The presentation begins from the next slide.

TAIWAN BRIDGES, March 20, 2026
Tamkang Clement and Carrie Chair

Dedication to Professor Yuan-Tseh Lee on the 90th Anniversary of his Birth and the 40th Anniversary of his Nobel Prize Award

Chemistry is the Science of Value Creation

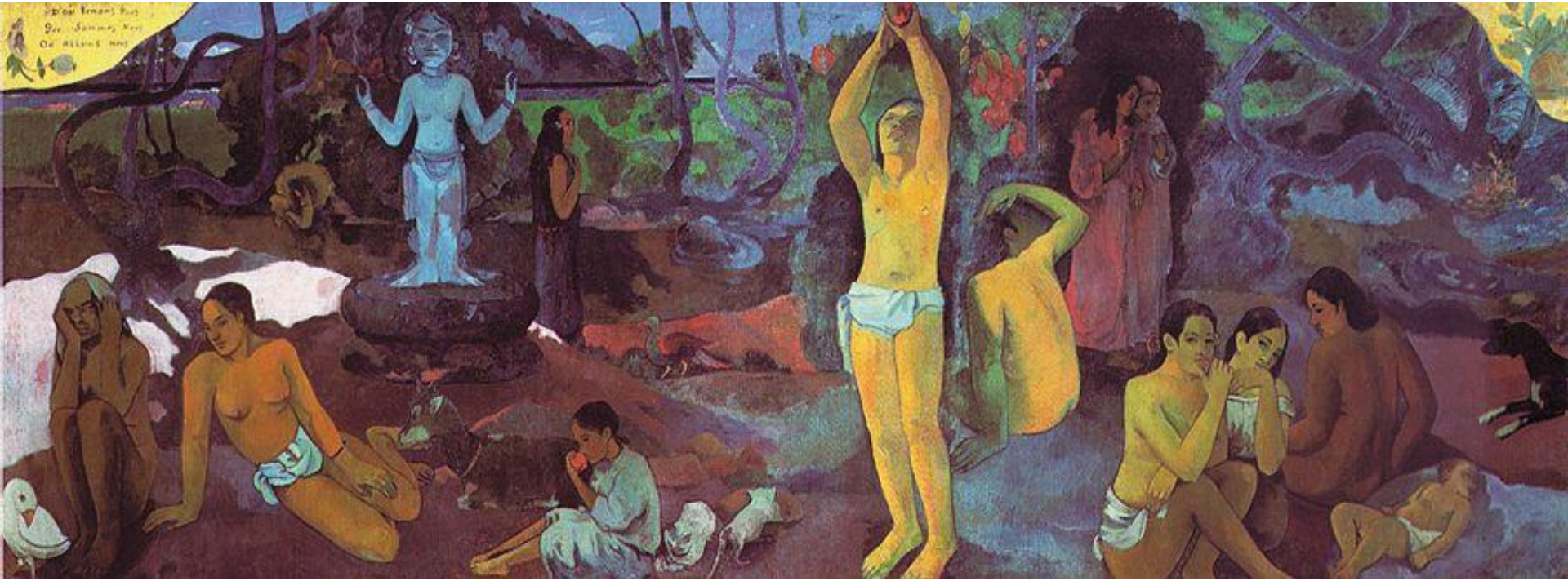
Ryoji Noyori

Where do we come from?

What are we?

Where are we going?

Paul Gaugin, 1897



Professor Hideki Yukawa as a role model

湯川博士にノーベル賞

日本人で最初の栄誉

世界に輝く「中間子論」

現に渡米中 兄弟そろって学者

湯川秀樹博士

賞金三万ドル

物理学界の詩り

文化

平和

1949 Nobel Prize in Physics

Asahi Newspaper, November

Ryoji Noyori (center), a fifth grader at elementary school affiliated to Kobe University

Admiration, excitement and aspiration

- 1949: Role model: Hideki Yukawa, Kyoto University professor, Nobel Prize in Physics
- 1951: Attend Toray industry conference with my father
  "Nylon, product of coal, water, and air"
- 1957: Enter Kyoto University, Faculty of Engineering.
- 1966: Discovery of asymmetric carbene reaction
- 1968: Move to Nagoya University
- 1969: Research at Harvard University


H. Yukawa


H. Nozaki


Y. Hirata


E. J. Corey

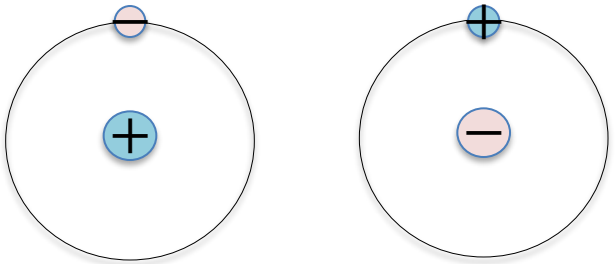
Where are we from?

