LECTURE SUMMARIES *by Dave Williams*

11/09/2019 **Plastics** - *Types, Properties, Processing, Selection and Recycling* Dr Ron Bennett

Plastics use simple, cheap, accessible building blocks, Highly automated production and wide ranging manufacturing options are available. A wide variety of shapes are possible without post-processing steps. They offer technical, retail and consumer benefits ("consumerism") compared with alternative materials.

Plastic is a polymer made from repeating monomer units (either same or different). It can be thermoplastic or thermosetting; higher performance types are referred to as engineering plastics. Thermoplastic may be many thousands in monomer units long and highly viscous at melt stage. Plastic is shaped by a physical process.

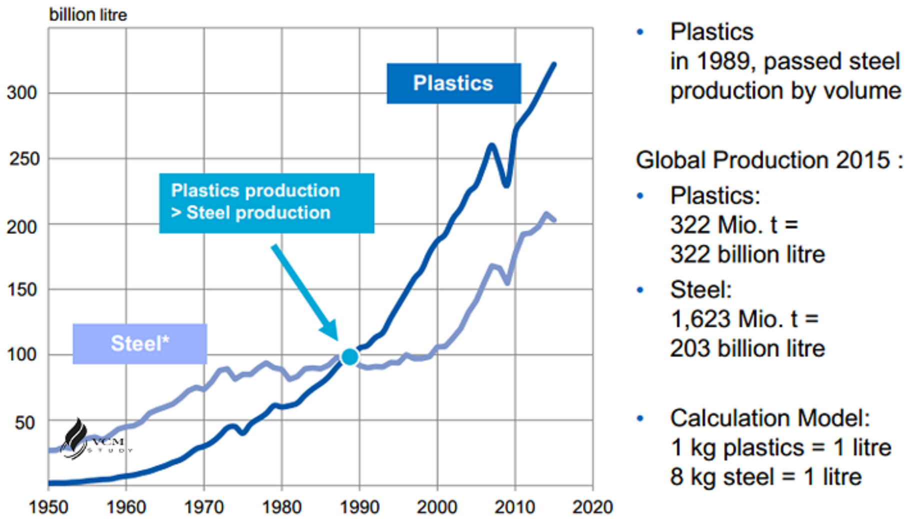
Thermoplastics can be divided into two types:

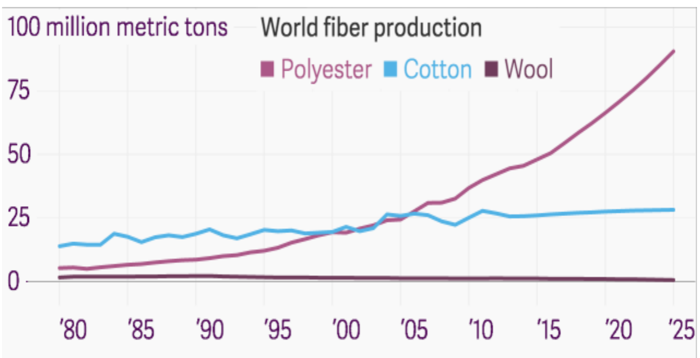
1. semi-crystalline e.g. polyethylene, PET, nylon

2. amorphous e.g. polystyrene, polycarbonate.

This graph shows how plastics have replaced steel

The graph below shows how polyester fibre has taken over from cotton.





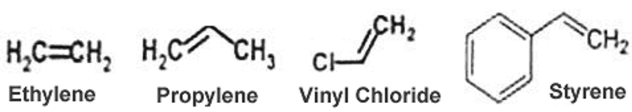
Plastics 1850 - 1960

Gutta Percha 1851 - cable
Ebonite - electrical fittings
Parkesine 1862 - sheet and balls
Shellac 1869 - castings
Plasticised Parkesine 1879 - Celluloid film
Casein plastics (reacted with formaldehyde) 1897
Bakelite 1907 - electrical fittings
UF Resins 1918 - moulded parts
Cellulose Acetate Plasticised 1927
Polyester, polyurethane, polyamide, polyethylene, PTFE, polystyrene (1930's)
Polyvinyl chloride, ABS, PET and 'super glue' (1940's)
Polypropylene, polycarbonate, cellophane (1950's)

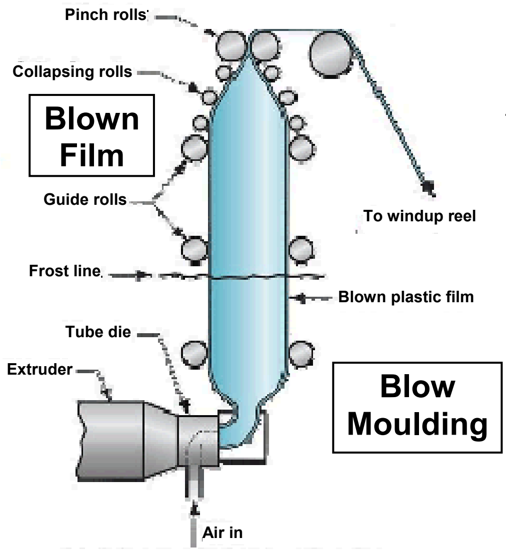
The early plastics were produced from natural materials like coal, but after1930 the plastics today are products of the petrochemical industries.

