HIS 2129

Technology, Society and Environment since 1800

(Winter 2014)

The Atomic Age

- The evolution of transportation systems, from canals and steamboats to cars and airplanes, turned movement, motion, mobility into a central trait of technological societies in the twentieth century
- Art reflected the new preoccupation with speed
- Beyond technological feats, Hiroshima's destruction demonstrated the raw power of a new science
- Art also reflected the dominance of science, the triumph of reason and its applications, by attempting to reveal the deep scientific structures of the world
- In turn, this infatuation with reason, simplicity, and the application of pure geometries to objects transformed the appearance of the modern world
- The new shapes and shaping of objects then changed our experience of them

Science literacy in the U.S.

(Percentage of right answers, Science and Engineering Indicators 2008, 2010)

2008*: a sample of 33 students in HIS 2129
2012**: a sample of 124 students in HIS 2129

	1988	1990	1992	1995	1997	1999	2001	2004	2006	2008 (M,F)		2010	**2008***	**2012****
Earth's centre is very hot	80	79	81	78	82	80	80	78	80	88	80	84	100	97
Radioactivity is all man-made	65	63	73	72	71	71	76	73	70	74	67	67	97	91
Lasers focus sound waves	36	37	37	40	39	43	45	42	45	64	34	47	88	90
Electrons smaller than atoms	43	41	46	44	43	46	48	45	53	59	47	51	88	94
Universe began with explosion	54	32	38	35	32	33	33	33	33	**38**		38	100	88
Continents move	80	77	79	78	78	80	79	77	80	82	73	80	97	99
Earth goes around Sun, or the reverse?	73	73	71	73	73	72	75	71	76	**72**		73	100	99
The father's gene makes boy or girl	—	—	65	64	62	66	65	62	**64**	**53**	**71**	**61**	**76**	**74**
Antibiotics kill viruses and bacteria	26	30	35	40	43	45	51	54	**56**	**47**	**60**	**50**	**70**	**67**
Humans descended from animals	46	45	45	44	44	45	53	42	43	**46**		47	91	89

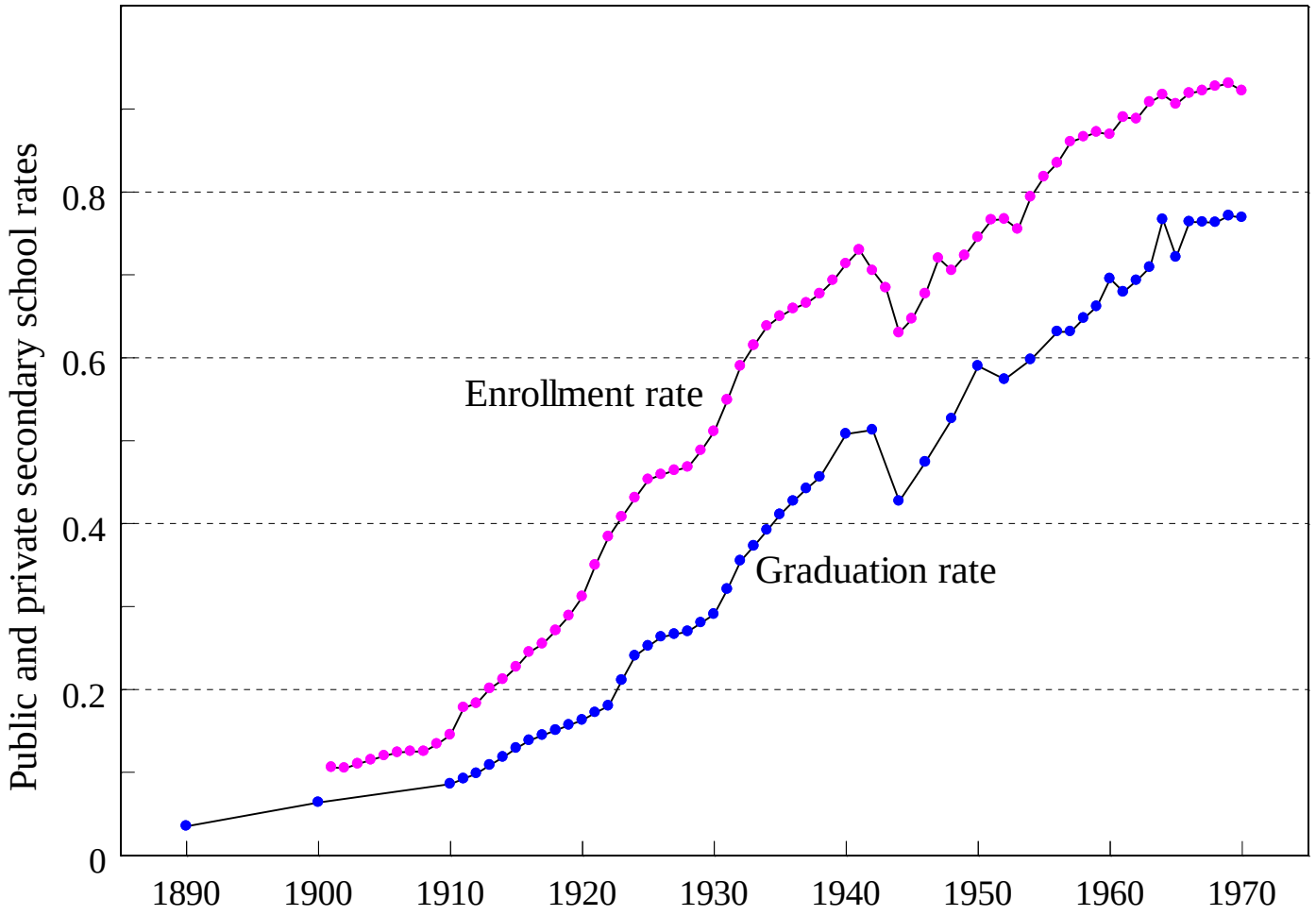
Science literacy in the world

(Percentage of right answers, *La Culture scientifique et technique au Québec : Bilan*, 2002)

2008*: a sample of 33 students in HIS 2129
2012**: a sample of 124 students in HIS 2129

N.B.: *Overall scores based on extended questionnaire*	Europe (2001-**60%**)	France (2001-**61%**)	United States (2001-**64%**)	Québec (2002-**62%**)	**2008**	**2012**
Earth's centre is very hot	88	89	80	89	100	97
All radioactivity is man-made	53	49	76	55	97	91
Lasers focus sound waves	35	36	45	52	88	90
Electrons smaller than atoms	41	46	48	46	88	94
Universe began with explosion	—	—	33	—	100	88
Continents move	82	87	79	85	97	99
Earth goes around Sun, or the reverse?	67	62	75	60	100	99
The father's gene makes boy or girl	48	54	65	49	**76**	**74**
Antibiotics kill viruses and bacteria	40	42	51	40	**70**	**67**
Humans descended from animals	69	74	53	64	91	89

High school education: when the United States led the world



Lawrence F. Katz, "Narrowing, Widening, Polarizing: The Evolution of the U.S. Wage Structure", 2006

Education and technology, hand in hand

- The increasing number of high school graduates were attracted in the United States to the newest and most sophisticated manufacturing industries, whereas the least educated were found in 1940 in manufacturing jobs mostly dating back to the first Industrial Revolution

PERCENTAGE HIGH SCHOOL GRADUATES BY INDUSTRY, 18 TO 34-YEAR OLD MALE BLUE-COLLAR WORKERS: 1940

Three-digit SIC manufacturing industries	*% H.S. grad.*	*Number of obs.*	*Three-digit SIC manufacturing industries*	*% H.S. grad.*	*Number of obs.*
High-education industries (from high to low)			*Low-education industries (from low to high)*		
Top 20% by employment			*Bottom 20% by employment*		
Aircraft and parts	52.7	541	Cotton manufactures	10.8	1512
Printing and publishing	44.7	1289	Tobacco	11.6	144
Office machinery	43.7	166	Logging	11.7	706
Petroleum refining	43.3	415	Sawmills and planing mills	14.1	1941
Dairy products	43.2	417	Not specified textile mills	15.6	128
Scientific and photographic equipment	40.8	227	Silk and rayon manufactures	16.6	350
Electrical machinery	40.5	977	Carpets and rugs	16.9	107
Misc. nonmetallic mineral products	36.2	135	Misc. fabricated textiles	17.0	94
Paints and varnishes	35.9	107	Cut-stone and stone products	17.1	101
Clocks, watches, jewelry	34.7	197	Misc. textile goods	17.6	117
Shipbuilding	34.4	528	Structural clay products	18.8	271
Miscellaneous machinery	33.5	1669	Cement and concrete, gypsum, and plaster products	19.2	263
Nonferrous metals	33.1	342	Hats, except cloth and millinery	20.5	60
			Dyeing and finishing textiles	20.6	191
			Misc. wooden goods	21.4	475
			Footwear industries except rubber	22.9	680
			Woolens and worsteds	23.1	368

The sample is limited to 18 to 34-year old, currently employed males in blue-collar occupations (craft, operative, laborer, service) in manufacturing. The mean for the entire sample of 31,531 is 27.6 percent. The industry names are those given in ICPSR [1984]. High-education (low-education) industries are obtained by ranking industries by their share of 18 to 34-year old, male, blue-collar workers with twelve or more years of schooling and selecting off industries from the top (bottom) until 20 percent of manufacturing employment (for all workers) is represented. The 1940 PUMS sampling weights are used in all calculations.

Source. 1940 Public Use Micro-data Sample, 1/100; ICPSR [1984].

Claudia Goldin and Lawrence F. Katz, *The Quarterly Journal of Economics*, August 1998

Turning innovation into a system

- The new spirit of the age *(Faster, higher, stronger)*
- When technology inspired art
- Designing new buildings and new cities
  (The beauty of streamlining in North America)
- WWII, the A bomb, and research
- The Cold War, the H bomb, and the space race
- Innovation systems and research funding
- The Jetliner Age: nuclear reactors, jet planes, and a century of chemical success

Reaching for speed, for height, for strength... (1)

- The motto of the Olympic movement resurrected by Pierre de Coubertin in 1896 was the Latin tag *Citius, altius, fortius*, which translates as: *Faster, higher, stronger*
- The motto (coined around 1891 by a Paris schoolteacher) expressed the mood of the age

Mechanical horses in the Jardin du Luxembourg in Paris (1898)
Eugène Atget (1857-1927)

Reaching for speed, for height, for strength... (2)

- Cars that had once been toys for the rich were being sold in increasing numbers
- Around 1900, pioneers of powered flight (Ader, the Wright brothers, Santos-Dumont) take to the air
- And artists such as the Italian Futurists also turned their attention to the new mobile way of life

Horse-drawn streetcar in Paris (1910)
Eugène Atget (1857-1927)

The Futurist Manifesto (1909)

- **Noi vogliamo cantare l'amor del pericolo, l'abitudine all'energia e alla temerità.**
- **2. il coraggio, l'audacia, la ribellione, saranno elementi essenziali della nostra poesia.**
- **3. La letteratura esaltò fino ad oggi l'immobilità pensosa, l'estasi e il sonno. Noi vogliamo esaltare il movimento aggressivo, l'insonnia febbrile, il passo di corsa, il salto mortale, lo schiaffo ed il pugno.**
- **4. Noi affermiamo che la magnificenza del mondo si è arricchita di una bellezza nuova: la bellezza della velocità. Un automobile da corsa col suo cofano adorno di grossi tubi simili a serpenti dall'alito esplosivo.., un automobile ruggente, che sembra correre sulla mitraglia, è più bello della Vittoria di Samotracia.**
- **5. Noi vogliamo inneggiare all'uomo che tiene il volante, la cui asta ideale attraversa la Terra, lanciata a corsa, essa pure, sul circuito della sua orbita.**
- **(...)**
- **9. Noi vogliamo glorificare la guerra — sola igiene del mondo — il militarismo, il patriottismo, il gesto distruttore dei libertarî, le belle idee per cui si muore e il disprezzo della donna.**
- **10. Noi vogliamo distruggere i musei, le biblioteche, le accademie d'ogni specie, e combattere contro il moralismo, il femminismo e contro ogni viltà opportunistica o utilitaria.(...)**