The origin of the universe: Big Bang 13.8B years ago

Is the universe symmetrical?

matter : anti-matter

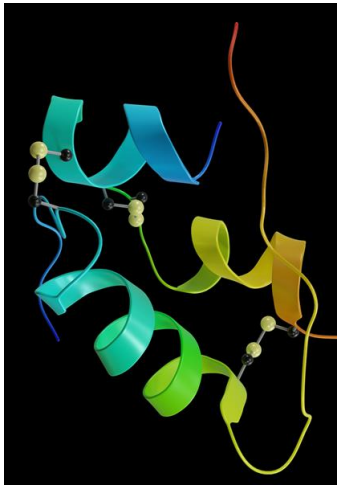
= 1,000,000,001:1,000,000,000



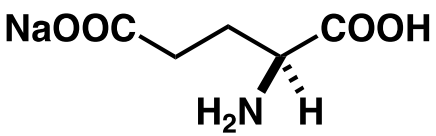
Life: 4 billion years of evolution

DNA genetic information and protein synthesis

The asymmetric world

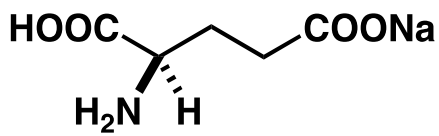


Life depends on molecular chirality

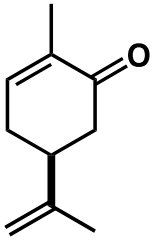


(*S*)- monosodium glutamate

Umami

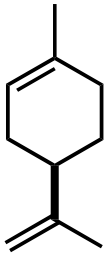


(*R*)- monosodium glutamate



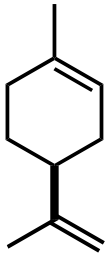
(*S*)-carvone

Caraway



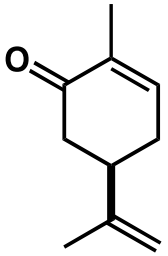
(*R*)-limonene

Orange



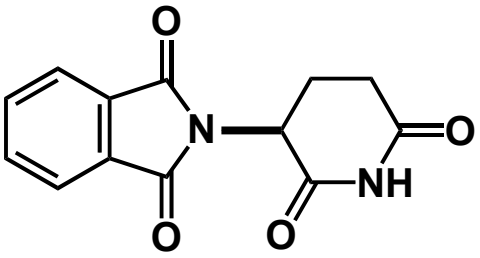
(*S*)-limonene

Lemon



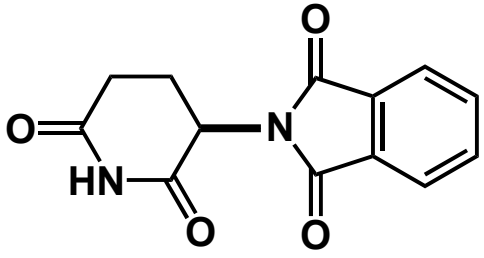
(*R*)-carvone

Spearmint



(*S*)-thalidomide

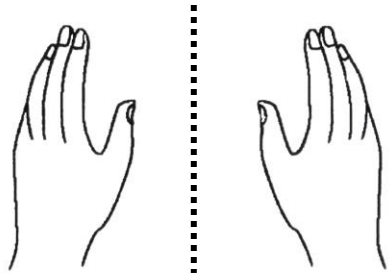
teratogenic

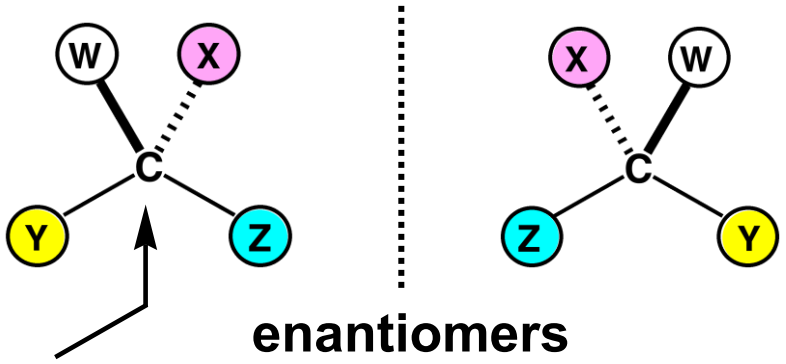


(*R*)-thalidomide

tranquilizer

Left- and right-handed molecules





enantiomers

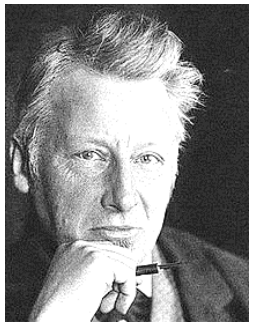
asymmetric carbon

Louis Pasteur

Joseph-Achille Le Bel

"**Asymmetry**. Thiis is the only clear boundary between the chemistry of inanimate matter and the chemistry of living matter. It is impossible to distinguish left from right using the forces of chemistry or physics."