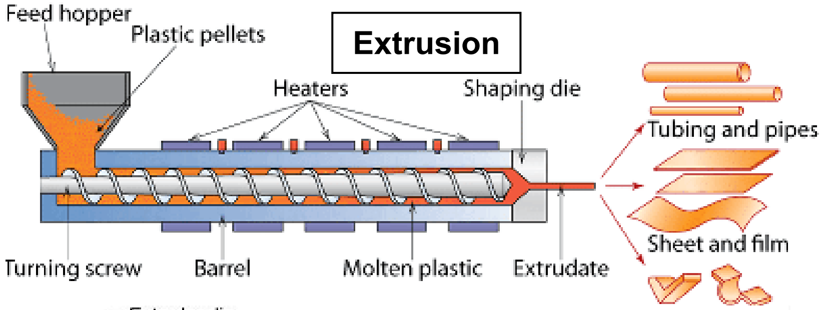
One interesting fact is that cellophane involved nasty substances like carbon disulphide and caustic soda during manufacture, so has been superseded by polypropylene, cheaper to produce. However cellophane can be screwed up to throw away, but polypropylene springs back .

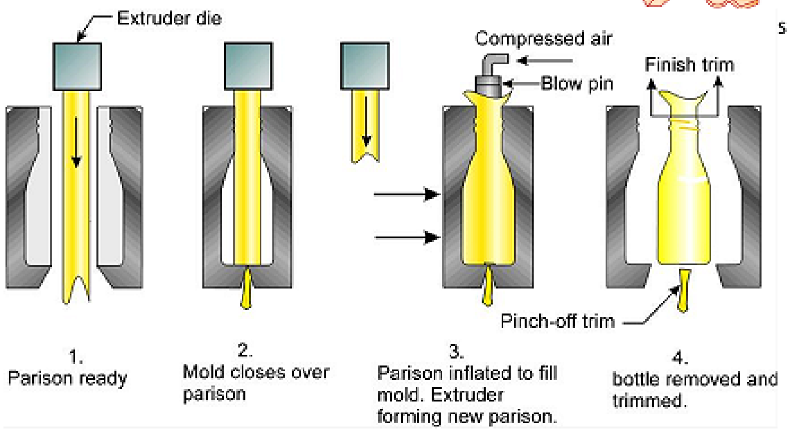
All plastics are composed of a common few building blocks joined together in a multitude of ways to produce many different properties.



Industrial processes such as extrusion, blow moulding and blown film production were described.







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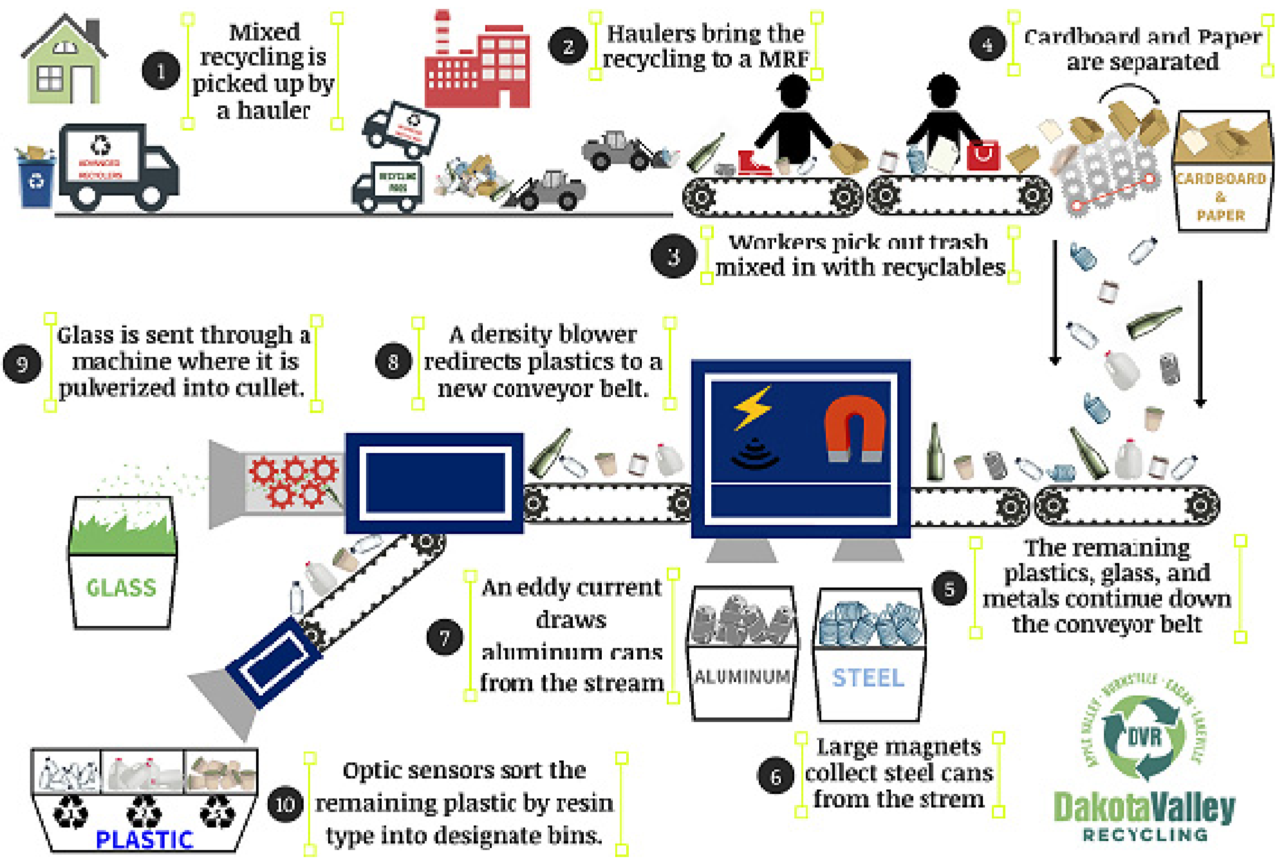
Now that more and more plastic is being produced, how do we get rid of it? Options are:

- Use as a filler
- Reuse without chemical change (mixed with virgin polymer for high level reuse
- Recycle with chemical change
- Degrade (controlled)
- Burn (incinerate)
- Landfill (last resort)

Mixed Recycling Facility



Near-infra-red spectroscopy is used to distinguish between different types of plastics (not black).

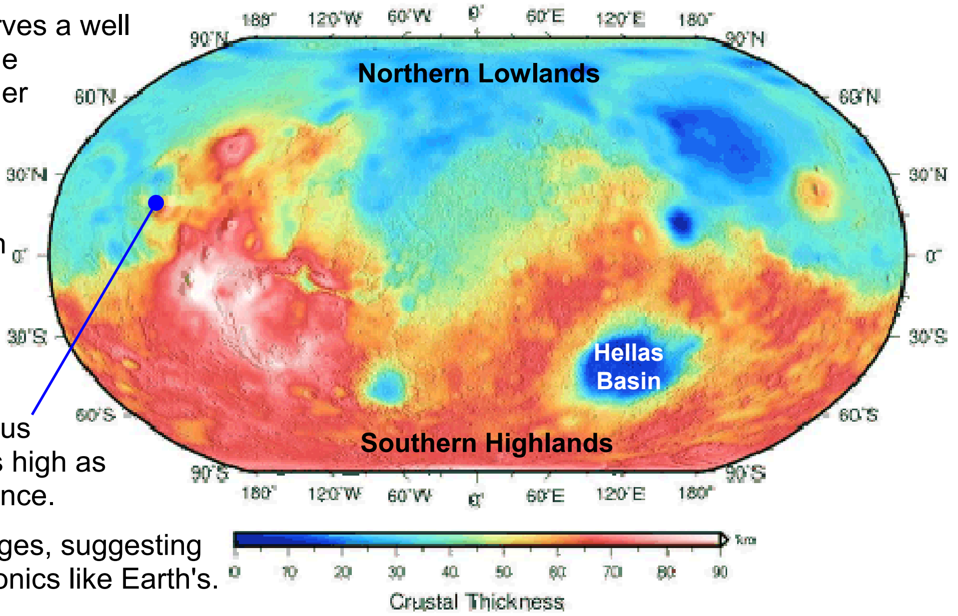
16/10/19 **The Surface of Mars: A Partial Geological History of the Red Planet**

Joel Davis, Postdoctoral Researcher, Natural History Museum.

The surface of mars preserves a well kept, diverse and accessible geological record of the inner solar system.

It is divided into two halves: the southern highlands, and the northern lowlands which are relatively flat with hardly any craters, and so thought to be younger.

A peak on the left is Olympus Mons, about three times as high as Everest and the size of France.



There are no mountain ranges, suggesting that there are no plate tectonics like Earth's.