FASTER…

Dynamism of a cyclist, by Umberto Boccioni (1913)

FASTER…

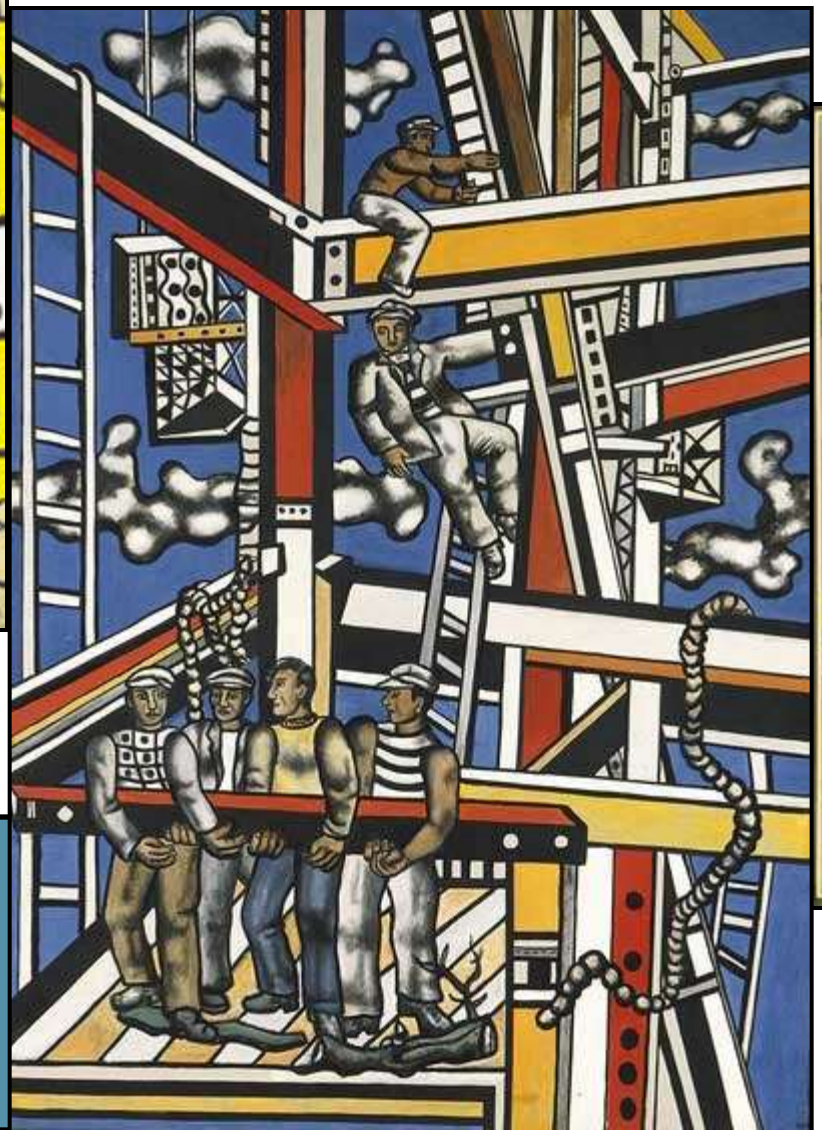
Gino Severini's *Train de la Croix-Rouge traversant un village* (1915)

HIGHER…

Fernand Léger's Industrial Portraits

Two Cyclists, 1951

The Builders, 1950



The Mechanic, 1920

Born in France, Fernand Léger (1881-1955) was almost killed by a mustard gas attack during World War I.

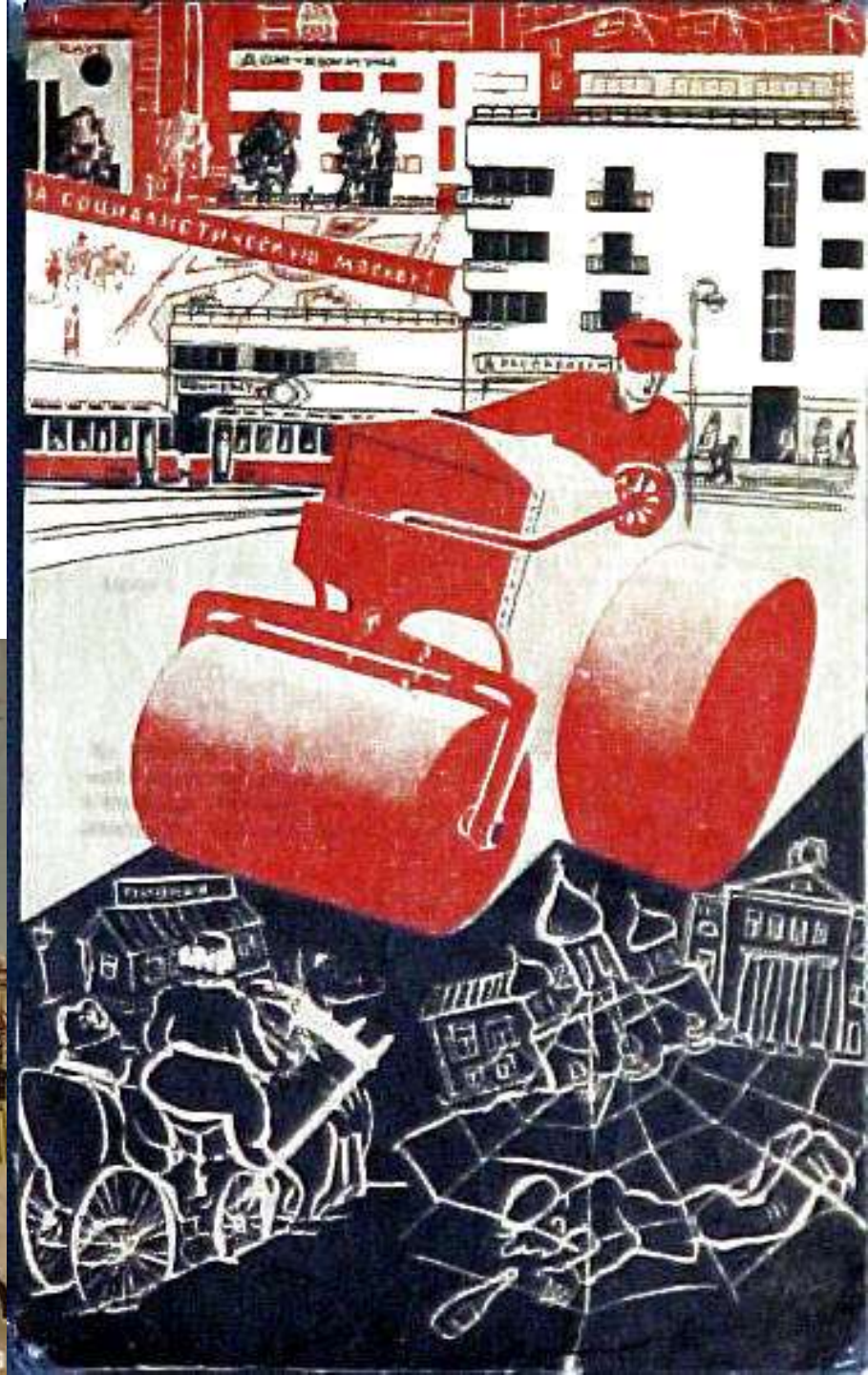
Léger was influenced by impressionism, cubism, and Futurism.

HIGHER…

Soviet Art

After World War I and the Revolution, artists in the U.S.S.R. are encouraged to depict the material progress of a society adopting electricity, paving city streets, and bringing tractors to farms.

Vyalov, 1932



Flight! (1918)

In these illustrations from *Dans le ciel de la patrie*, Spanish artist Eduardo Garc á Benito (1891-1981) shows WWI biplanes and attempts to evoke pictorially the novel impressions that are associated with the experience of flight.

STRONGER…

War!

The old way

Umberto Boccioni (1882-1916),
The Cavalry Charge, 1914

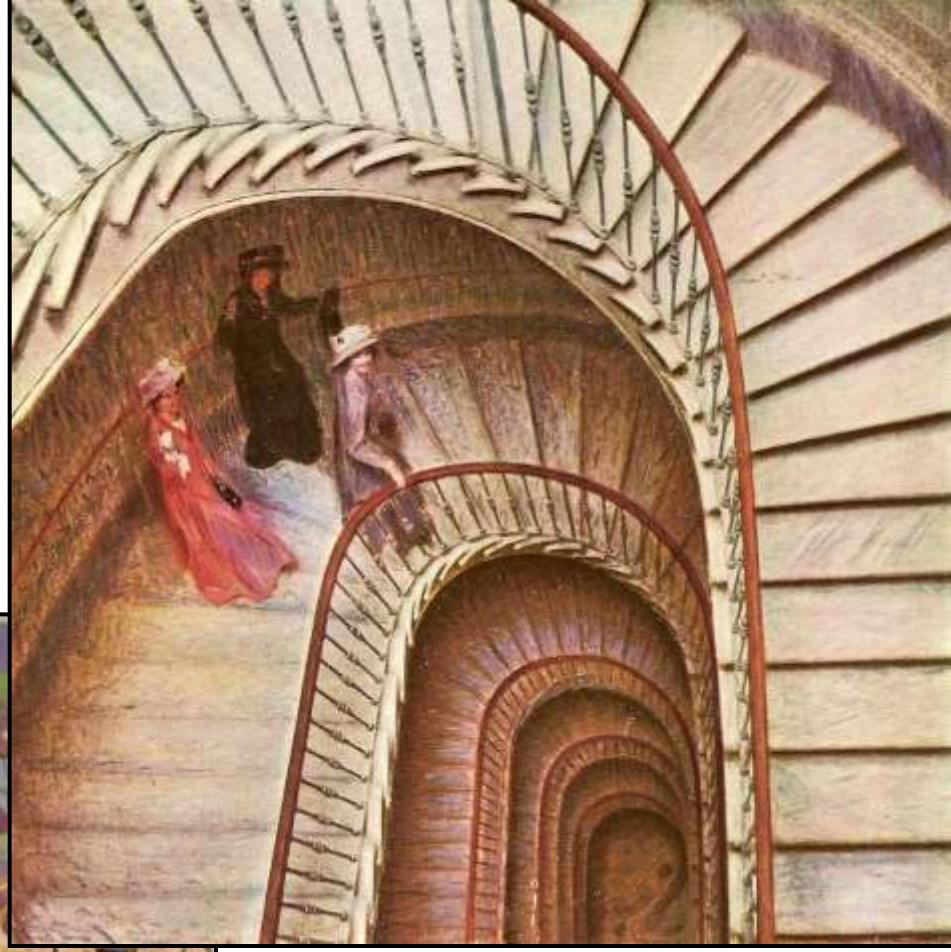
The new way

Gino Severini,
The Armoured Train, 1915

Boccioni was killed in a military cavalry exercise.