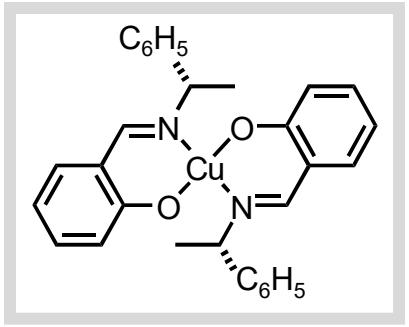
Louis Pasteur, 1851



Jacobus H. van't Hoff

Noyori's asymmetric synthesis

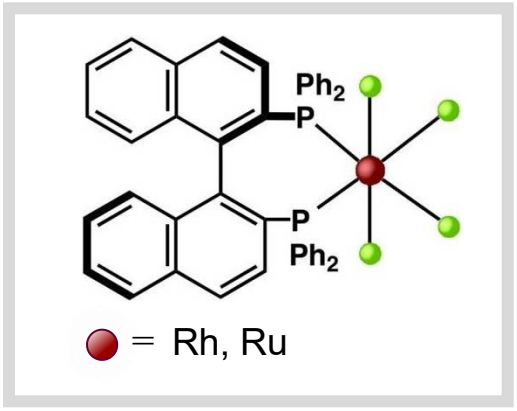
Discovery



1966
Discovery of the principle of asymmetric catalysis

Kyoto University

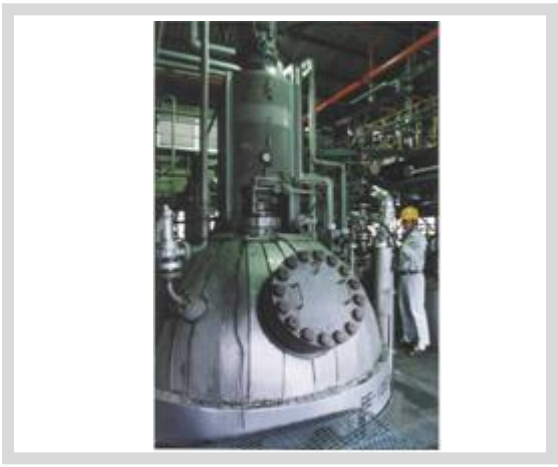
Development



1980—
Asymmetric hydrogenation
（Nobel Prize in Chemistry）

Nagoya University

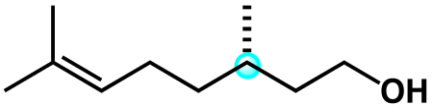
Application



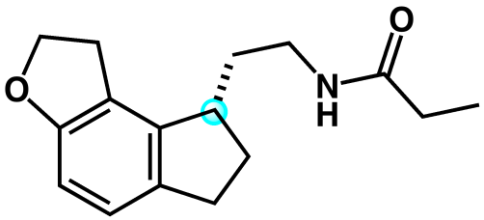
Industrial production of bio-active substances

Takasago International Co.

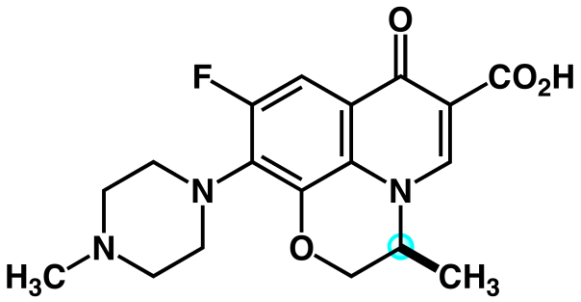
Industrial applications of Noyori asymmetric hydrogenation



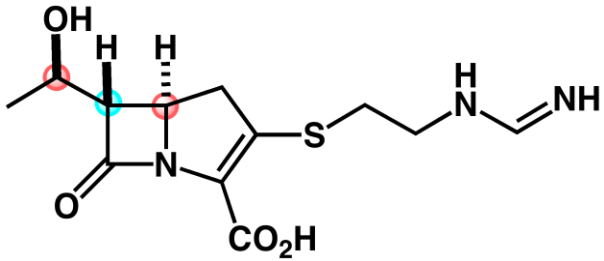
Citronellol



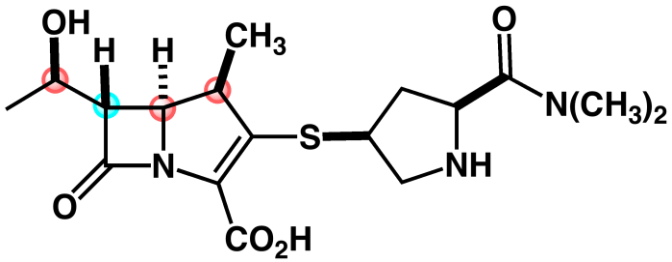
Ramelteon (Rozerem)



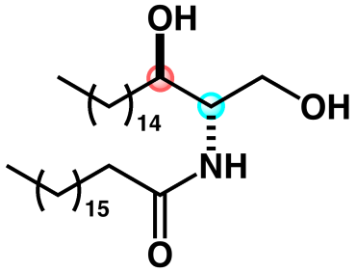
Levofloxacin (Cravit)



