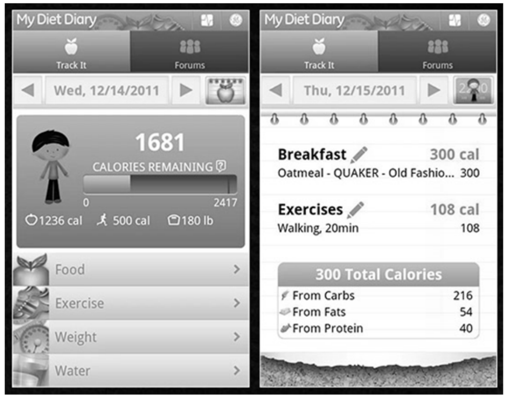
USE OF ARTIFICIAL INTELLIGENCE IN OPTIMIZING NUTRITION

Shaji Krishnan, TNO, The Netherlands

NUTRITION/DIET APPS AND MARKET



Market is flooded with nutrition/diet apps

APPS TEST-BED SAYS…

… these are not apps, but are traps

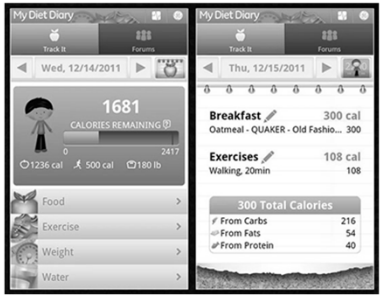


Illustration by Brobel Design for TIME; TIME Health June 5, 2017 Weight Loss

APPS TEST-BED (CONT.)

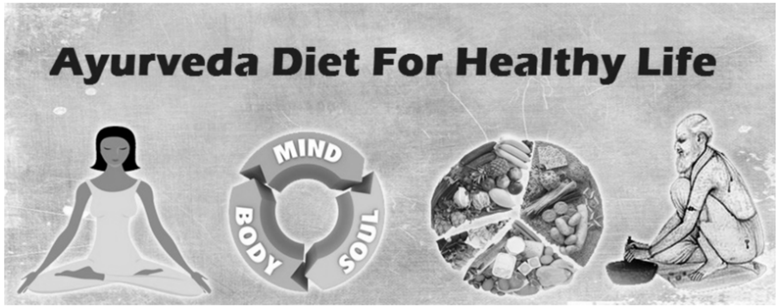
- Does these diet apps do any good?
- Are they modelling nutrition all right?
- How much of the biological (nutritional) knowledge is taken into consideration while designing this apps?
- What is the role of AI in nutrition?
- Is it all feasible or are their any known limitations?

CONTENT

- History of optimizing nutrition
- Expert systems
- Marriage of science and AI
- Big-data analytics in nutrition
- Conclusions

Ayurvedic diet prescriptions ~3000 years ago in India

OLDEST HISTORY



Ayurvedic diet incorporates nearly all the natural ingredients that have the positive influence throughout the body.

HISTORY ~ 1960

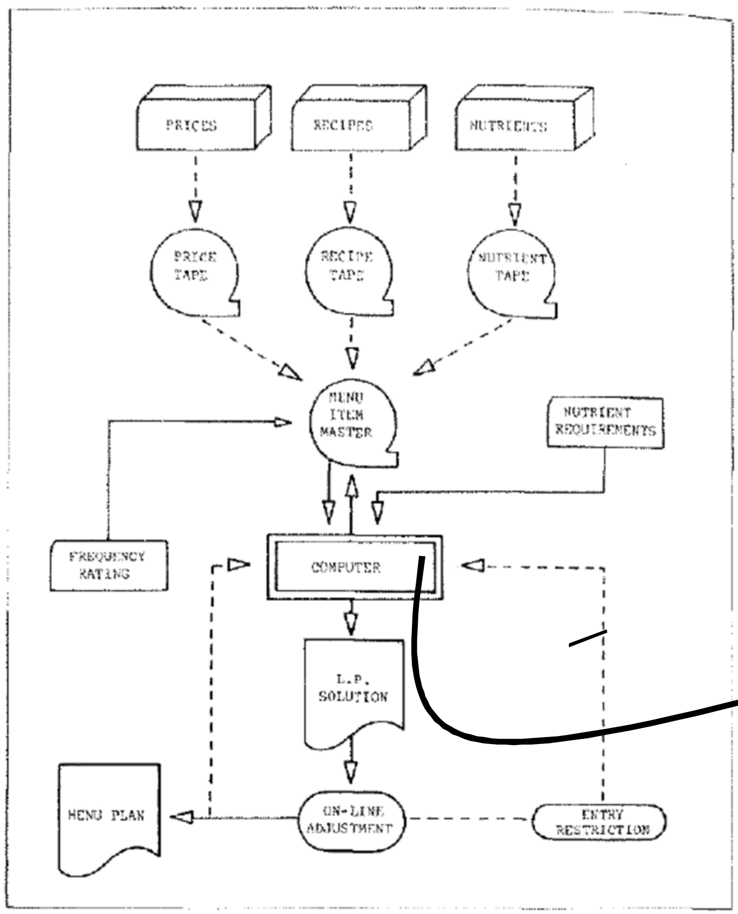


FIG. 1

Menu planning with a computer

The general objectives of the menu planning are recognized as achieving:

1. palatable,
2. nutritionally balanced and
3. economical diet

Linear programming method:
has an objective function and constrains and a feasible solution need to be obtained

Balintfy, Joseph L. "Menu planning by computer." Communications of the ACM 7.4 (1964): 255-259.

HISTORY ~ 1960 (CONT.)