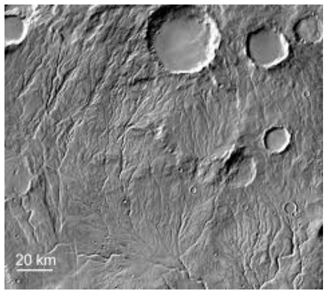
Geological eras are named Noachian (4.1 - 3.7 billion years ago), Hesperian (3.7 - 2.9 billion years ago), and Amazonian (2.9 billion years ago to the present).

Valley networks are some of the strongest evidence for widespread river erosion on the martian surface - analagous to river valleys on the Earth. They are up to thousands of kilometres in length.

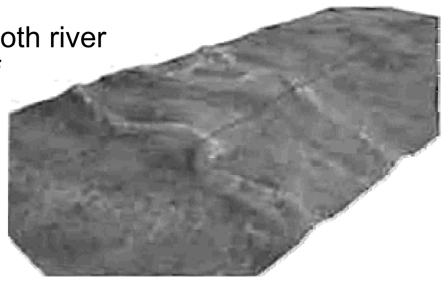
90% of known networks are on Noachian terrains.

Formation timescales range from 10^6 to 10^7 years.

Dense pluval valley network with multiple tributaries which extend up to watersheds (craters).



Inverted River Channels are ridges of indurated river deposits, which form due to differential erosion. They comprise both river and floodplain deposits. Fluvial deposits are reliable indicators of paleoclimate.



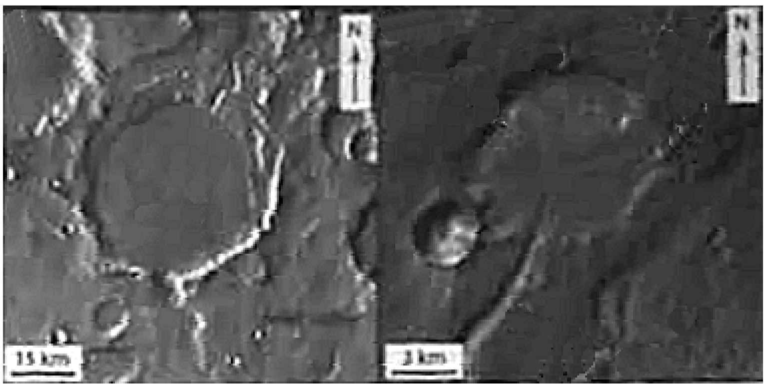
Craters are the primary source of relief on Mars. They acted as source regions for sediment and sinks, forming basins. Paleolakes are identified where fluvial valleys intersect basins.

There are around 200 paleolakes on Mars (mostly Noachian and early Hesperian periods).

Many basins 'outlets' are observed, indicating that water filled the basin enough to reach the rim.

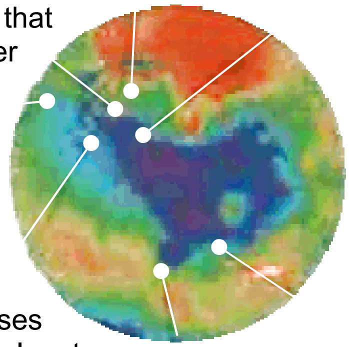
Lakes on early Mars

Open basin paleolake with terraces. Note the presence of both inlet and outlet valleys.



Open basin lake with sediment fan.

The blue area of this north polar view of Mars shows a low flat area that could have been an ocean. Close-ups at the white spots show river deltas on the shoreline, and they are all at the same height within 150 metres, further evidence of an ocean.



A changing climate. After the Noachian era the availability of liquid water decreased. Lack of magnetic field meant atmosphere is removed by solar wind. However it is thought that water migrated underground as liquid and ice.

While the availability of water was decreasing, volcanic processes increased during the Hesperian era. Volcanoes resurfaced much of the planet.

After the Hesperian era, water was mostly frozen, with stable water ice caps at the poles.

The Mars Odyssey spacecraft detected large concentrations of hydrogen in shallow sub-surface in mid-latitudes, confirmed to be water by the Phoenix Lander by digging.

Numerous debris-covered mountain glaciers are frozen to the surface. They may have been active under different orbital conditions.

Today, wind is the dominant medium shaping Mars. Ranges of sand dunes and ripples are active in numerous locations. Dunes are dark owing to their basaltic composition.

30/10/19 **From Gout to Mad Cow Disease - My Biochemical Journey**
David Perrett, Professor Emeritus of Bioanalytical Science at Barts and the London School of Medicine & Dentistry, Queen Mary University London.

The professor was born in the coalmining community of Grovetown, Pontefract, Yorkshire. He originally wanted to be a historian but was told he couldn't do Latin and so History was ruled out. His next choice was Chemistry at Exeter University. After graduating he came to work for two years at Barts Hospital; it eventually became 50 years.