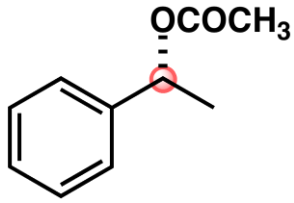
Imipenem



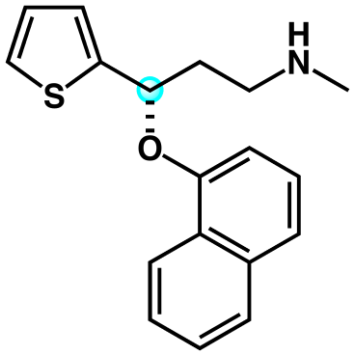
Meropenem



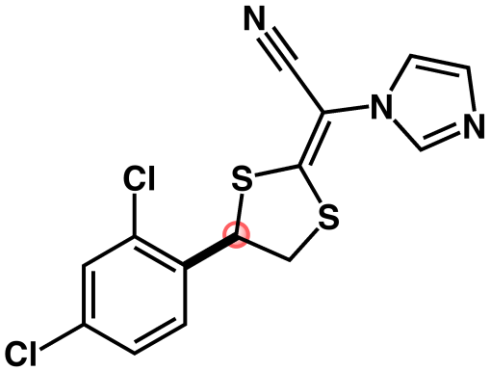
Ceramide



Styrallyl acetate

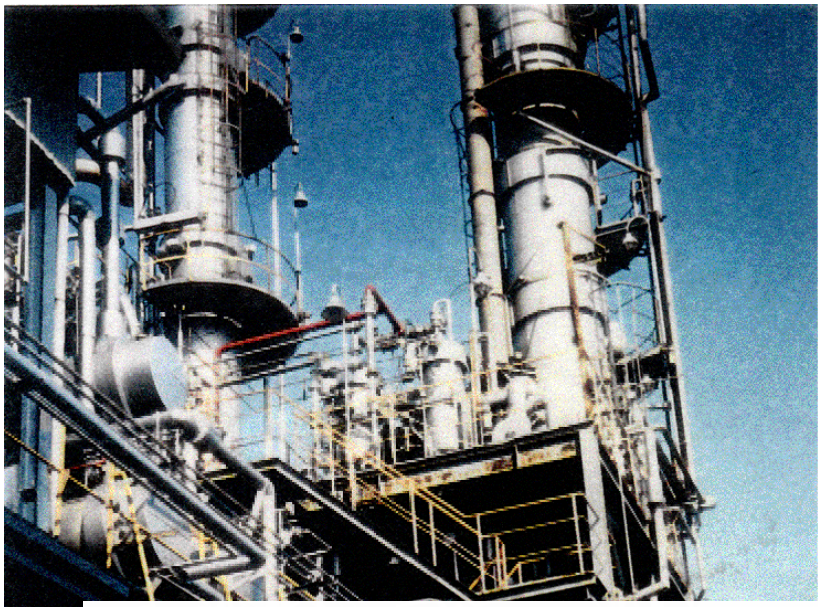


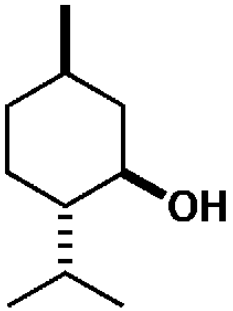
Duloxetine



Luliconazole

Asymmetric production of menthol





(–)-menthol

In 1992, the US Food and Drug Administration set guidelines for “racemic switches”, thereby contributing to major improvements in medicine.

(*S*)-BINAP–Rh catalyst

Takasago International Co., 1984

2001 Nobel Prize in Chemistry

Kungliga
Svenska Vetenskapsakademien
har den 10 oktober 2001 beslutat
att med det
NOBELPRIS
som detta år tillerkännes den
som gjort den viktigaste kemiska
upptäckten eller förbättringen
med ena hälften gemensamt belöna
Ryoji Noyori
och William S. Knowles
för deras arbeten över kiralt katalyserade hydrogeneringsreaktioner

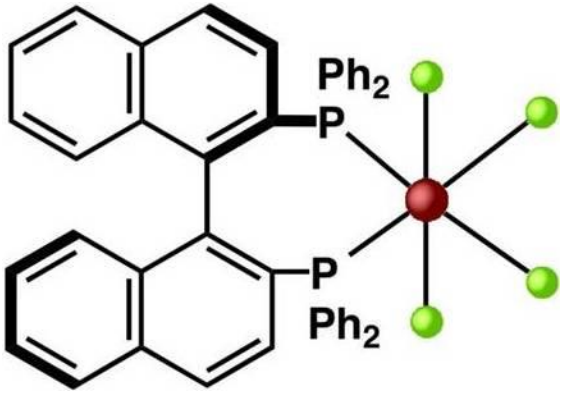
STOCKHOLM DEN 10 DECEMBER 2001

Erling Norrby

Origins of our scientific competience

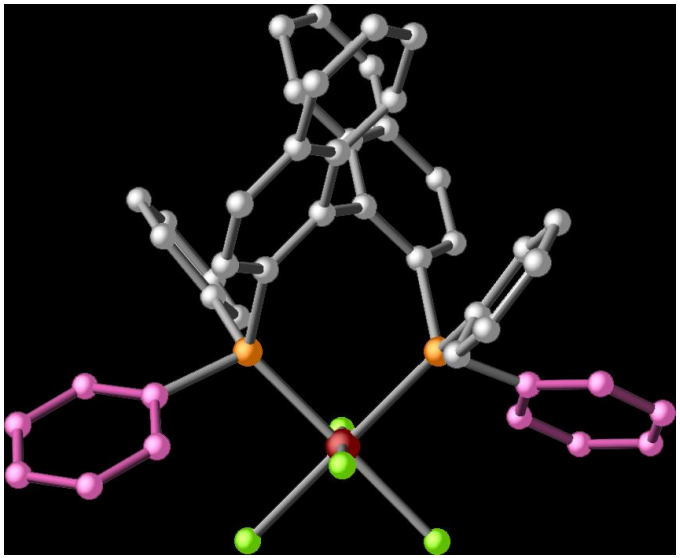
- Poverty in the youth
- Academic freedom
- International partnership
- Industrial collaboration
- Japan's cultural heritage

Chiral environment of (*R*)-BINAP–transition metal catalysts

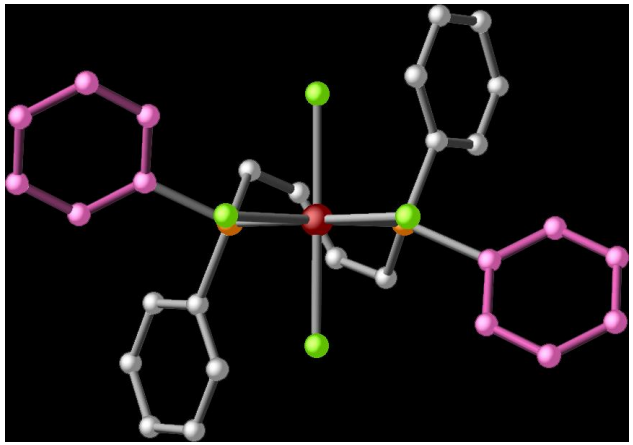


= Rh, Ru

(*R*)-BINAP



top view



side view

NOBEL SYMPOSIUM, September 2-7, 1984

"Binaphthyls: The Beauty and Chiral Uses"