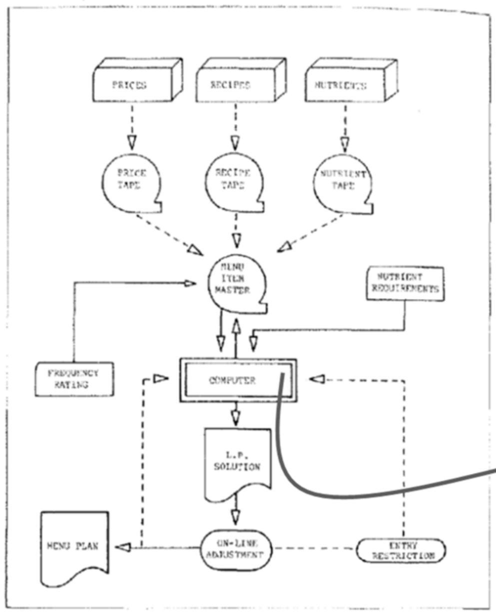


FIG. 1

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1. palatable,
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Linear programming method:
has an objective function and constrains and a feasible solution need to be obtained

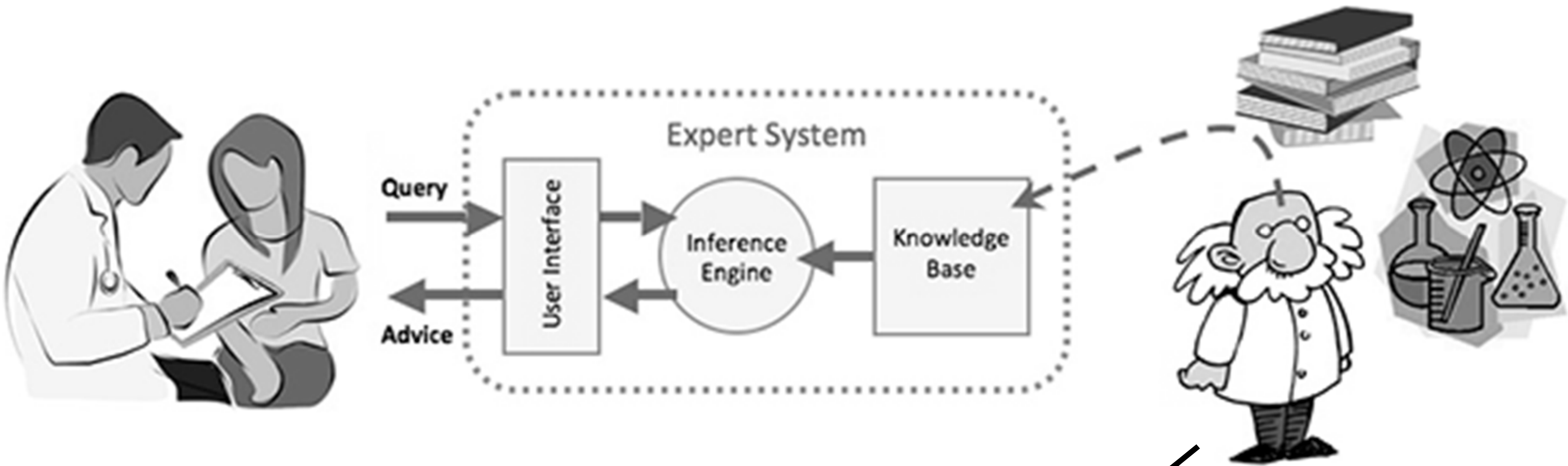
Other methods:

1. Evolutionary computation (Genetic algorithms)
2. Collective intelligence (e.g. Bacterial foraging)

Until 90's computer-assisted menu planning were not widely used.
Human experts consistently outperform computers.

HISTORY ~ 1990 – 2000

Expert system: AI system that attempts to model the processes of an human expert



Methods for inference were majorly:
1. Cases based reasoning
2. Rule based reasoning

Novelty: Incorporation of expert knowledge

HISTORY ~ 1990 – 2000 (CONT.)

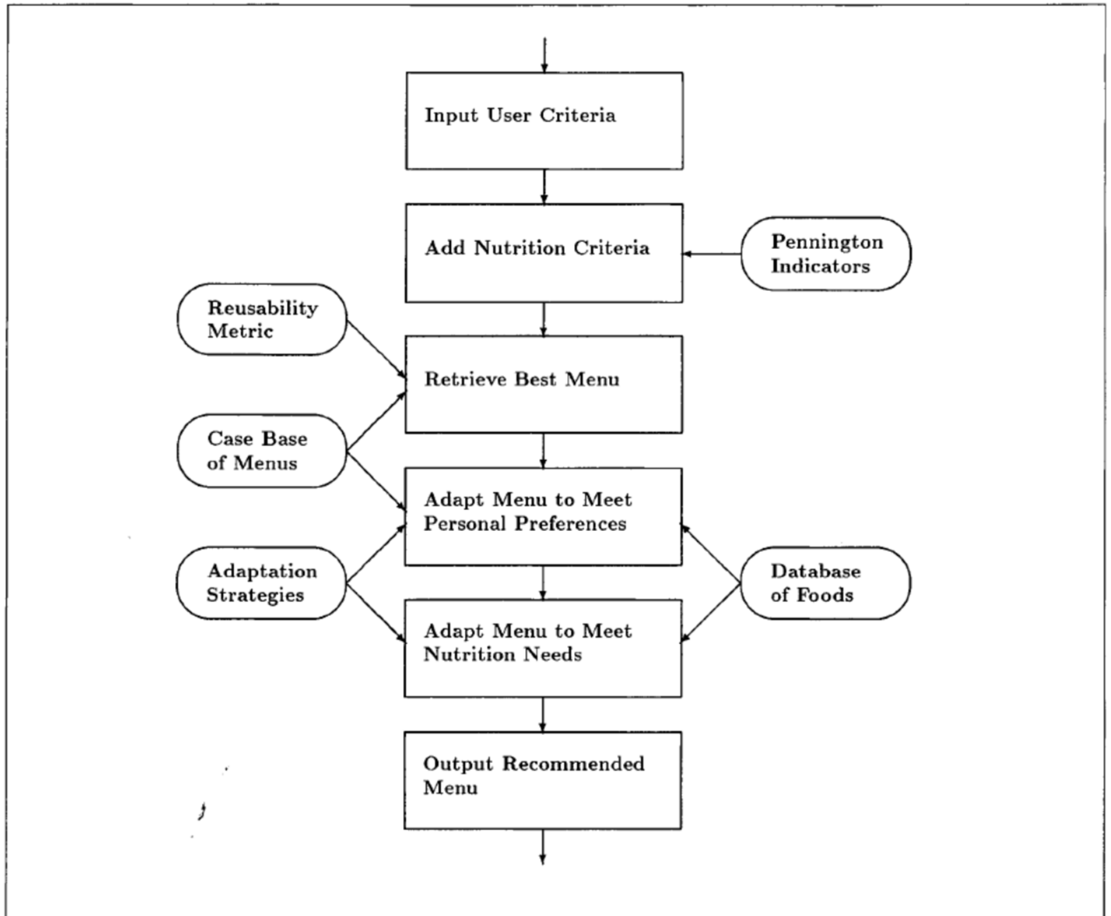
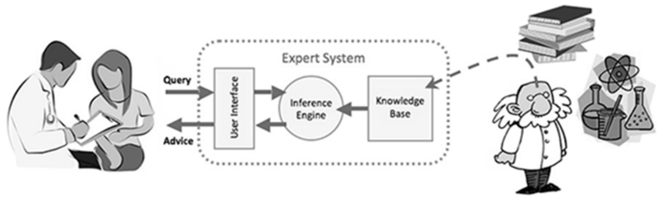


FIG 1. A flow chart for the CAse-based Menu Planner.