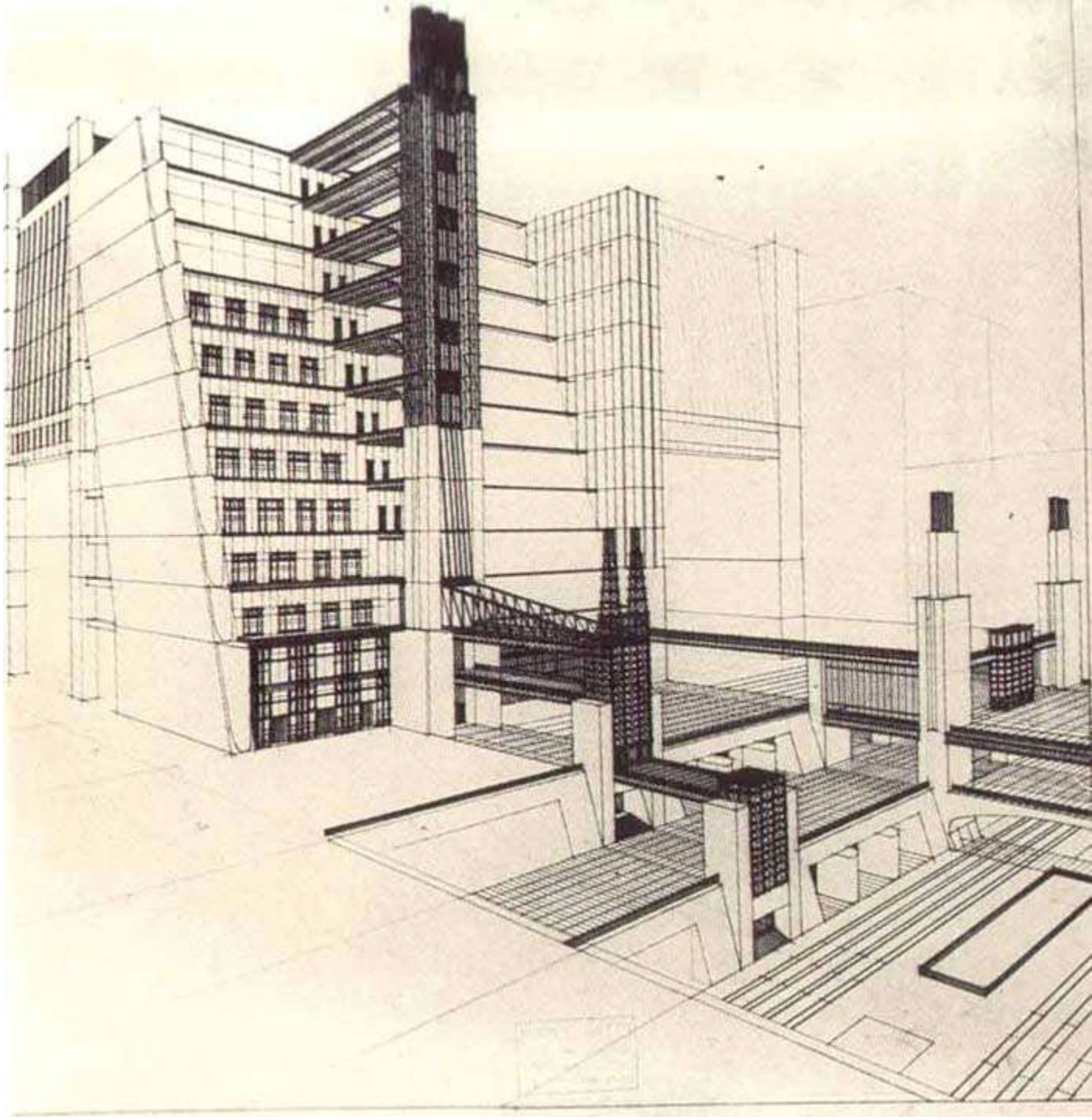
The Modern City

Giacomo Balla (1871-1958), *The Stairway of Farewells*, 1908 ➔

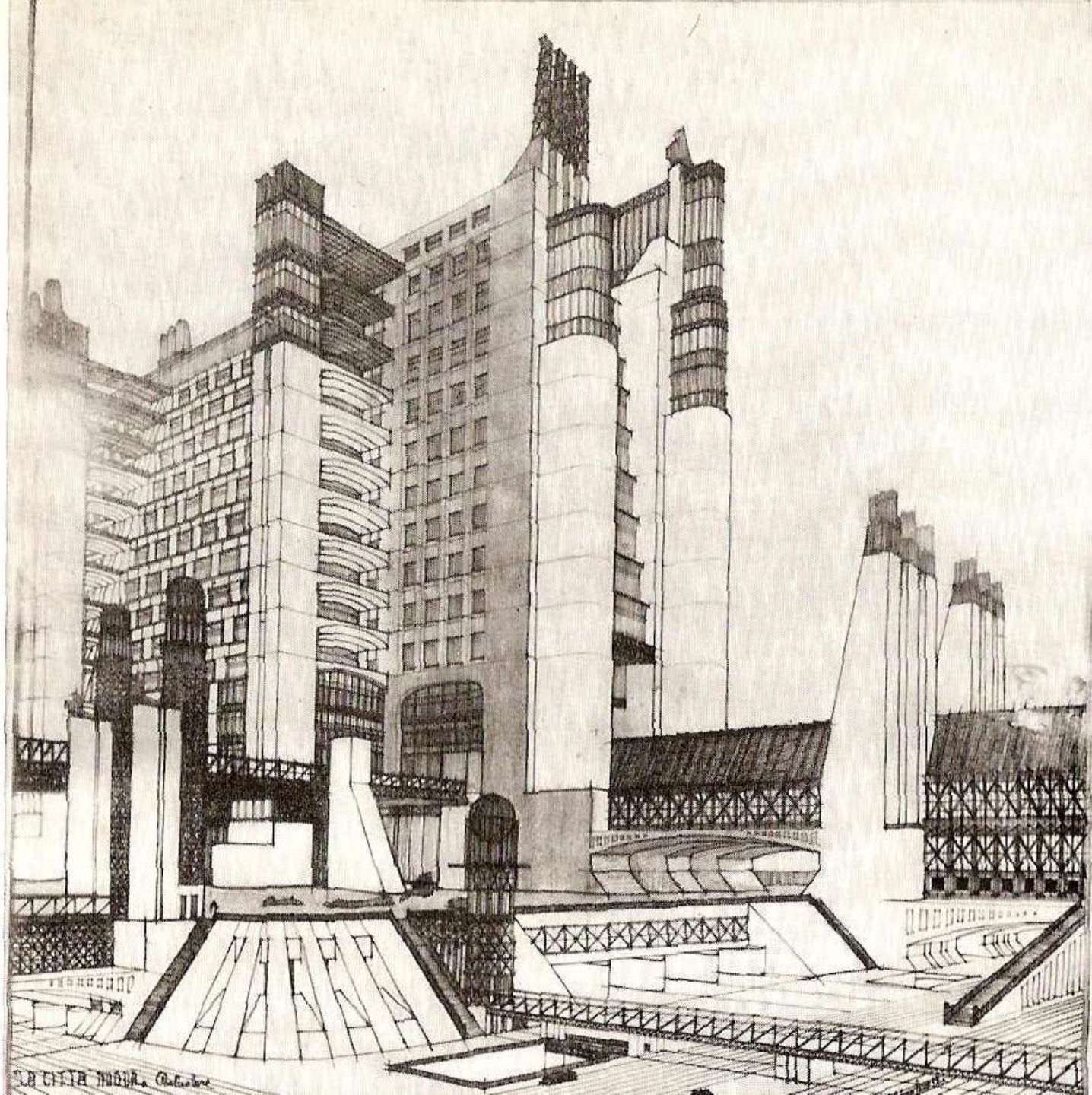


Gino Severini (1883-1966), ➔ *The Boulevard* (1910)

La Città Nuova (1914), Antonio Sant'Elia (1)

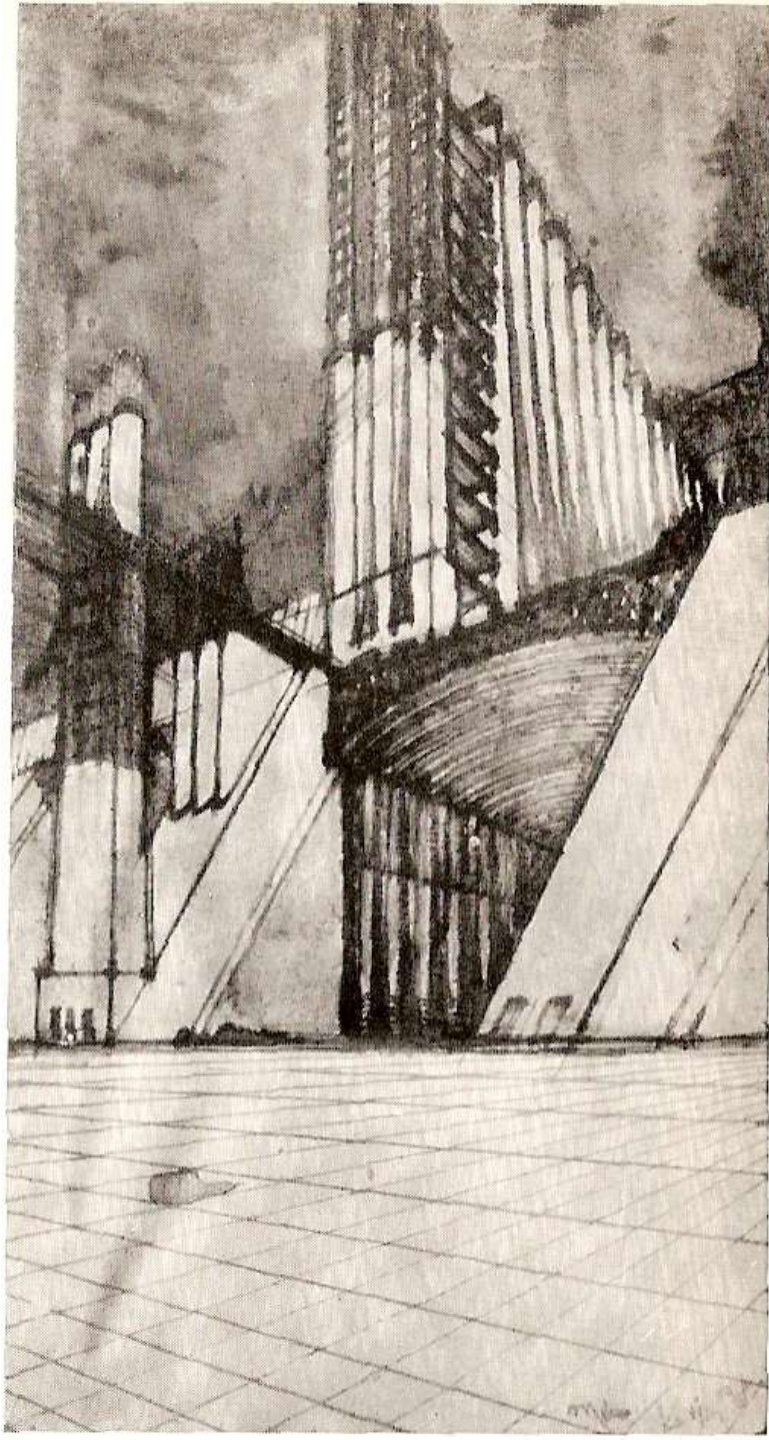


La Città Nuova (1914), Antonio Sant'Elia (2)



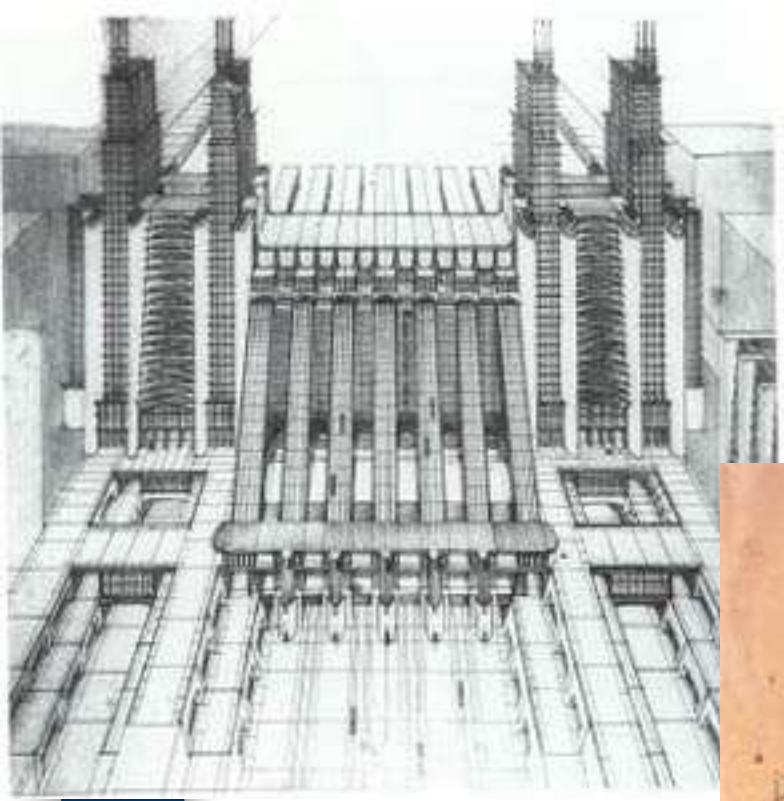
La Citt à Nuova (1914), Antonio Sant'Elia (3)

Drawing of a dirigible hangar (1913)



Futurists, the Bauhaus...