H. E. Plutschow, D. Keene, "Introducting Kyoto," Kodansha International, 1979

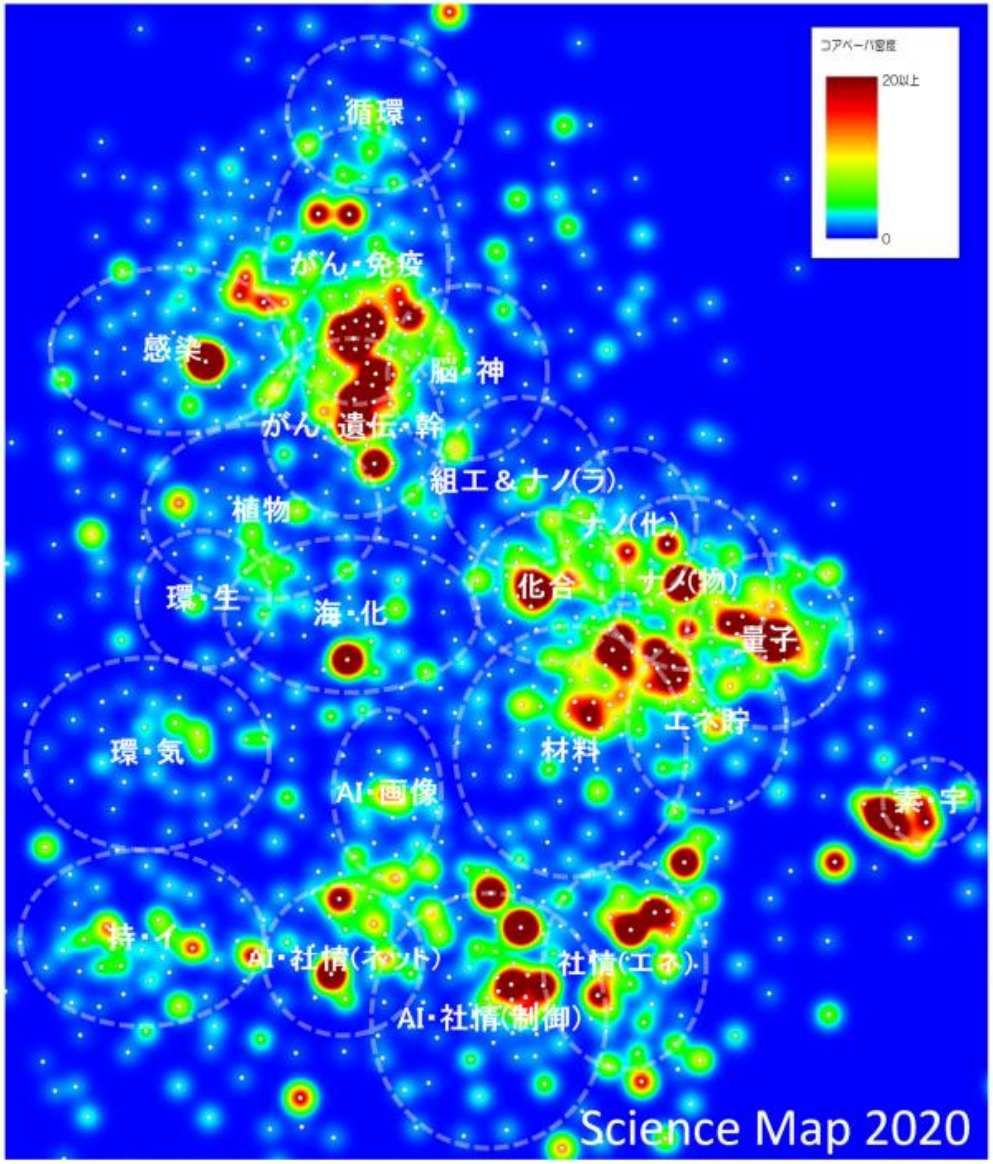
So-etsu Yanagi, "The beauty of utility"
Bauhaus movement, "Form follows function"
Steve Jobs, "Technology is the intersection of science and art"

Explicit knowledge + tacit knowledge

科学 is probably not entirely the same as science or Wissenschaft.

Science Map

Science Map 2020. National Institute of Science and Technology Policy (NISTEP), NISTEP Report No. 196 (2023)



Science is One

All disciplines are based on materials/substances and connected by information.

Be more interdisciplinary, trans-disciplinary, or even anti-disciplinary.

Chemistry is to be a Central Science.