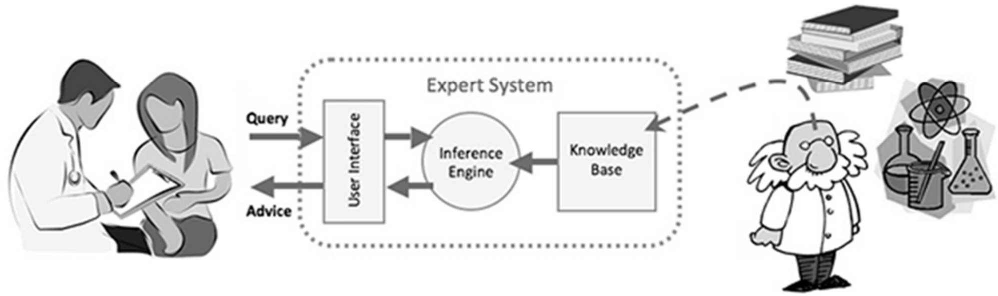
Petot, Grace J., et al. Journal of the American Dietetic Association 98.9 (1998): 1009-1014.



Knowledge:
1. Database of foods
2. Case base of menus (dietary guidelines)
3. Nutritional risk indicators

HISTORY ~ 1990 – 2000 (CONT.)

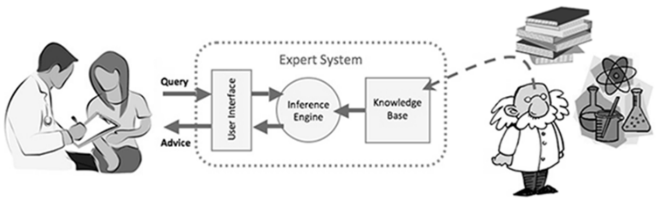
The anthropometry data	• Calculation of obesity • BMI • Waist/hip ratio • Kaup index
The computation of calorie expenditure	• Basal metabolic expenditure • Specific dynamic action • Total calorie expenditure
The state of eating habits	• The analysis of eating habits • Eating habits for hyperlipidemia • Convenient method for analysis of nutrients
Nurtition prescription	• Prescription of each test • Synthetic prescription by experts
The computation of calorie expenditure	• CAGE • NAST • AUDIT-K



Diet advice based on health state and health goals were added

Clinical measurement data + Physiology

HISTORY ~ 1990 – 2000 AND BIT BEYOND…



A typical outcome from an expert system

CAMP's Recommended Menu

Breakfast
¾ c pineapple chunks, packed in juice
2 English muffins with
2 tsp margarine
1 c skim milk

Lunch
Sandwich
- 1 slice whole wheat bread
- 2 oz chicken breast
- 1 leaf lettuce
- 1 slice tomato
- 1 tsp mayonnaise-type salad dressing

1 c vegetable soup
6 saltine crackers
1 ½ medium oranges
1 c skim milk

Dinner
Salad
- 1 c mixed salad greens
- ½ medium tomato, sliced
- 1 Tbsp Italian dressing

3 oz roast leg of lamb
¾ c spinach
1 medium baked potato
1 tsp margarine
½ c corn
Coffee, tea, or water

Snack 1
¼ c raisins

Nutritional Profile[a]
Energy: 1,830 kcal
Percentage of energy from fat: 23
Percentage of energy from protein: 19
Percentage of energy from carbohydrate: 61
Percentage of energy from alcohol: 0

Percentages of Reference Daily Intakes (RDIs)[b]

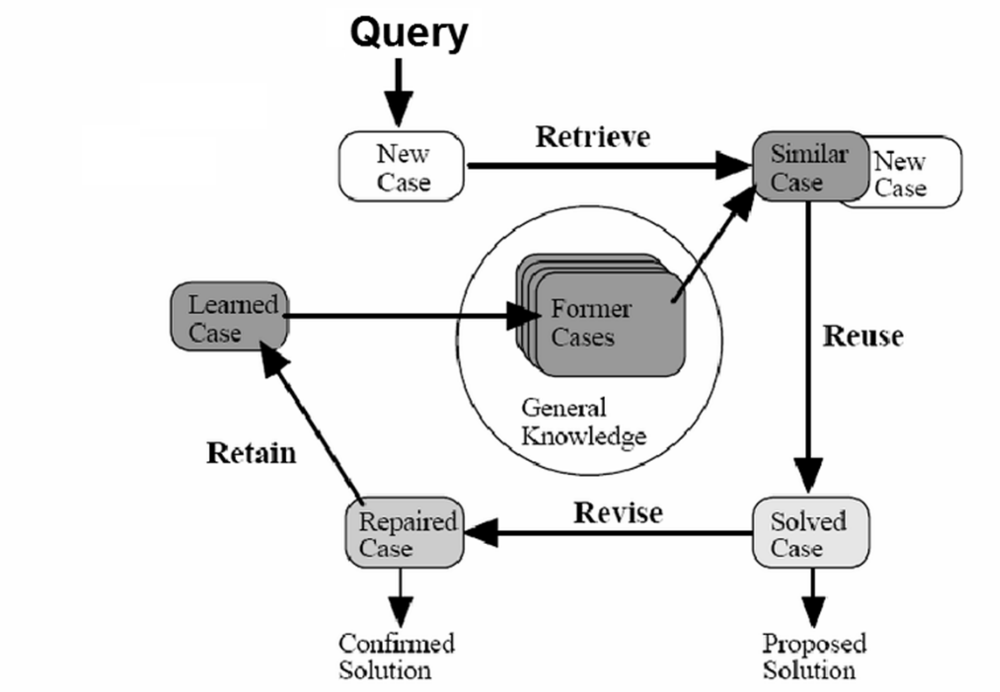
Protein: 173%	Vitamin C: 333%	Thiamin: 134%
Niacin: 137%	Riboflavin: 135%	Vitamin B-6: 124%
Vitamin B-12: 71%	Folic acid: 146%	Vitamin A: 369%
Vitamin E: 36%	Iron: 108%	Calcium: 123%
Phosphorus: 140%	Potassium: 132%	Magnesium: 113%
Copper: 102%	Zinc: 72%	