In 1968 he started working at Dunn Laboratories, Oxford, as well as in Barts. He was in the Medical Professorial Unit led by Sir Eric Scowen. Facilities included 10 small general labs, a Metabolic ward, an animal house with operating theatre, and a mass spectrometry unit. Research was in the fields of inborn errors of metabolism, clinical pharmacology, endocrinology, and an MRC atmospheric pollution unit.

He finished his working days at Barts Medical College, Charterhouse Square.

The following table shows the typical sample sizes required for analysis at the time:

Year	Sample weight	Techniques
1930	gram	Distillation, precipitation, liquid extraction
1940	milligram	Electrophoresis, column chromatography, counter-current distribution
1950	microgram	Paper chromatography, TLC
1960	nanogram	Radioimmunoassay, Gas-liquid chromatography, GC-MS
1970	picogram	High performance LC (HPLC), HPLC on silica.
1980	femtogram	ELISA. Ion-pair extraction, capillary electrophoresis
1990	attogram	
2004	zeptogram	LC-mass spectrometry, LC-MS/MS
2008	yoctogram	Ultra-performance LC
2019	??	???

Biomedical samples can be of blood (or plasma), urine, breath, calculi (kidney stones), taken from many species e.g. mice, fish, racehorses, cattle.

Humans have a wide range of biological diversity due to ethnicity, culture, food etc., unlike inbred lab animals in which many factors can be controlled.

Samuel Pepys was bothered by bladder and kidney stones. Stone formation also affected his mother, uncle and brother. At age 25 he could bear the pain no longer and resorted to the knife of a master barber surgeon Thomas Hollyer. The operation on 26 March 1658 was without anaesthetic, antiseptic, or pain relief, and a stone 'the size of a tennis ball' was removed. Amazingly, Pepys survived.

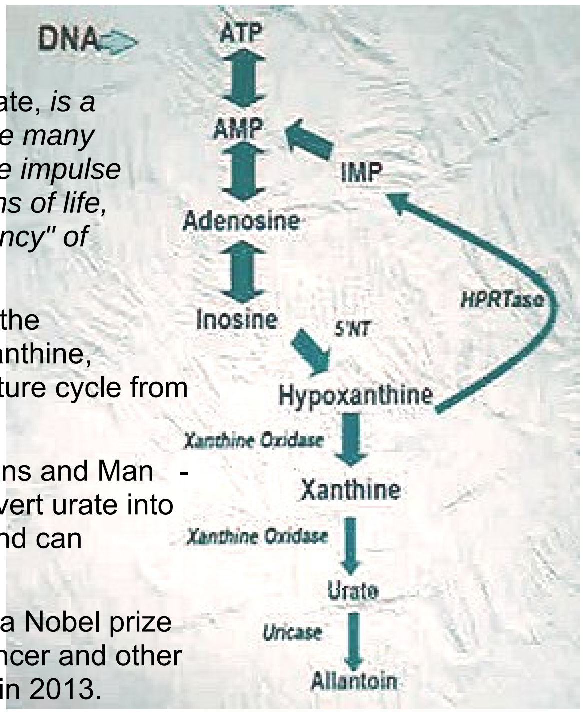
The picture is from 'A Treatise on Lichotomy' by François Tolet 1683 (Wellcome Library, London)

Prof Perrett's start in Barts concerned Cystinurea, an inherited autosomal recessive disease. Cystine is an amino acid, insoluble in urine, leading to big kidney stones. In affected patients, it is not transported in the intestine or kidney.

Treatment with D-Penicillamine had been discovered at Barts in 1966. It reacts with insoluble cystine to form more soluble Cys-Pen; even cystine stones could slowly disappear.

The professor also became involved in the study of purines and pyrimidines, part of our RNA and DNA, essential for life and energy metabolism in the body.

This slide was shown entitled
Partial Metabolic Pathway for ATP degradation.



[According to Wikipedia, ATP, or adenosine triphosphate, *is a complex organic chemical that provides energy to drive many processes in living cells, e.g. muscle contraction, nerve impulse propagation, and chemical synthesis. Found in all forms of life, ATP is often referred to as the "molecular unit of currency" of intracellular energy transfer.*]

The ATP breaks down from the triphosphate (ATP) to the monophosphate (AMP), to adenosine, inosine, hypoxanthine, xanthine, urate and soluble allantoin. There is a recapture cycle from hypoxanthine to AMP so we don't lose all our ATP.