Chemistry is the science of value creation

A century of innovation

ELECTRIFICATION

AUTOMOBILES

AIRPLANES

WATER SUPPLY AND DISTRIBUTION

ELECTRONICS

RADIO AND TELEVISION

AGRICULTURAL MECHANIZATION

COMPUTERS

TELEPHONY

AIR CONDITIONING AND REFRIGERATION

HIGHWAYS

SPACECRAFT

INTERNET

IMAGING

HOUSEHOLD APPLIANCES

HEALTH TECHNOLOGIES

PETROLEUM AND PETROCHEMICAL TECHNOLOGIES

LASERS AND FIBER OPTICS

NUCLEAR TECHNOLOGIES

HIGH PERFORMANCE MATERIALS

G. Constable, B. Somerville, 2003

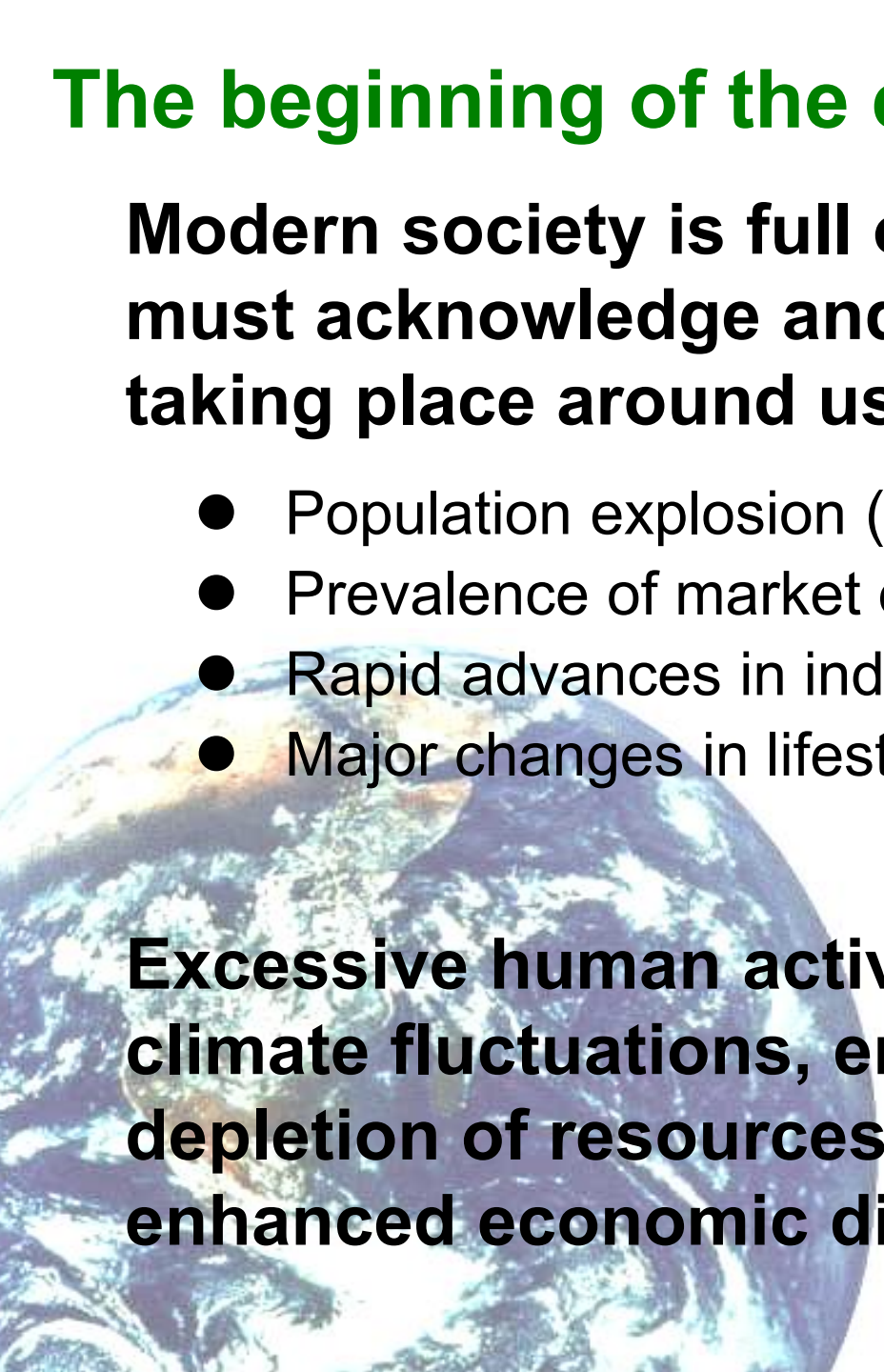
Chemistry goes beyond the science of mere observation and understanding of Nature. Our science is capable of generating very high values from almost nothing. Man-made substances and materials determine the quality of our life.

- **Energy**
- **Materials**

The beginning of the endgame

Modern society is full of contradictions, but we must acknowledge and cope with the changes taking place around us. These include:

- Population explosion (8 billion)
- Prevalence of market economies (globalization)
- Rapid advances in industrial technology
- Major changes in lifestyles



Excessive human activity is causing grave climate fluctuations, environmental changes, depletion of resources and energy, and enhanced economic disparity.

Why is this so?

We can take great pride in the high level of civilization achieved through human intellect.

But:

We must reflect deeply on the fact that national ambitions have ignited wars and decimated societies and that excessive personal appetites have caused irreparable environmental destruction.

GREEN CHEMISTRY: A creative, prosperity-bringing, and responsible science

- Safe starting materials
- Renewable resources (biomass)
- Safe solvents
- Avoiding waste
- Conserving energy
- Green waste

“Problems cannot be solved at the same level of awareness that created them.”