Nutrient Data

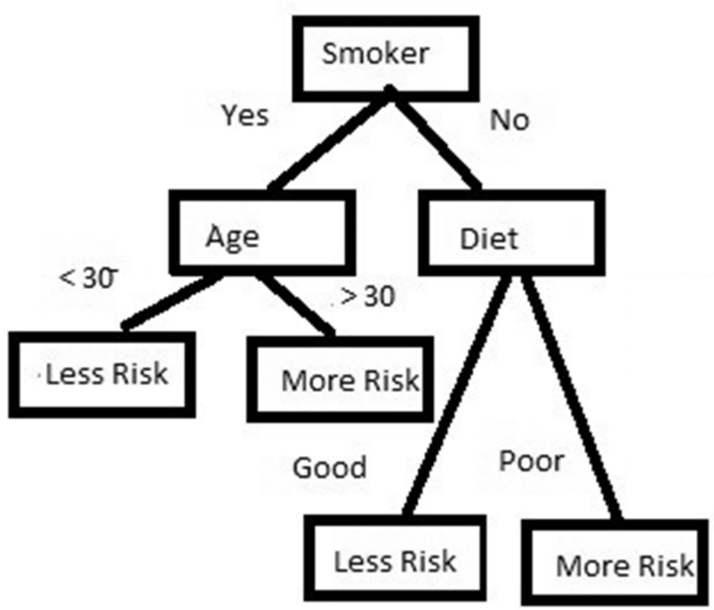
Energy: 1,830 kcal	Protein: 86.3 g	Fat: 47.6 g
Carbohydrate: 278 g	Alcohol: 0.0 g	Fiber: 26.7 g
Cholesterol: 131 mg	Vitamin C: 199.60 mg	Thiamin: 2.01 mg
Niacin: 27.42 mg	Riboflavin: 2.29 mg	Vitamin B-6: 2,471 µg
Vitamin B-12: 4.27 µg	Folic acid: 0.59 µg	Vitamin A: 18,455 IU
Vitamin E: 7.26 mg	Iron: 19.44 mg	Calcium: 1,229 mg
Phosphorus: 1,398 mg	Sodium: 2,230 mg	Potassium: 4,617 mg
Magnesium: 453 mg	Copper: 2.03 mg	Zinc: 10.86 mg

FIG 4. The CAse-based Menu Planner's menu and analysis for the input shown in Figure 3.
[a]The standard method of calculation does not ensure that percentages add to 100.
[b]The RDI for Vitamin B-12 is 6 µg, which is higher than other standards. See reference 13.

LIMITATIONS OF EXPERT SYSTEM



Case based reasoning



Rule based reasoning

Not suitable for personal dietary advice

Adapted from Rajagopal, Diss. University of Washington, 2007.

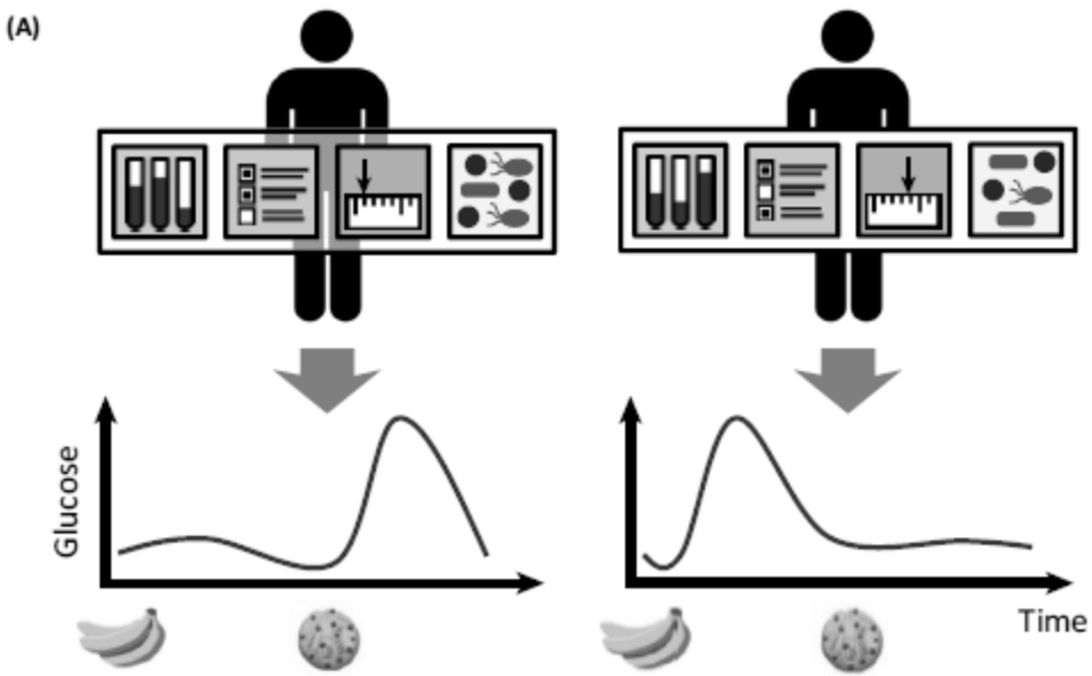
MARRIAGE OF SCIENCE AND AI

- How much of the **biological (nutritional) knowledge** is taken into consideration while designing this apps?
- What is the role of AI in nutrition?

Drivers for success; Science; AI; Marriage of science and AI ?