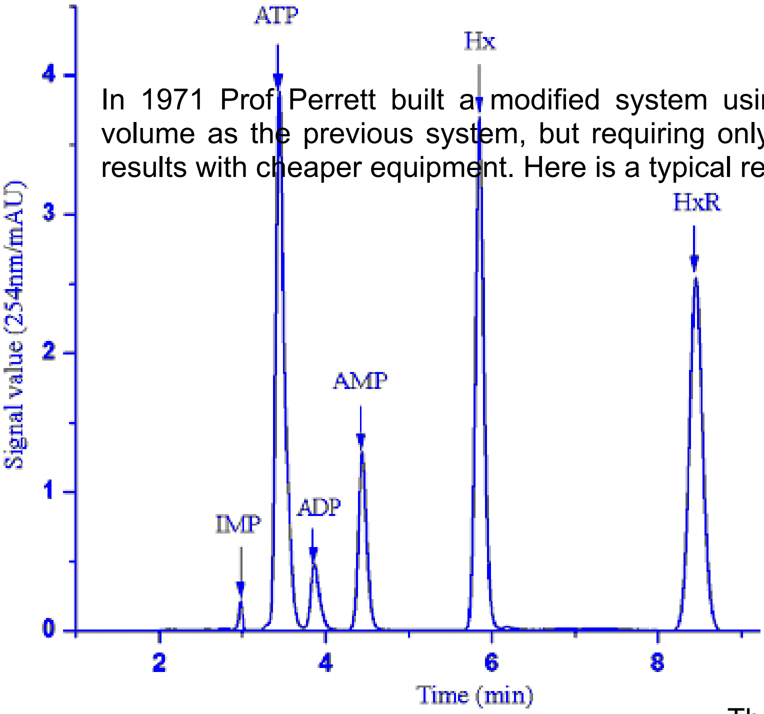
That is what happens in every animal except Dalmations and Man - we are all suffering from an absence of uricase to convert urate into allantoin. Instead, uric acid accumulates in the body and can manifest itself as gout.

At Wellcome Labs in USA, Ellon & Hitchings received a Nobel prize in 1968 for discovering 7 major drugs to treat gout, cancer and other maladies. Prof Perrett co-authored a book about gout in 2013.

Sir Humphry Davy said in 1812 "Nothing tends so much to the advancement of knowledge as the application of a new instrument". In 1903 a botanist Tswett invented a method that came to be called chromatography, which he used to separate complex mixtures of plant pigments. A sample mixture was put on top of a column of silica in a clear tube, and when a suitable solvent was poured on top, the colours separated out into bands down the tube.

The purines and pyrimidiines absorb ultraviolet light around 260nm. In 1967 High Performance Liquid Chromatography (HPLC) was developed. This involved a 3m long column containing anion exchange water-softening resin, into which the sample mixture was pumped at 3000psi pressure.

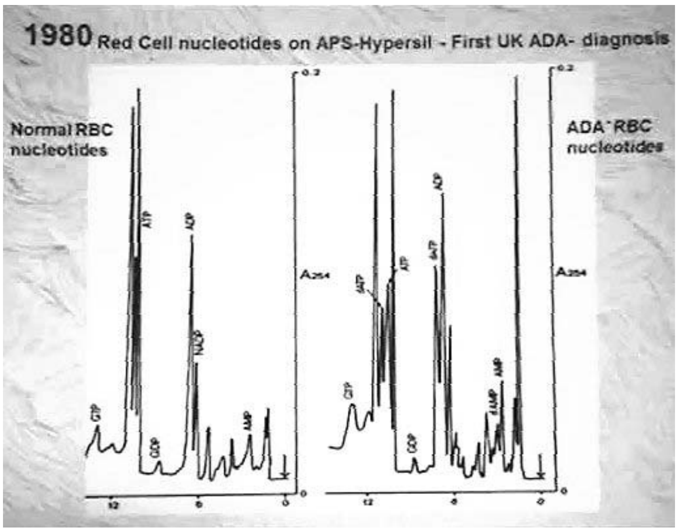
In 1971 Prof Perrett built a modified system using a short but wide tube with the same volume as the previous system, but requiring only 25psi pressure, resulting in much faster results with cheaper equipment. Here is a typical result [from ultraviolet response v time].



Prof Perrett became routinely able to separate 23 nucleotide peaks in a 13 mins run.

Then along came a new disease - Severe Combined Immuno-Deficiency (SCID) in infants due to Adenosine Deaminase deficiency. They had a total lack of B- and T- cells and had to live inside a plastic bubble to avoid infection.

Most of these children were in the USA but eventually one case cropped up in Great Ormond Street Hospital.



The patient's red blood cells were tested and it was obvious that extra nucleotides were present in the ADA-deficient blood that were not in normal blood, as shown here. They have the effect of neutralising the immune system.

In 1989 the professor was involved in Capillary Electrophoresis for separation of amino-acids with 30kV DC, the first to be used in the UK for clinical studies.

It seems the vast majority of drugs only work at best in 30% of people, so new drugs are always being sought.

There are diseases caused by prions, an abnormal form of a normally harmless protein found in the brain that is responsible for a variety of fatal neurodegenerative diseases of animals, including humans, called Transmissible Spongiform Encephalopathies (TSE's), showing as BSE in cattle and Scrapie in sheep, resulting in holes developing in the brain. A similar disease is Creutzfeldt Jackob Disease (CJD) which began with a cow dying at a farm in West Sussex in 1984. It turned out that it can spread to humans.