(the Dessau school, designed by Gropius)

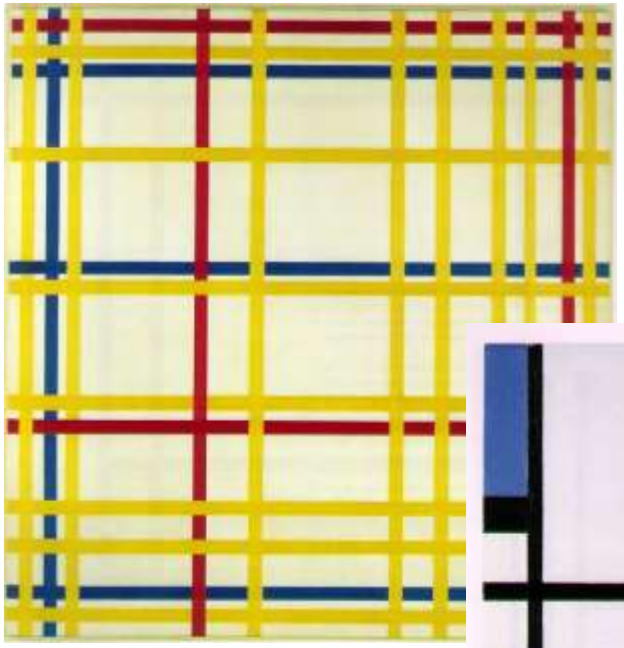


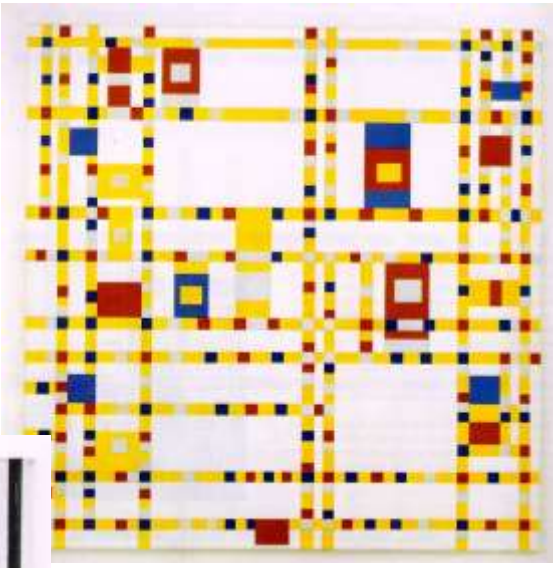
(Sant'Elia)

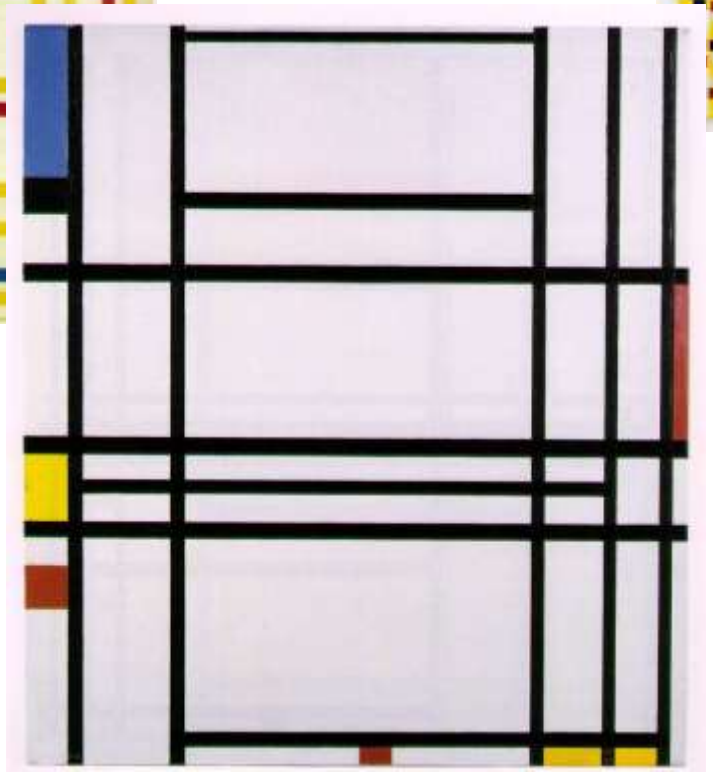
(the Model B-3 chair designed by Marcel Breuer in 1925-1926)

Antonio Sant'Elia, born in 1888, joined the Futurists in 1914. He was killed in the First World War in 1916.

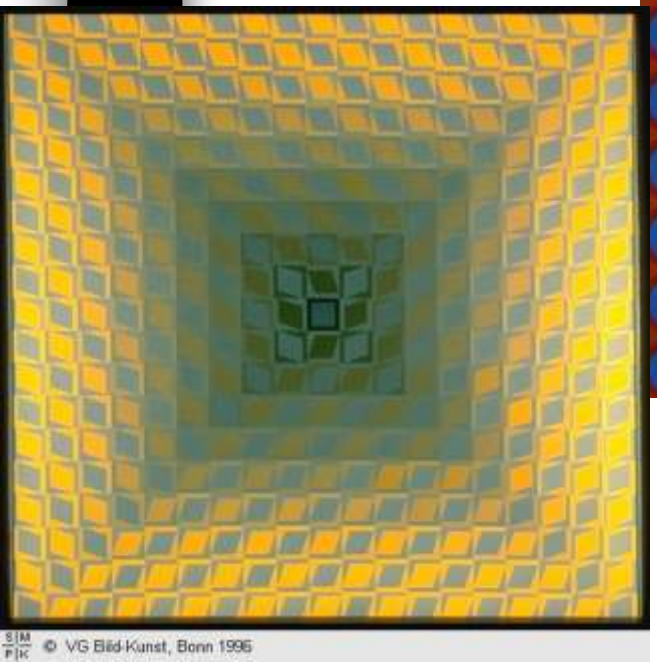
… Piet Mondriaan (1872-1944) in New York...

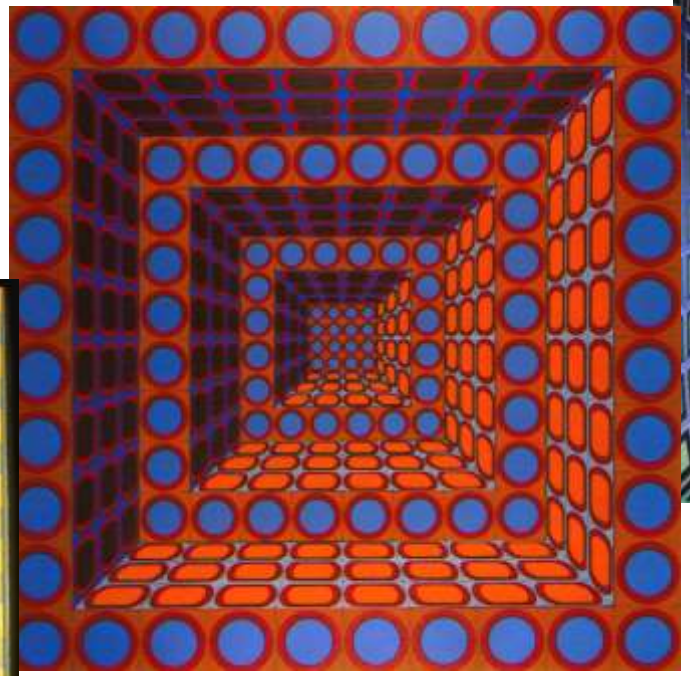


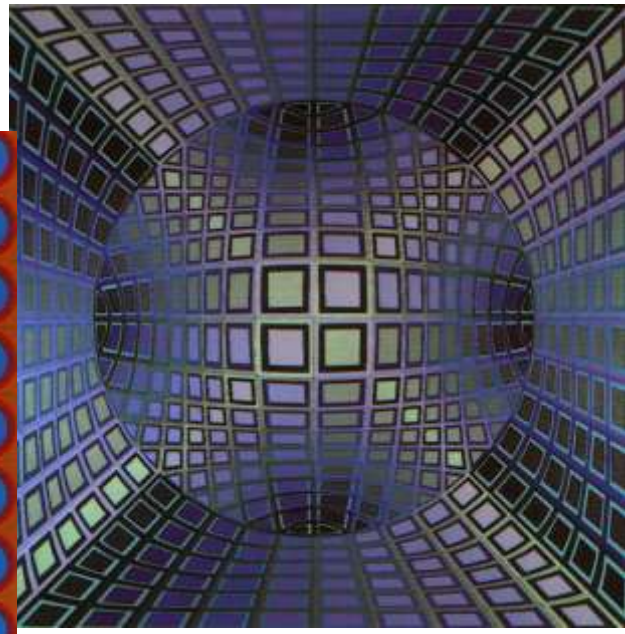




… and Victor Vasarely (1906-1997), a medical student who dropped out but remained impressed with science







From art to reality: Le Corbusier (1887-1965)

La Cité du Refuge (1933)
This is actually a Salvation Army building in Paris designed by Le Corbusier according to his new principles of architecture.

A Calgary "Skyscraper" (1910)

In the early part of the twentieth century, it became possible to build tall buildings thanks to innovations like elevators, better steel frames, and reinforced concrete. In style, however, the new "skyscrapers" often resembled their more conservative precursors.

From Athens to Calgary…

Parthenon, Athens

arched pediment

cornices

pediment

frieze

architrave

columns

Roman arch

The Old and the New

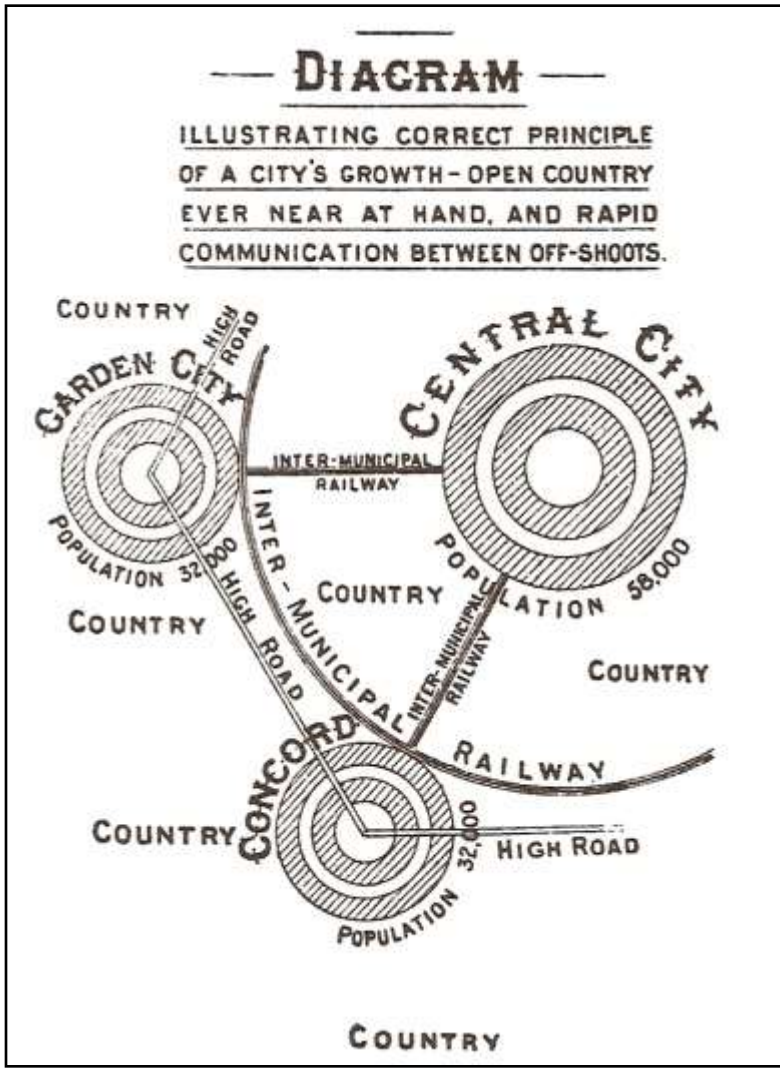
This Winnipeg skyscraper known as the Sterling Building (*c.* 1910) is overshadowed by the Kensington Building (1975) and its modernistic design

To recapitulate (1)

- According to available data, is the U.S. adult population less scientifically literate than Europe's?
- The architect known as Le Corbusier was a Futurist who drew up plans for the modernistic buildings of an imaginary new city: true or false?
- By 1940, the U.S. industries born during the original Industrial Revolution needed the largest number possible of high school graduates: true or false?
- Why did U.S. high school enrollment and graduation rates dip during World War II?
- Can you explain why the Futurists were in favour of war as an expression of modern values?