Albert Einstein

Green indices in chemical synthesis

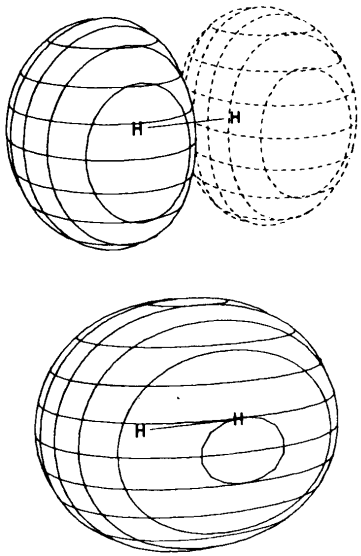
- A + B $\longrightarrow$ C + by-products

$$\text{Atom economy} = \frac{\text{Mw of C}}{\text{Mw of (A + B)}} \times 100\ (\%)$$

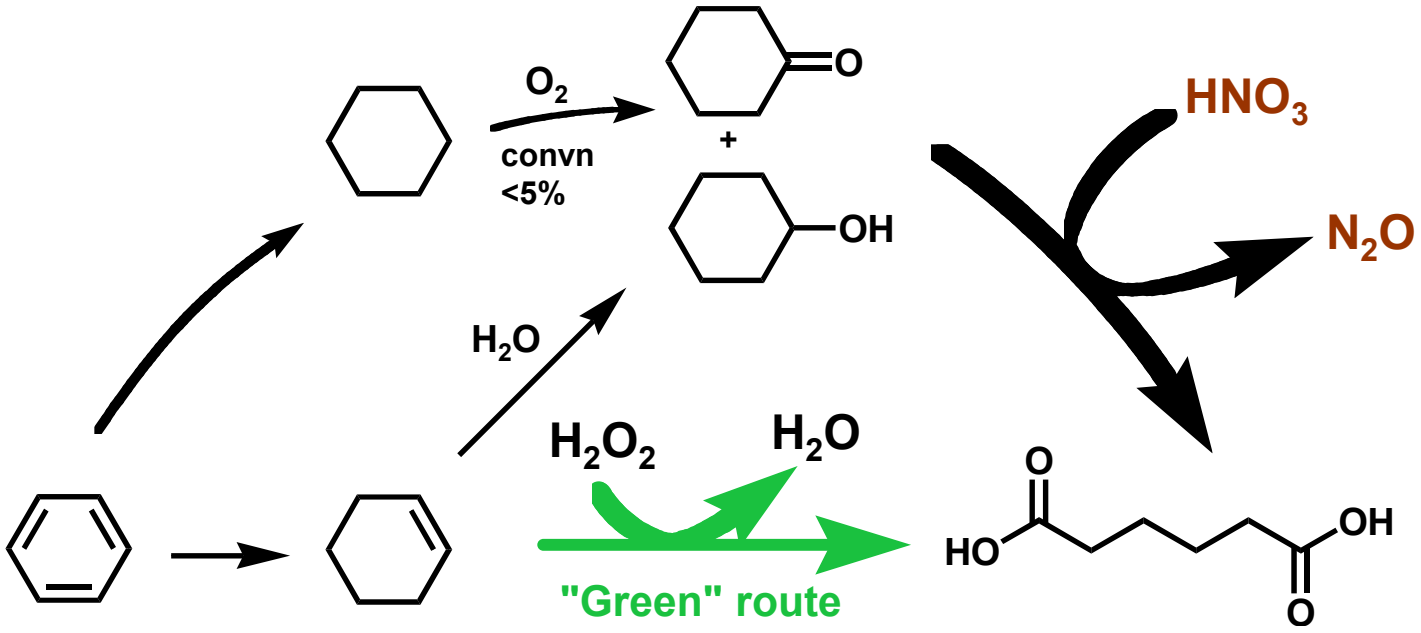
- E-factor

	production, ton/y	kg waste/kg
Gasoline (naphtha cracking)	10^6-10^8	0.1
Commodity chemicals	10^4-10^6	1-5
Fine chemicals	10^2-10^4	5-50
Pharmaceuticals	10-10^3	25-100

H_2



Industrial synthesis of adipic acid



2 200 000 tons/year
mostly for nylon-6,6 synthesis

N_2O

- emission of about 400 000 tons/year (5–8% of anthropogenic emission, 1990)
- catalytic stratospheric ozone destruction
- greenhouse gas effect
- acid rain and smog

The greatest pioneers of polymer chemistry

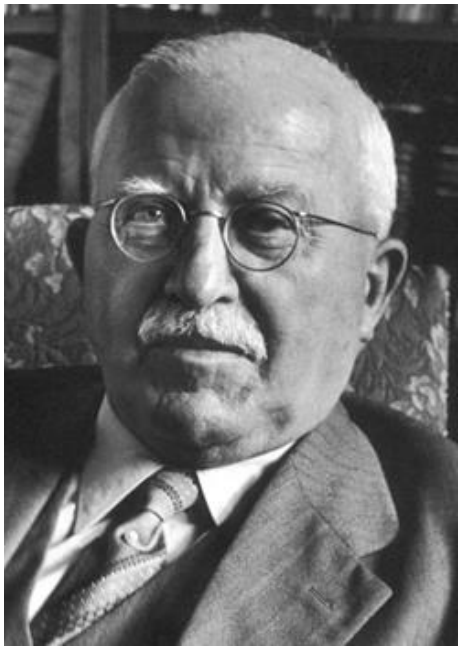
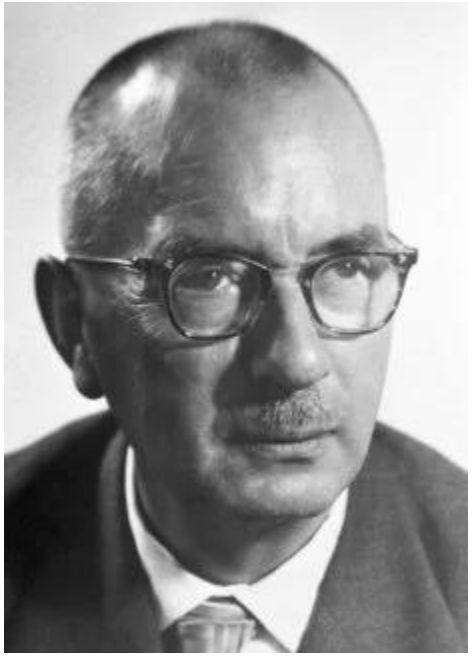


Photo from the Nobel Foundation archive.