In 1995 variant-CJD killed a teenager. vCJD is very infectious, Surgical instruments used in affected brains will transfer the disease to healthy brains even though the instruments are sterilised. It is very difficult to rid the instruments of prions clinging to the stainless steel.

In 1999 the Department of Health assembled a research group on vCJD transmission, which identified the need for research into models of infectivity, decontamination of prions on instruments, protein detection, practices in hospitals and dentistry, and redesign of instruments.

Other than incineration, physical and most chemical methods do not eliminate prions. One method is to boil the instrument in sodium hydroxide at 121°C for an hour, but it turns the instrument black.

Professor Perrett investigated chemical methods and used ultraviolet fluorescence to show how much protein remained after treatment. Government guidelines can be found here: **http://tinyurl.com/PKVRL7L** A general upper limit of 5µg per instrument side is likely to give meaningful risk reduction, except for neuro instruments when a lower level is essential.

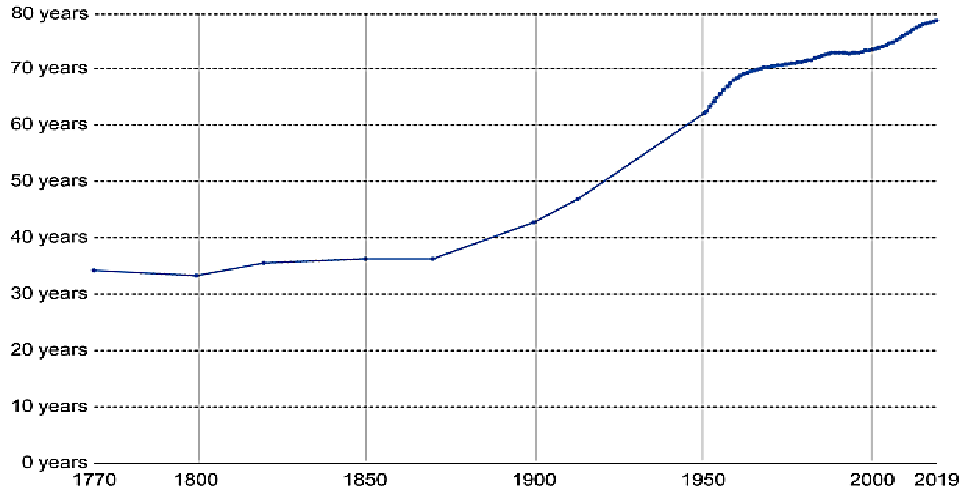
The professor has also worked on arthritis (drug treatment, bone turnover, free radical damage), forensics (drugs in athletes, bruising, alcohol), and has contributed to 250 scientific publications.

13/11/19 **Human Longevity** by David Goldhill (inspired by his book 'How to live to be 1000')

Living into old age is for most people a very recent thing. Mr Goldhill said that the secret of long life will not be heard from him! We are living longer than ever before, and new discoveries may allow us to live for hundreds of years.

The oldest person we know of was Jeanne Calment, shown here on her 122nd final birthday in 1997.

This chart of <u>average</u> life expectancy shows that up to about 1900 it was less than 40 years of age, but this was largely due to infant mortality.



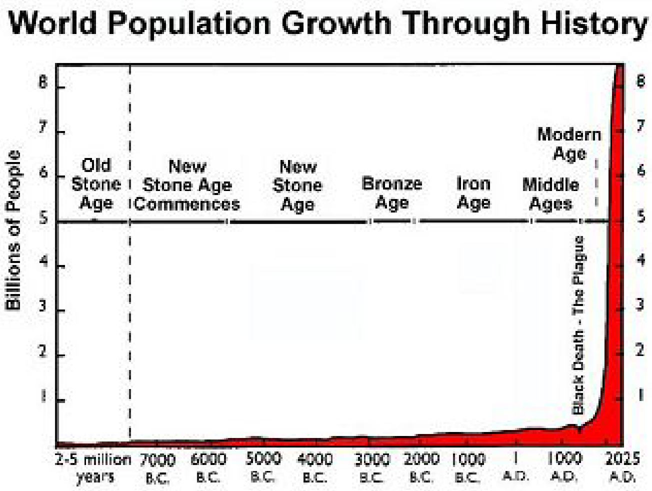
UK deaths before the age of 5 were:

1800: 33%
1900: 20%
1950: 4%
2015: <1%

However, people who survived this lived as long as we live now.

King Solomon (990 BC) lived to about 80. Michaelangelo (1475 AD) lived to 88.