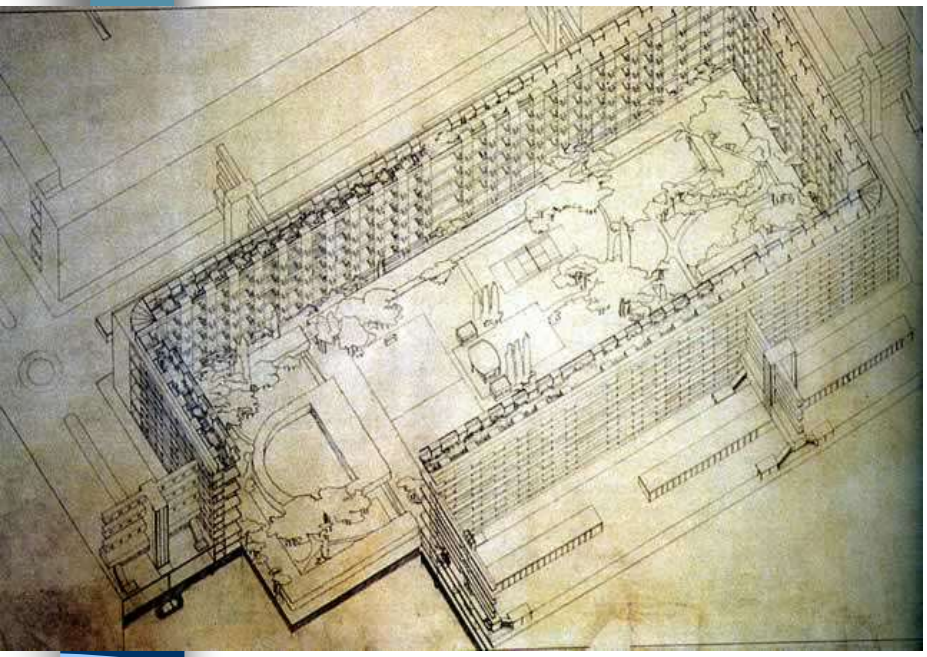
Vertical Cities and Garden Cities (1)

- The Industrial Revolution had already led to the building of well-planned company towns (New Lanark, *c*. 1800)
- Nevertheless, poor housing for workers and grim living conditions for all city-dwellers led reformers to propose better urban designs
- By 1898, British utopian Ebenezer Howard had come up with a way to combine the advantages of city and country living

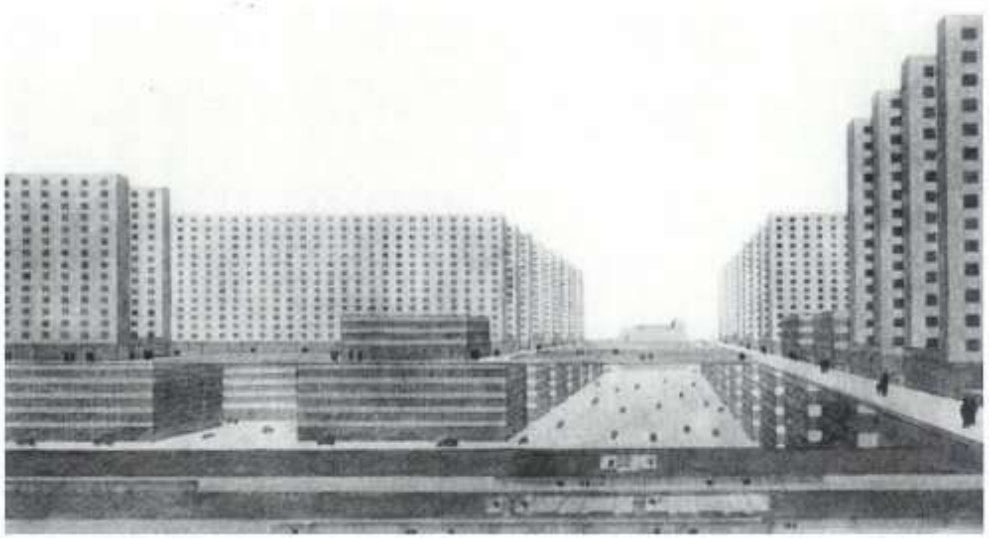


From Ebenezer Howard's *Garden Cities of To-morrow* (1902)

Vertical Cities and Garden Cities (2)



Drawing by French architect
Le Corbusier

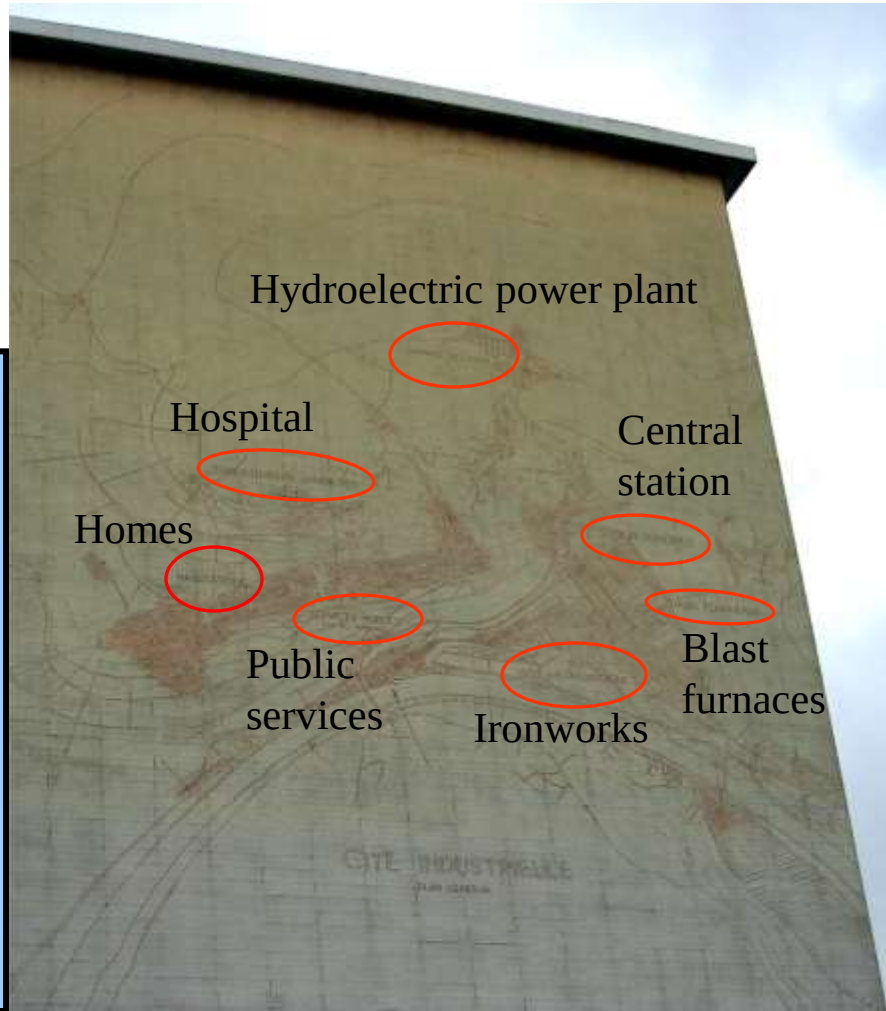


Drawing by German architect
Ludwig Hilberseimer in 1924

Vertical Cities and Garden Cities (3)

- **Planning cities**: in France, architect Tony Garnier (1869-1948) publishes in 1917 his plan for an imaginary "*cité industrielle*" with zoning and many amenities

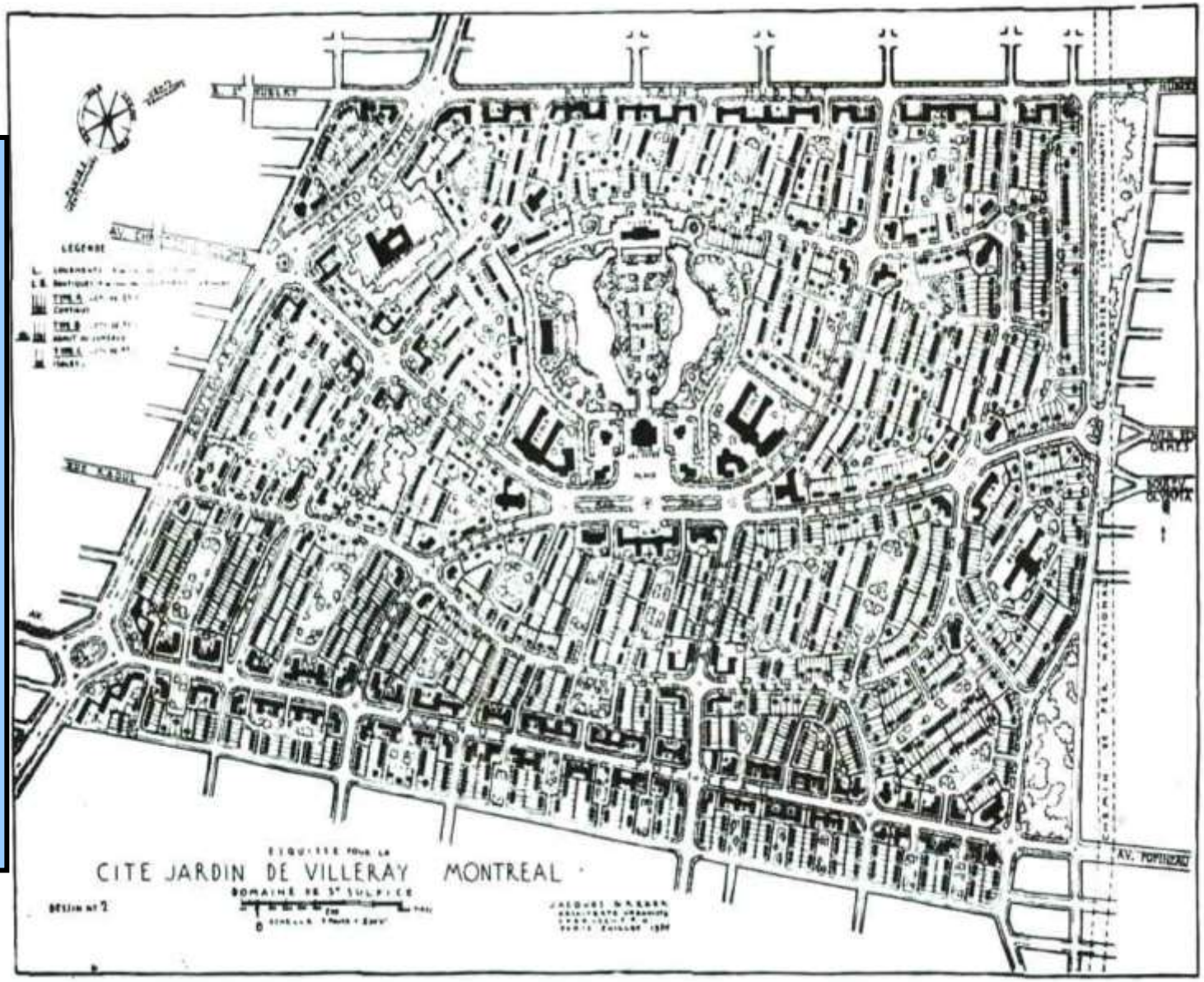
Garnier designed for the city of Lyons (France) a public housing project known as the "Quartier des États-Unis" (1920-1934). The low-rise buildings (left) are still standing today and still in use. Garnier was one of several European architects, such as Auguste Perret and Le Corbusier, whose ideas proved influential.