SCIENCE (1)

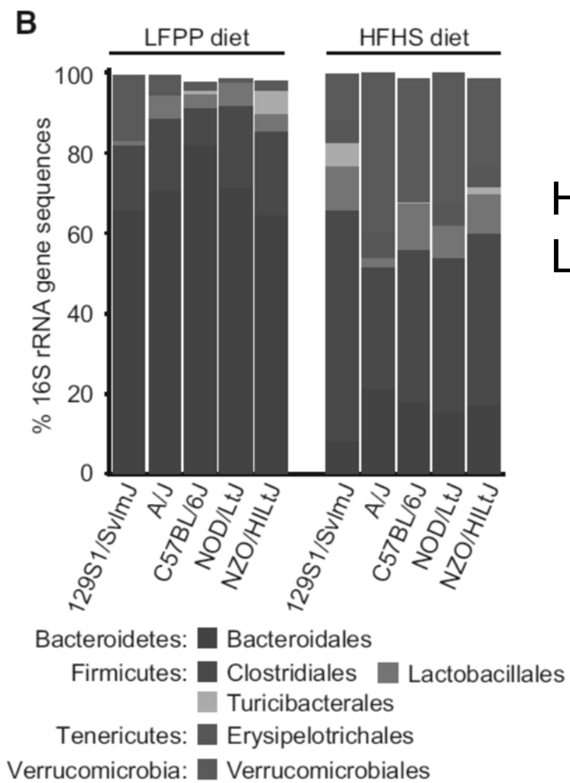
People eating identical meals present high variability in post-meal blood glucose response.



Zeevi, David, et al. Cell 163.5 (2015): 1079-1094.

SCIENCE (2)

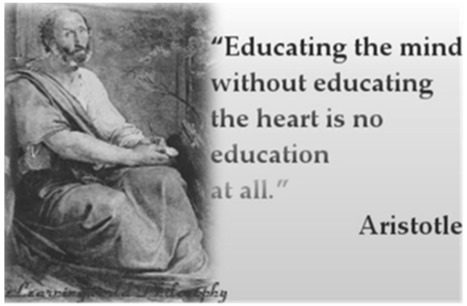
Diet dominates host genotype in shaping the murine gut microbiota.



HFHS: high-fat, high-sugar diet
LFPP: low-fat, high-plant-polysaccharide diet

Carmody, Rachel N., et al. Cell host & microbe 17.1 (2015): 72-84.

AI (1)

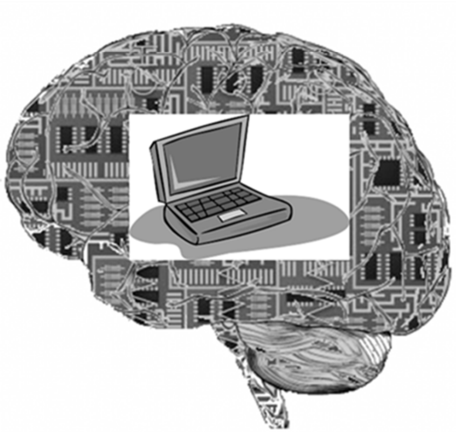


Syllogism →
deductive reasoning or inference

e.g.
All men are mortal.
Socrates is a man.
Therefore Socrates is mortal.

→ First order logic: resulted in several AI languages. e.g. PROLOG
→ Key: mathematically expressed

Very successful: e.g. building expert systems



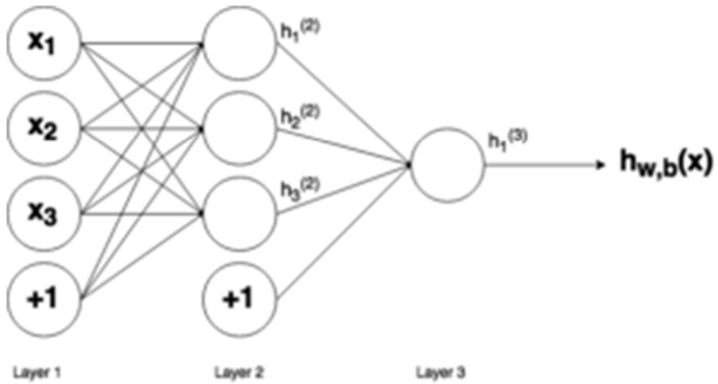
→ Artificial Neural network (mimic the working of the brain)
→ Driven by data

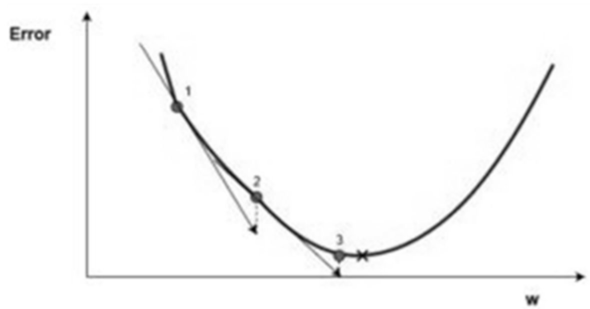
Least successful and enthusiasm over neural net came down around 1970

Today's algorithms crunch voluminous data and discover patterns, relationships among data variables………teach themselves too.

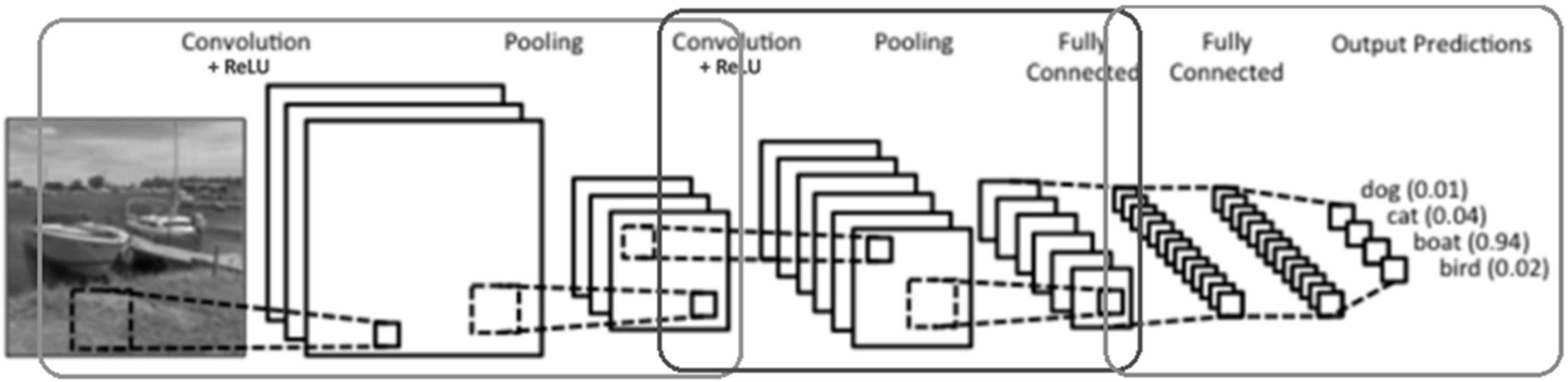
AI (2)