Population has grown exponentially in recent years, owing to advances in science:



From "World Population: Toward the Next Century," copyright 1994 by the Population Reference Bureau

It is worth noting that we are composed of 3.72 x 10^{13} cells of more than 200 different types; billions of cells are made each day and billions die.

Also we have more than 100 trillion micro-organisms in and on our body (1%-3% of body weight) each with their own DNA.

Longevity is 20%-30% determined by genes, but in very long lived humans they may be more important.

In summary, currently there are limits to lifespan; healthy ageing is a legitimate goal; longevity is malleable and a target for intervention, and we have an unprecedented understanding and knowledge of relevant factors.

It is even conceivable that the first person to live to 1000 may be alive today.

CALENDAR OF SCIENTIFIC EVENTS February to May 2020

Day	Date	Time	Host	Title
Tue	04/02/20	1pm	GC	Hubble: Battle of the Space Giants. Dr Maggie Aderin-Pocock MBE
Tue	11/02/20	1pm	GC	Great Mathematical Myths
Tue	11/02/20	1pm	UCL	The loss of bumblebees – why is it happening and why is it important?
Wed	**12/02/20**	**8pm**	**RSS**	**The Carbide Age: Superlative Tool Materials for the 21st Century**
Thu	13/02/20	6.30pm	RS	Generating high-intensity, ultrashort optical pulses
Wed	18/02/20	1pm	RAS	The gravitational wave spectrum
Tue	25/02/20	1pm	UCL	Recording from a myriad of neurons to understand behaviour
Wed	26/02/20	3pm, 6pm	GS	Jurassic brain teasers – modern technology inside the heads of fossils
Wed	04/03/20	1pm	GC	Simple Laws, Spectacular Astrophysics.
Tue	10/03/20	1pm	GC	The Art of Maths
Tue	10/03/20	1pm	UCL	5G: the what, why and how of the next generation of Mobile Technology
Tue	10/03/20	6.30pm	RS	Ripples from the Dark Side of the Universe – a bright future ahead
Wed	11/03/20	6pm	RSC	Plastics and Their Effect on the Marine Environment
Thu	12/03/20	6pm	GC	Corpse Roads: Digital Landscape Archaeology
Mon	16/03/20	6.40pm	IET	Photonics - practical and optimized
Wed	**18/03/20**	**8pm**	**RSS**	**The Blockchain and Bitcoin**
Thu	19/03/20	1pm	UCL	Bitcoin unfolded: an introduction to cryptocurrencies
Thu	19/03/20	6pm	GC	A History of the Stomach
Tue	24/03/20	1pm	UCL	The Rosalind Franklin Rover's mission: looking for life on Mars
Fri	27/03/20	2pm	IET	Wearable electronics embedded in clothing
Wed	01/04/20	12.30pm	LS	The Inside Out of Flies and Why It Matters
Mon	06/04/20	1pm	GC	Caroline Herschel: Discoverer of Comets
Wed	**15/04/20**	**8pm**	**RSS**	**Pathology**
Mon	20/04/20	6pm	GC	The World of Isaac Newton
Mon	27/04/20	1pm	GC	Mysteries of the Dark Cosmos
Tue	28/04/20	1pm	GC	Equations that have Changed the World
Tue	05/05/20	6pm	GC	Is Robocop now a Reality?
		6pm	RSC	DNA Sequencing for Precision Medicine
Tue	12/05/20	1pm, 6pm	RAS	How can we use bacteria in the search for life beyond the Earth?
Wed	**20/05/20**	**8pm**	**RSS**	**Domestication, Agriculture and Civilisation across Asia and Africa**

All events are free but booking may be required. Some can also be viewed online live and later.

Host Venues: (RSS denotes Richmond Scientific Society lectures)

GC: Gresham College, Museum of London, 150 London Wall, EC2Y 5HN
http://www.gresham.ac.uk/lectures-and-events

GS: Geological Society, Burlington House. Piccadilly, London W1J 0BG
https://www.geolsoc.org.uk/Events/public-lectures-2020

IET: Institution of Engineering and Technology, 2 Savoy Place, London WC2R 0BL
https://events.theiet.org

IOP: Institute of Physics, 37 Caledonian Road, King's Cross, London N1 9BU
https://www.events.iop.org

LS: Linnean Society, Burlington House, Piccadilly, London W1J 0BF
https://www.linnean.org/meetings-and-events/events

RAS Royal Astronomical Society, Burlington House, Piccadilly, London W1J 0BQ
https://www.ras.org.uk/events-and-meetings

RS: Royal Society, 6-9 Carlton House Terrace, London SW1Y 5AG,   (020) 7451 2500
https://royalsociety.org

RSC Royal Society of Chemistry, Burlington House, Burlington House, London, W!J 0BA
https://www.rsc.org/events

UCL University College London, Darwin Lecture Theatre, Gower St., London WC1E 6BT
https://www.ucl.ac.uk/events