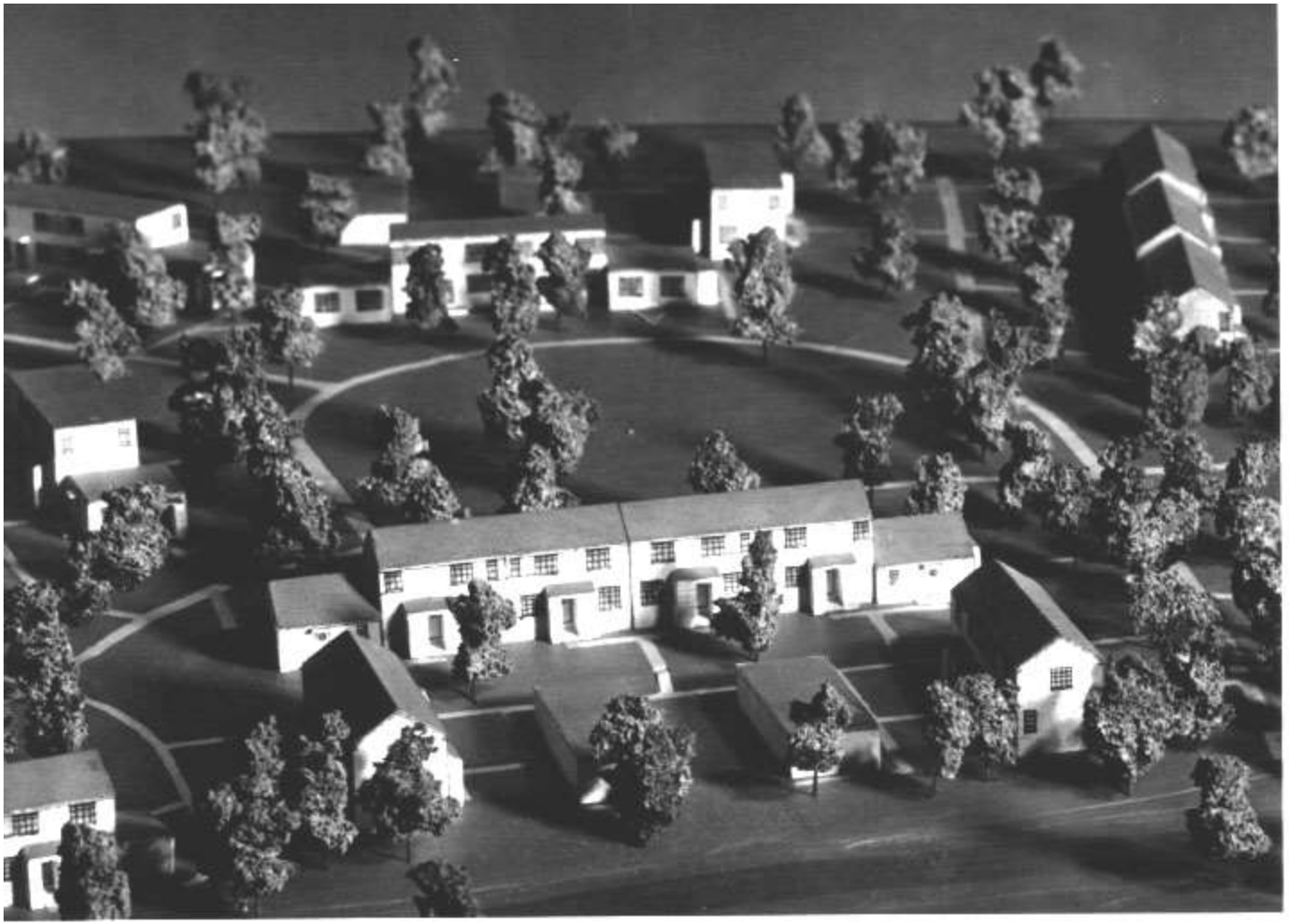
Vertical Cities and Garden Cities (4)

Léon Ploegarts, "Un projet inconnu de Jacques Gréber", *Urban History Review*, **XXIX** (March 2001).

Drawing by French architect Jacques Gréber in 1935 of a projected "Garden City" for a Montreal neighbourhood, perhaps modelled on the 1912 Town of Mount Royal; Gréber later delivered the 1950 master plan for the development of the National Capital Region in and around Ottawa.

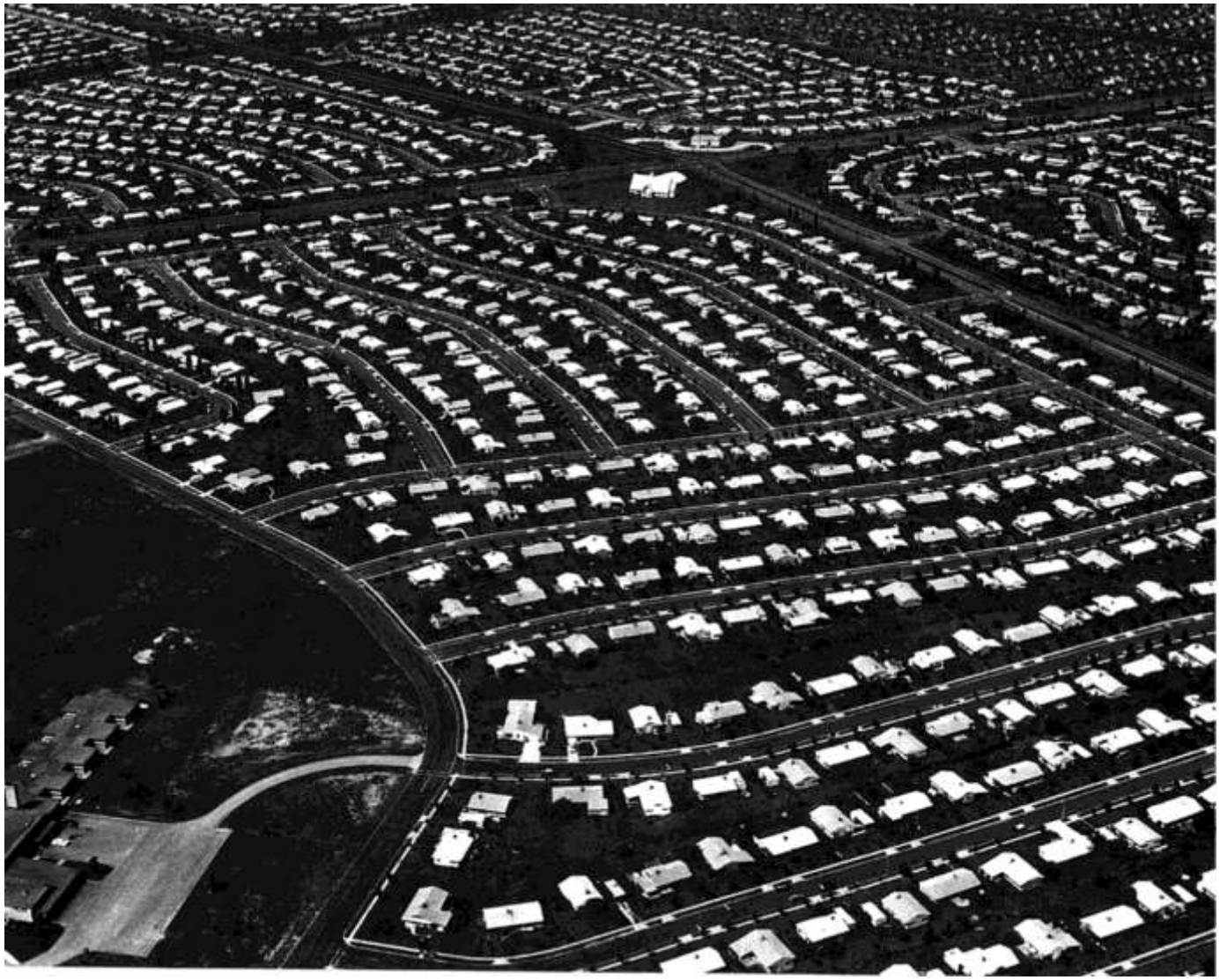


Vertical Cities and Garden Cities (5)



Greenbelt (Maryland) was one of four model towns planned during the Roosevelt administration as garden cities. This architect's model from 1936 shows clearly the mix of clean-contoured houses and greenery.

Vertical Cities and Garden Cities (6)



Levittown, Pennsylvania, 1959
National Archives and Records Administration

Levittown (Pennsylvania) was the next step in the evolution of modern suburbs. Built in 1951-1958, it improved on the first Levittown near New York.

Industrial Design: The Look of the Future

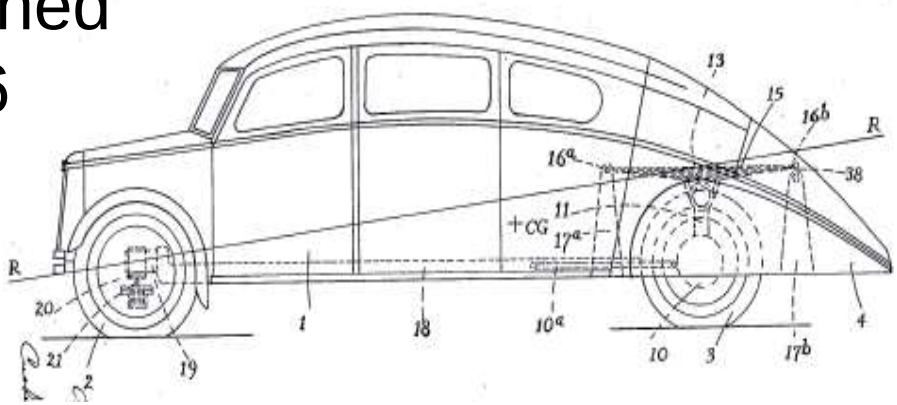
- Before World War I, architecture and design often relied on older models, whether Gothic (Ottawa's neo-Gothic Parliament) or classical (Ottawa's Beaux-Arts Union Station)
- The Great War and then the Depression discredited many traditional values
- Hope was invested instead in the future, and the future was going to be scientific
- By 1939, *streamlining* had come to express all that was hopeful about science

Peter Behrens (1868-1940)

- Trained in painting and the decorative arts, he is named in 1903 the director of the Düsseldorf College of Arts and Crafts
- In 1907, he is hired as an artistic consultant of AEG (*Allgemeine Elektricitäts Gesellschaft*)
- He seeks to *humanize the industrial world*
- Among his students and collaborators are Walter Gropius (1883-1969), Le Corbusier (1887-1965), and Ludwig Mies van der Rohe (1886-1969), whose famous pronouncement “Less is more” was taken from Behrens

Streamlining, from airships to cars

- Paul Jaray (1889-1974) worked in Germany on the streamlining of seaplanes and zeppelins
- As early as 1921-1923, he began patenting and designing streamlined car bodies that were licenced to car manufacturers in Europe and the United States
- Charles Dennistoun Burney (1888-1968) managed the construction of the British R-100 airship and then designed streamlined cars from 1927 to 1936