After a silence, interest in Artificial Neural Network (ANN) sparked again



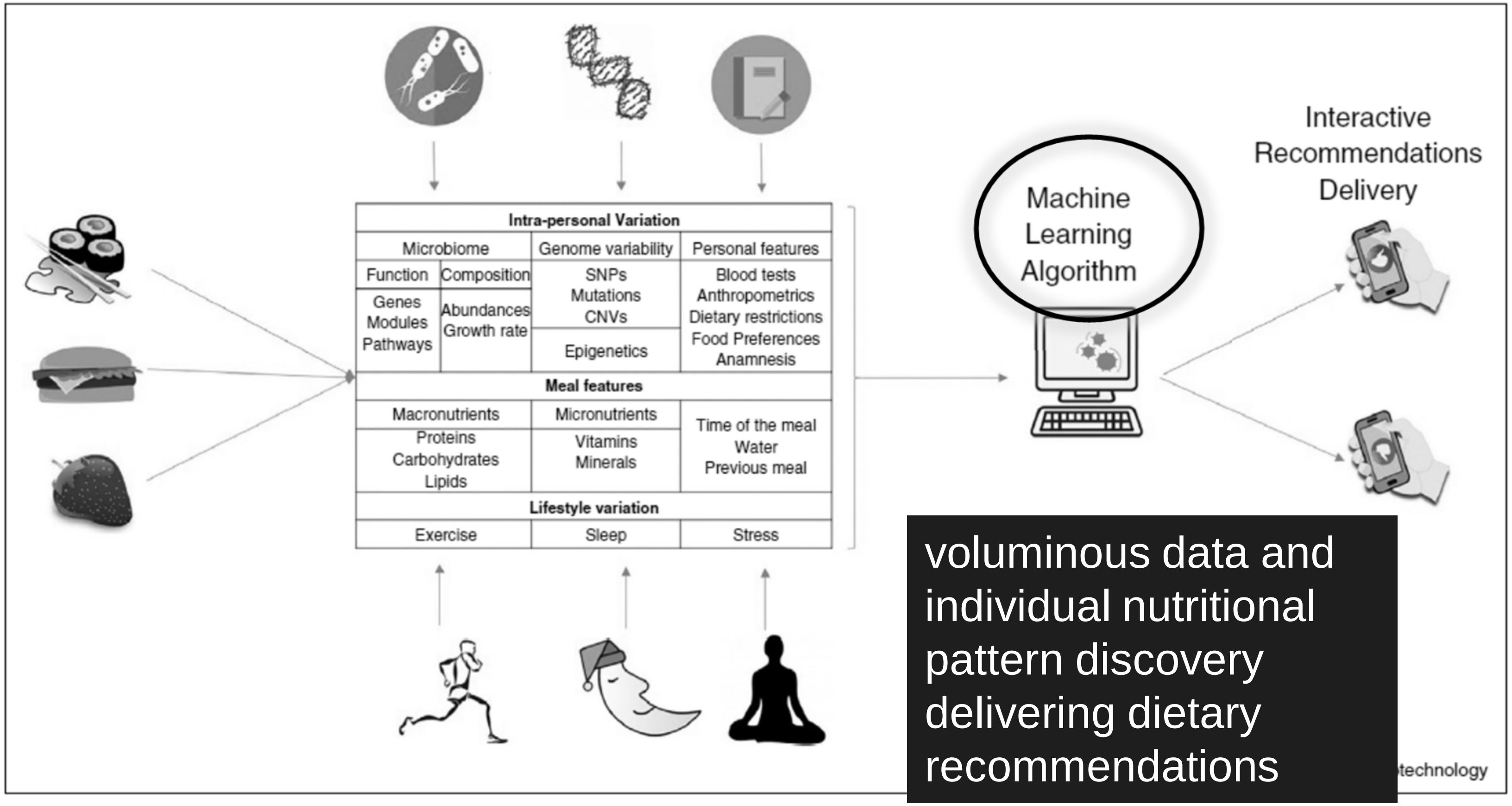


Hidden layers is greater than 2 then Deep learning architecture



Shift in paradigm…

MARRIAGE OF SCIENCE AND AI



voluminous data and individual nutritional pattern discovery delivering dietary recommendations

Rationally designed personalized dietary approaches determine the effects of numerous parameters on diet response (e.g. microbiome composition, genome variability, personal lifestyle, medical metadata). Machine learning algorithms utilize these comprehensive data sets to deliver dietary recommendations.

Bashiardes, Stavros, et al. Current opinion in biotechnology 51 (2018): 57-63.

BIG-DATA ANALYTICS

Precision nutrition aims **to prevent and manage chronic diseases by tailoring dietary interventions** or recommendations to one or a combination of an individual's genetic background, metabolic profile, and environmental exposures.