Hermann Staudinger
1881–1965
Concept of macromolecules

Wallace H. Carothers
1896–1937
Invention of Nylon

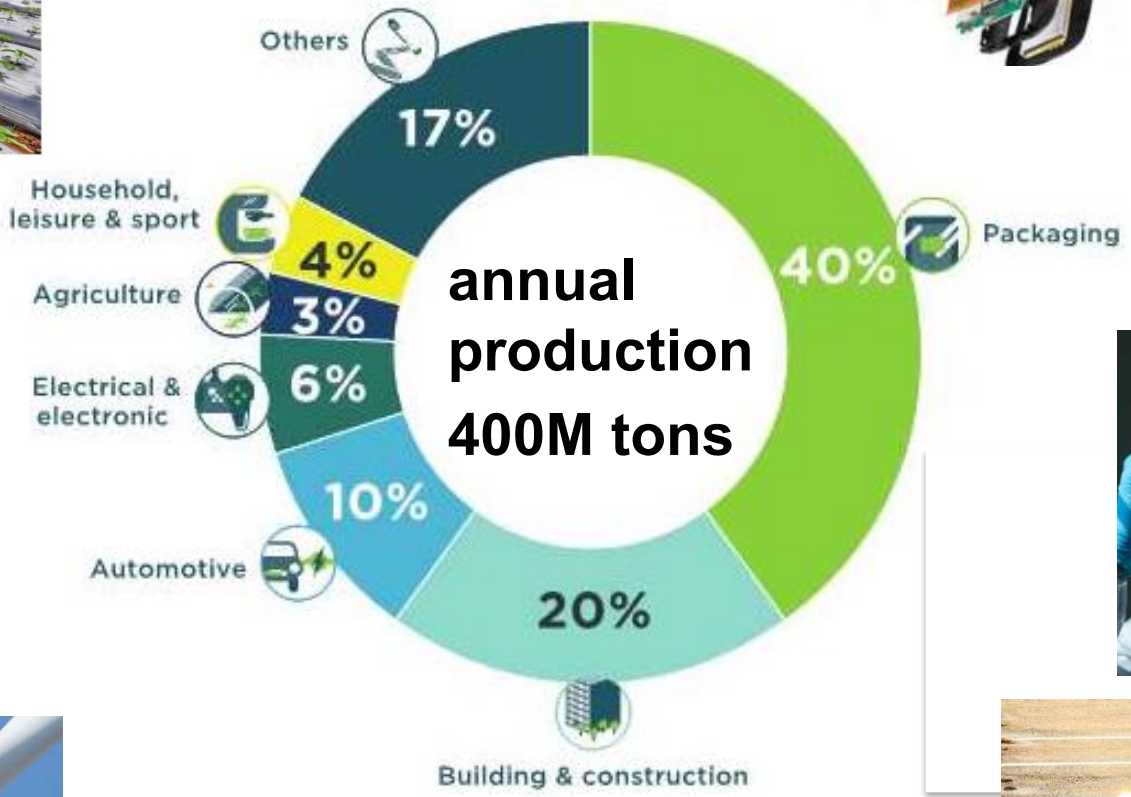


Karl Ziegler
1898–1973
Invention of
olefin polymerization

Plastics for energy-saving and -efficiency

- Plastic production emits an 860M tons/y of CO_2, 2.4% of a total emission of 36B tons/y. However, much less energy-intensive compared with manufacturing of steel, cement, glass, etc.
- Light-weight plastics secure fuel-efficiency in mobiles such as cars and airplanes.
- Gas-shielding function allows long-term storage of food, reducing total transportation cost.
- Heat-insulating plastics enormously contribute to energy-saving of buildings and others.
- Engineering plastics are used in technological devices for electricity and energy efficiency.
- Plastics contribute to new energy production such as fuel cells, solar and wind energy.

Plastics: Glorious invention shaping the material civilization



cumulative total production: 8.3B tons
total waste: 6.3B tons

Science to enable sustainable plastics, A white paper from the 8th CS3, 2020

Life-cycle assessment toward circular economy

- **3R (recovery, reuse, recycling)**
  thermal, material or chemical recycling, incineration, reclamation…
- **Replacement of single-use disposable plastics by biodegradable materials**
- **Invention of unique functional plastics and "supra-molecular" or ion-pairing polymers via multiple non-covalent, reversible bonding**

The law of conservation of matter

Matter never disappears

万物流転, 輪廻転生

Governance of ELSIs (ethical, legal, and social issues) is not functioning as it should.

Compared to the rapid advances being made in industrial technology, moral and social progress has been deplorably slow.

We need value innovation to straighten ourselves out.

“The world is one”

The 20th century was an era of international competition, symbolized by war and economic rivalry. In the 21st century, we will have to cooperate internationally for the survival of our species within the limits of this planet.

Countries all have different histories and viewpoints, and their interests sometimes clash. But no country can exist on its own. Strong ties among Asian nations are essential.

Everything begins with understanding between individuals. Friendships across the seas and firm relationships of trust are the cornerstones of international security.

With respect and gratitude to Professor Yuan-Tseh Lee

Professor Y-T. Lee receives the title of RIKEN Honorary Fellow. March, 2011