One of Burney's streamlined car designs from a 1934 United States patent

The American School

- **Norman Bel Geddes** (1893-1958) advocates “water drop” shaping in *Horizons* (1932) and designs GM’s “Futurama” exhibit for the 1939-40 New York World Fair
- **Henry Dreyfuss** (1904-1972) works on train design (1938-1940) and comes up with “The City of Tomorrow” exhibit for the New York World Fair
- French-born **Raymond Loewy** (1893-1986) designs streamlined locomotives and extends streamlining to many other celebrated products (cars, refrigerators, Greyhound buses)
- **R. Buckminster Fuller** (1895-1983) conceives a three-wheeled, teardrop-shaped car in 1934 (*Dymaxion*), proposes prefabricated housing, and perfects the geodesic dome in 1949 as the concrete embodiment of “doing more with less”

Streamlined Trains in the United States

Arthur Rothstein (born 1915) took the above picture in the summer of 1939. The streamlined locomotive enters the landscape of La Crosse (Wisconsin) as an amazingly novel presence. (Library of Congress)

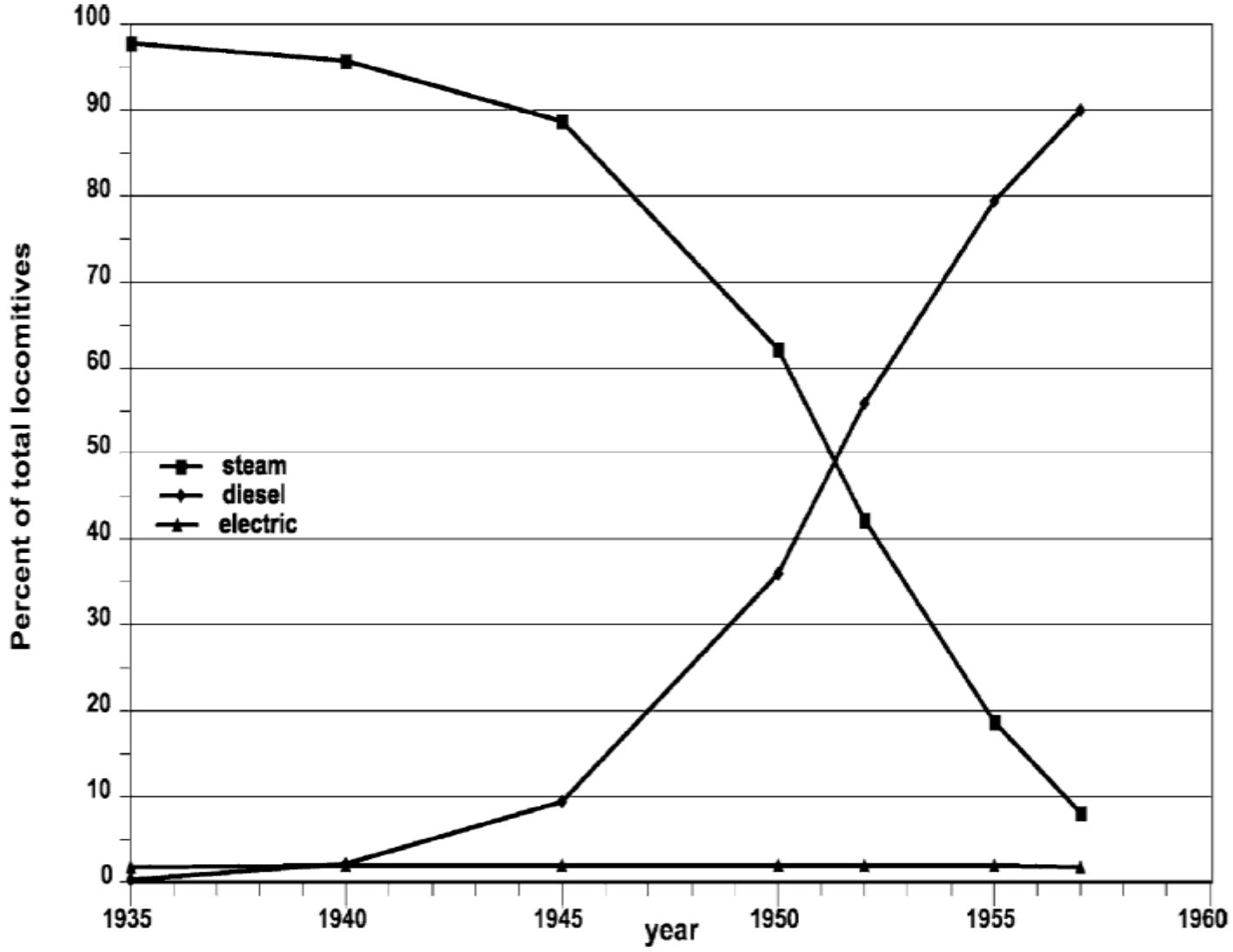
Santa Fe Streamliner at the depot in Albuquerque (New Mexico) in 1943 ↓

Streamlining in the United States

Santa Fe Streamliner
in Kansas City (Kansas)
in March 1943 ➔

The birth of the one-piece
Eames chair (“La Chaise”)
in 1948

Replacement of steam by diesel locomotives (U.S., 1935-1957)



Cited by: Robert U. Ayres, Leslie W. Ayres, and Benjamin Warr, *Energy* (March 2003)

To recapitulate (2)

- Between what two years did diesel trains become more numerous than steam trains in the U.S.?
- Name five (5) technological objects streamlining was applied to between WWI and WWII.
- Who designed the “Futurama” exhibit at the 1939-1940 World Fair?
- Is Ebenezer Howard associated with the original concept of the garden city or of the vertical city?
- Explain why Ottawa is best described as a garden city or a vertical city.
- Explain how streamlining could fit with the Modernist design ideal of “Less is more”.

Science delivers...

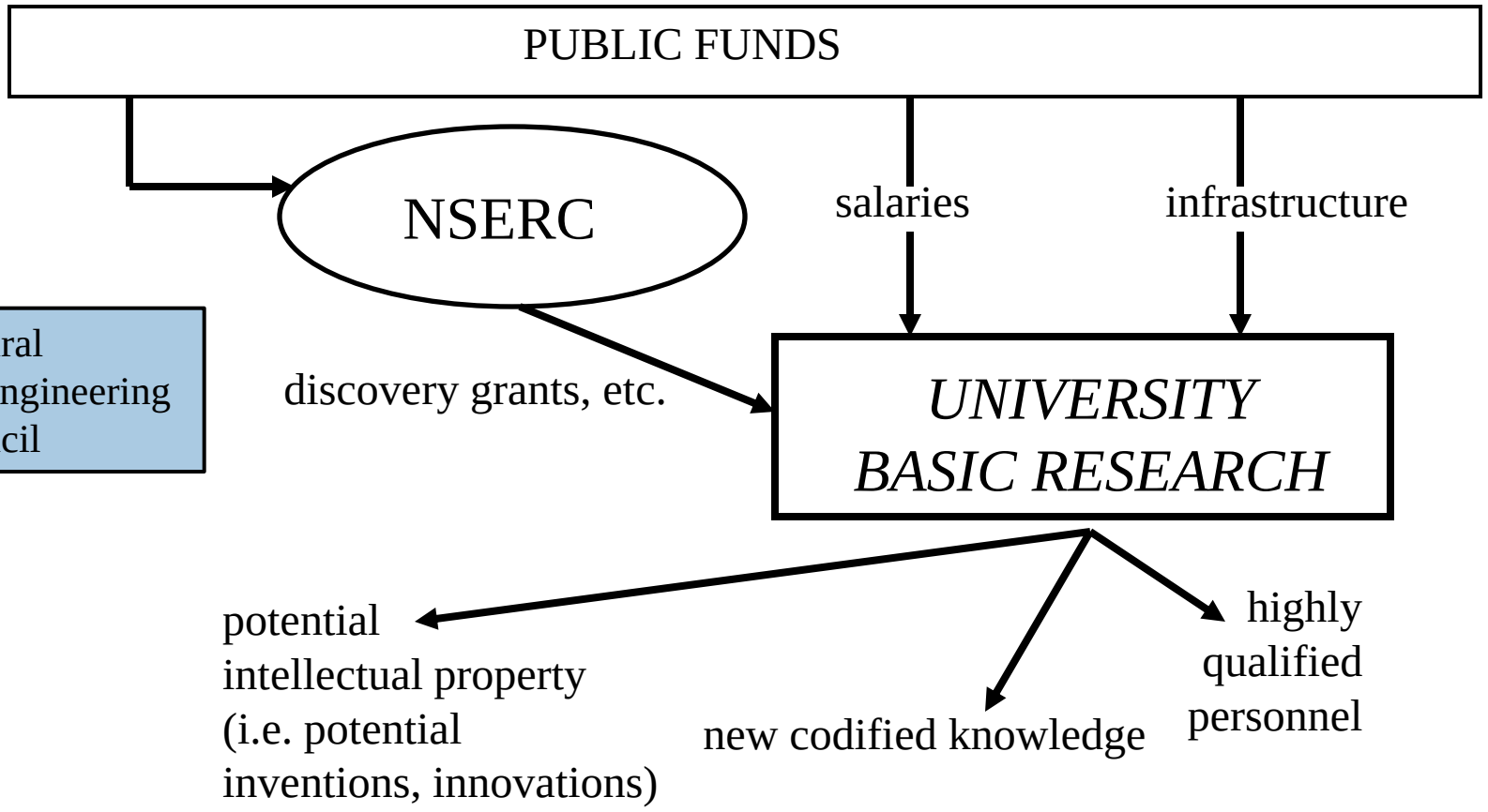
- For good or ill, it became clear in the first half of the 20th century that science and technology could deliver the goods
- Automobiles, airplanes, and streamlined trains (*Faster…*)
- Skyscrapers (*Higher…*)
- And new weapons for war: airplanes, zeppelins, poison gas, tanks, radar, jet propulsion, rockets… and the atomic bomb (*Stronger…*)

Research Councils (1)

- The initial collaboration of industry and the military, both partnering with universities in different ways, built upon the existing model of university research backed by public funds
- World War I stimulated the creation of the first research councils (Great Britain: July **1915**, United States: April **1916**, Canada: November **1916**)
- After the war, they were set the goal of tackling the research problems of industry by drawing on the knowledge of universities
- The National Research Council of the U.S. took on a purely advisory and coordinating role, while its Canadian counterpart took on a more active research role by the time of World War II

Research Councils (2)

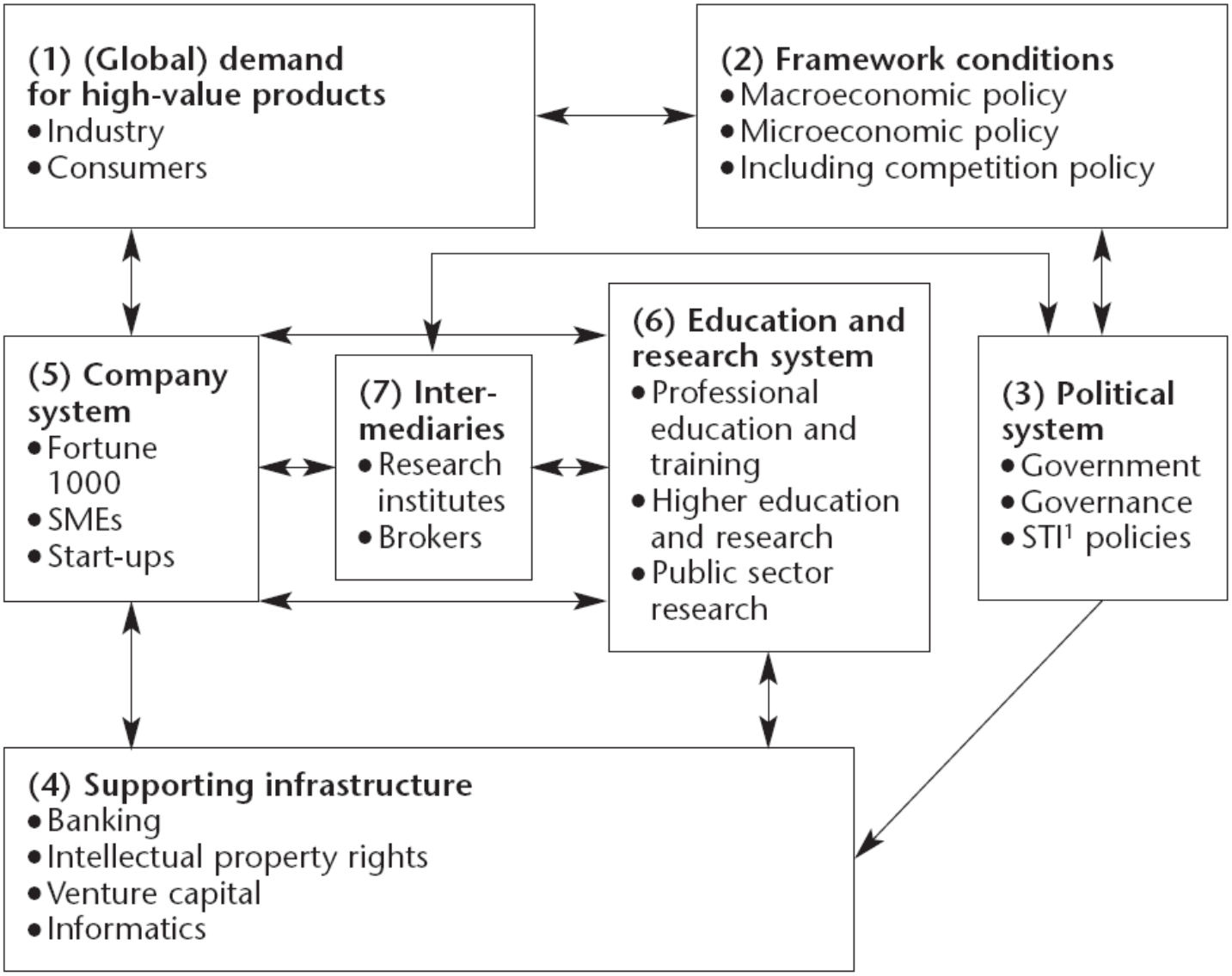
(Idealized schematic of current university research inputs and outputs in Canada)