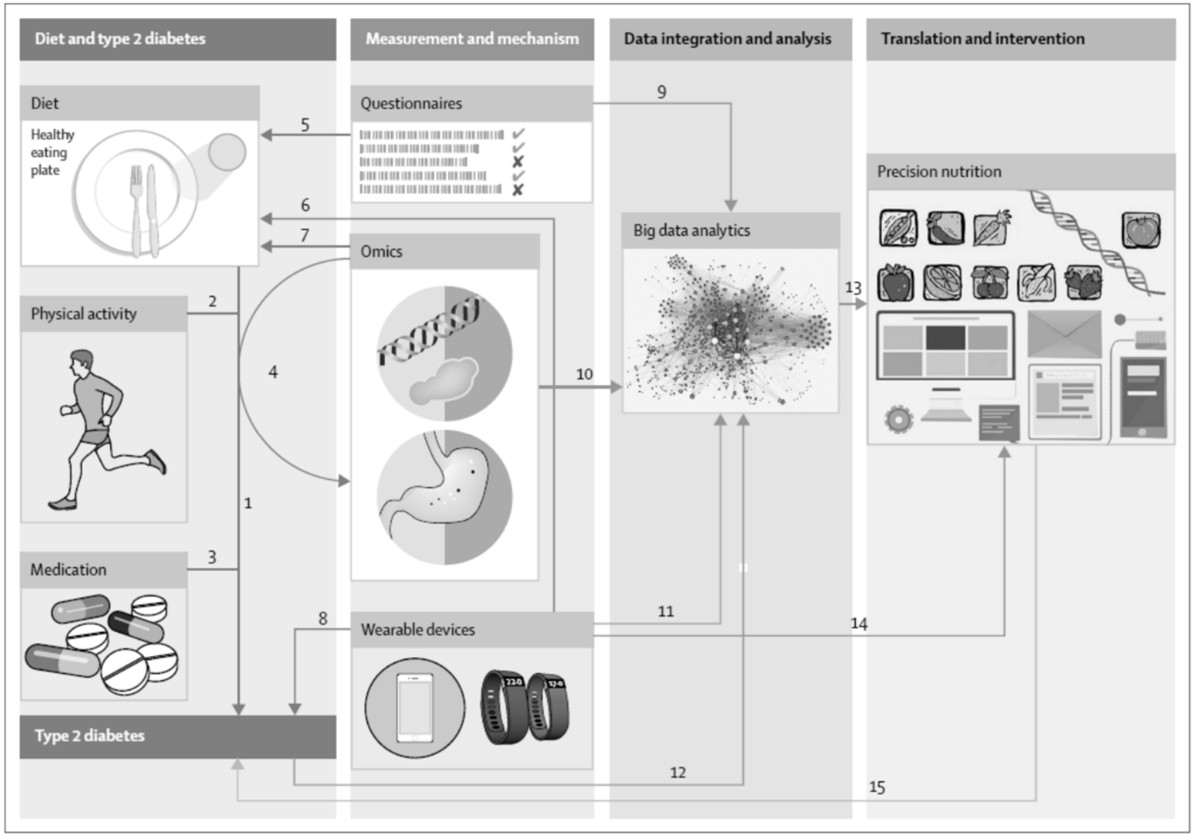


Figure 1: Conceptual framework for precision nutrition in prevention and management of type 2 diabetes

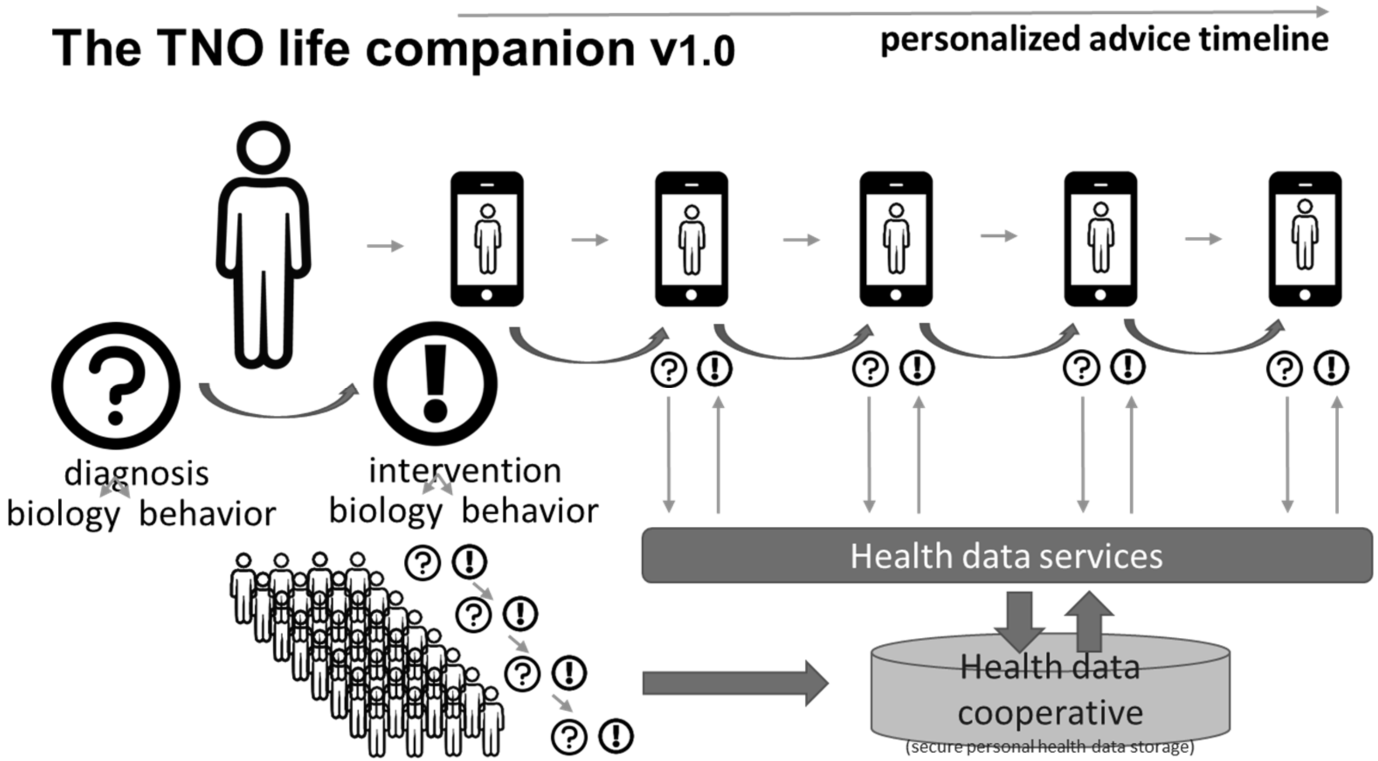
Wang, Dong D., and Frank B. Hu. *The Lancet Diabetes & Endocrinology* (2018).

WORD OF CAUTION

Several commercial companies have started to **market personalised nutrition assessment and treatment based on genotypes**, but the benefits of such approaches on improving diet quality and health outcomes have not been demonstrated.

Wang, Dong D., and Frank B. Hu. *The Lancet Diabetes & Endocrinology* (2018).

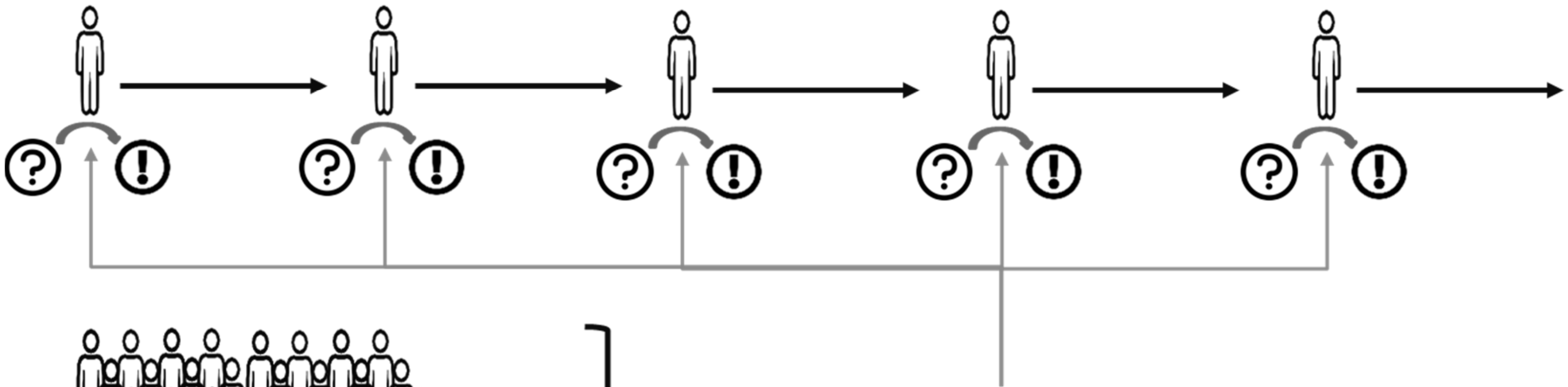
AT TNO

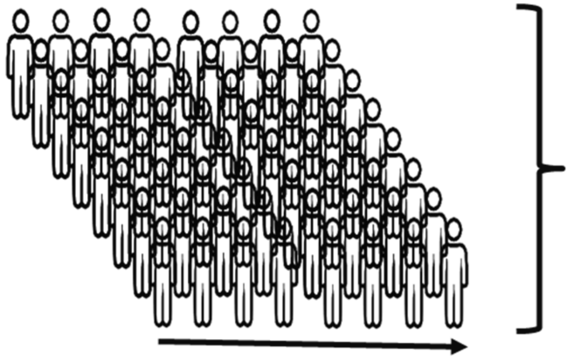


Personal nutrition is part of a personal health package

AT TNO (CONT.)

I make regular adjustments to my diet and behavior in order to stay on track



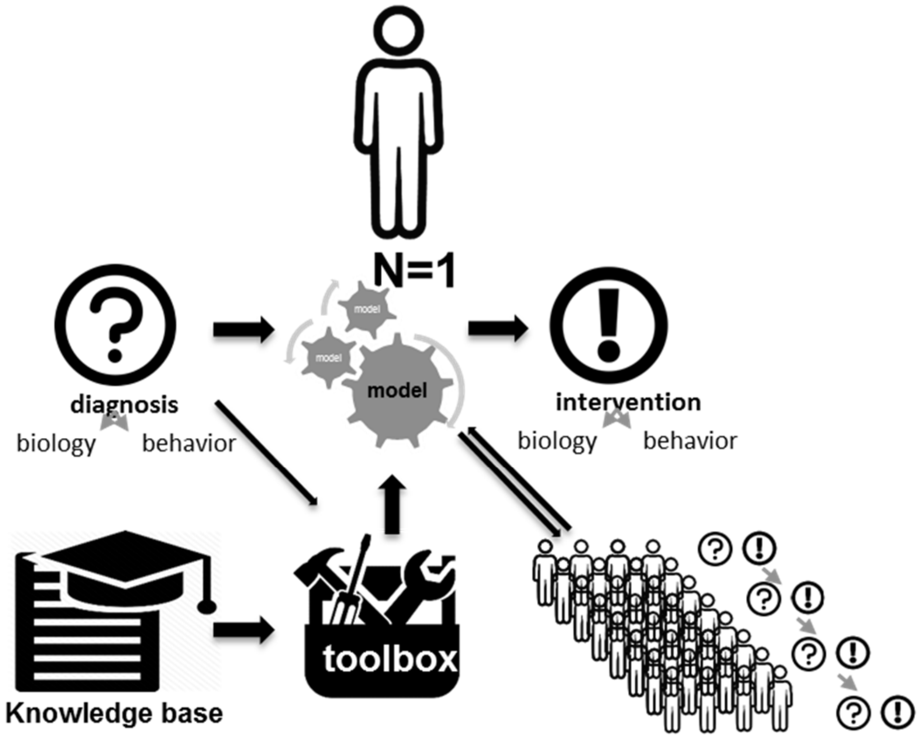


Can we make use of thousands
of other personal health timelines
to optimize every decision I make
for my personal health ?

Bayesian networks
Artificial Intelligence

AT TNO (CONT.)

So how does personalized nutrition work?



1. It is personal
2. The intervention or advice is based on a diagnosis
3. A (science based) model is used to translate diagnosis into advice
4. The model is tailored to specific conditions and goals from a large toolbox
5. The toolbox is continuously and systematically updated with all relevant scientific knowledge
6. Exploit/use information from large numbers of personal health data

MAJOR CONCLUSIONS

- AI assist in increasing and applying our current knowledge in science
- Science based models augmented with the number crunching power of AI must drive nutritional research (health advice: dietary)

- Precision medicine is to become a reality soon (AI on a chip is available today)

THANK YOU FOR YOUR ATTENTION