NSERC: Natural Sciences and Engineering Research Council

Adapted from: T. A. Brzustowski, "Innovation = Invention + Commercialization: A Systems Perspective", *Optimum Online*, **36**, Number 3 (2006).

A Generic National Innovation System



Source: OECD, 2005.
[1] Science and technology information.

Guy Stanley, "What's Wrong with Canada's System of Innovation", *Policy Options* (December 2006-January 2007)

Research Councils (3)

- (Innovation is often understood to include both a new invention and everything that leads to its commercialization)
- University research also benefits from other inputs, including (i) the acquired expertise of researchers, (ii) knowledge gained in the community, and (iii) other sources of funding (corporate, etc.)
- Industrial countries fund research, but also support scientific literacy and employment
- Public funding remains key for basic research and for scholarship with fewer applications (social sciences and humanities), but corporate funding sponsors an increasing share of other research

The World After Hiroshima (1)

- The conviction that science and technology had delivered victory in World War II enabled U.S. industrial designers, urban planners, architects, and highway builders to push forward with the ideas gathered from sources as diverse as the German autobahns, the futuristic buildings of the 1939 World Fair, and the general belief that an uncluttered and "streamlined" exterior was modern
- The creation of the nuclear bomb became the model for a new innovation system relying on the melding of science, government funds, and engineers
- The enthusiasm for modernity peaked in the 1950s with the advent of jetliners and space travel, as well as the great hopes invested in nuclear power

“I am become Death”

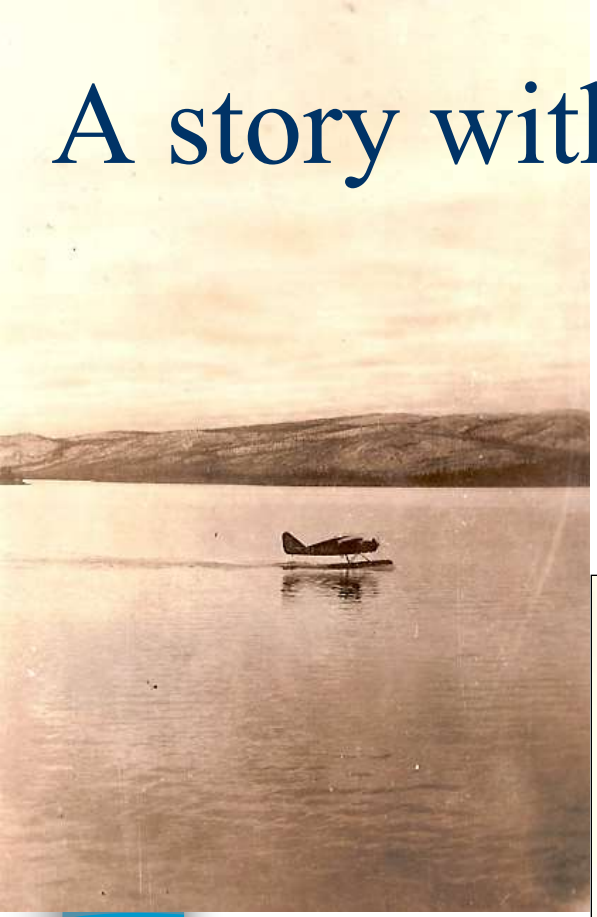
(Robert Oppenheimer at Trinity Test, from the *Bhagavad-Gita*)

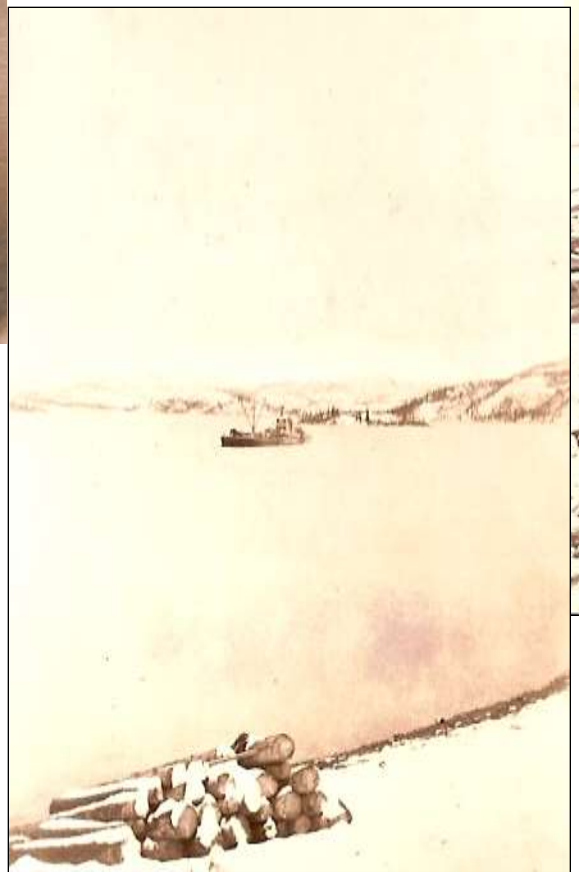
- By the 1930s, the idea of the nuclear bomb had occurred to scientists in several countries, though most clearly to Leo Szilard in London
- During the Second World War, the fear that the Germans might be first led the Allies to engage in a huge effort to complete a nuclear bomb before them
- In the space of a decade, scientists and engineers combined forces in order to go from the production of the first sustained chain reaction to the first fission bomb, nuclear reactor, and fusion bomb
- This was arguably **technoscience** in action

Robert Oppenheimer and general Leslie Groves inspecting the remains of the Trinity test tower (9 September 1945)

A story with beginnings in Canada…

Pictures of Cameron Bay in 1934, designated as the administrative center of the Port Radium district.





Two views of Great Bear Lake near Cameron Bay, showing a supply plane and a supply ship.

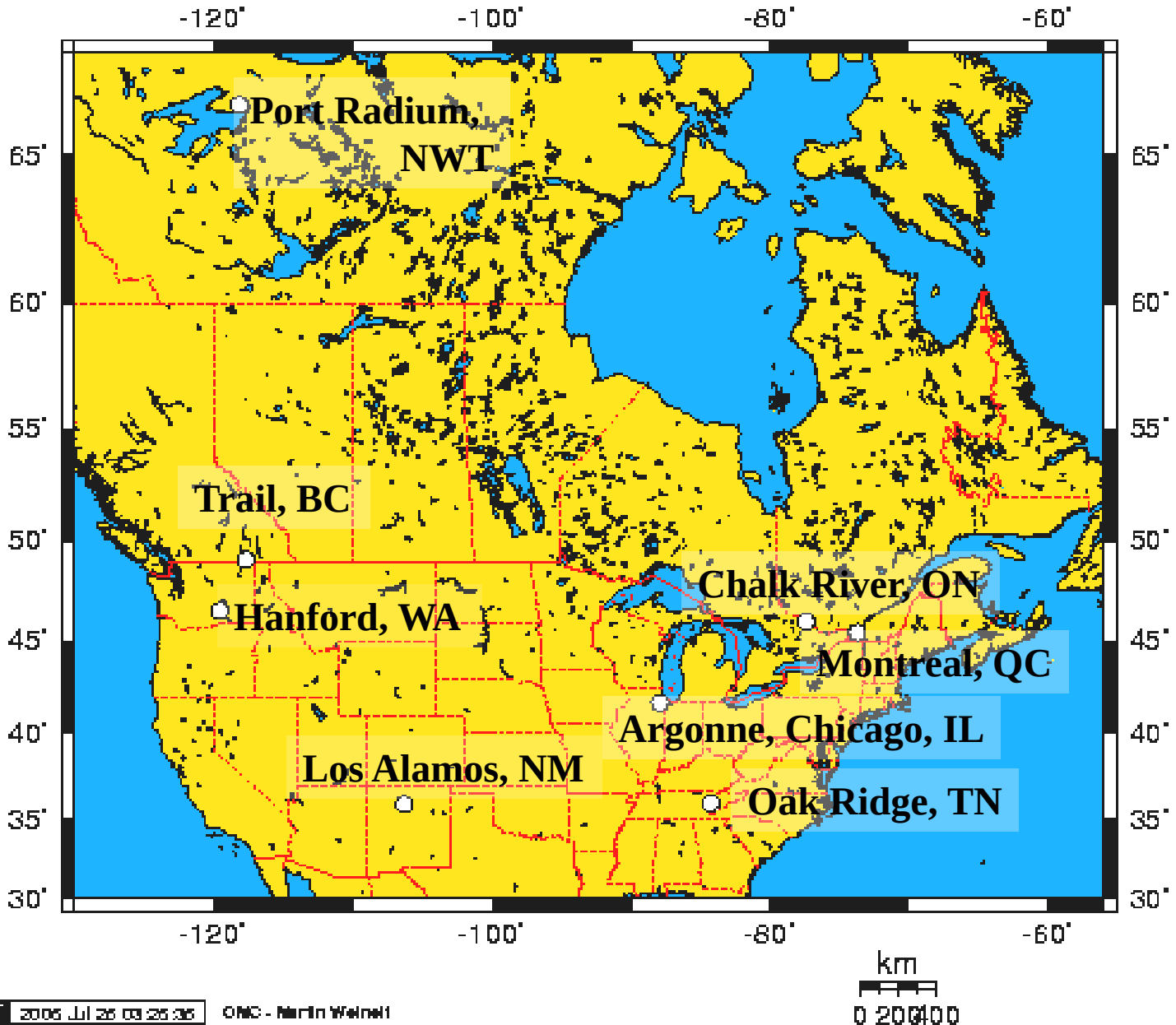
Above: the Mining Recorder's Office, with the Hudson's Bay store just visible behind

Miner with a car of silver radium ore around 1930 at the Eldorado Mine (Great Bear Lake, NWT)

Eldorado Mining & Refining Ltd., Library and Archives Canada

Eldorado ended radium mining by 1939, but the mine was secretly reopened in 1941 for the mining of uranium for the atomic bomb. The Canadian government secretly bought out the company in 1942.

The Manhattan Project



Main Sites

- Argonne and Chicago, IL
- Hanford, WA
- Los Alamos, NM
- Oak Ridge, TN
- Chalk River, ON
- Montréal, QC
- Port Radium, NWT
- Trail, BC

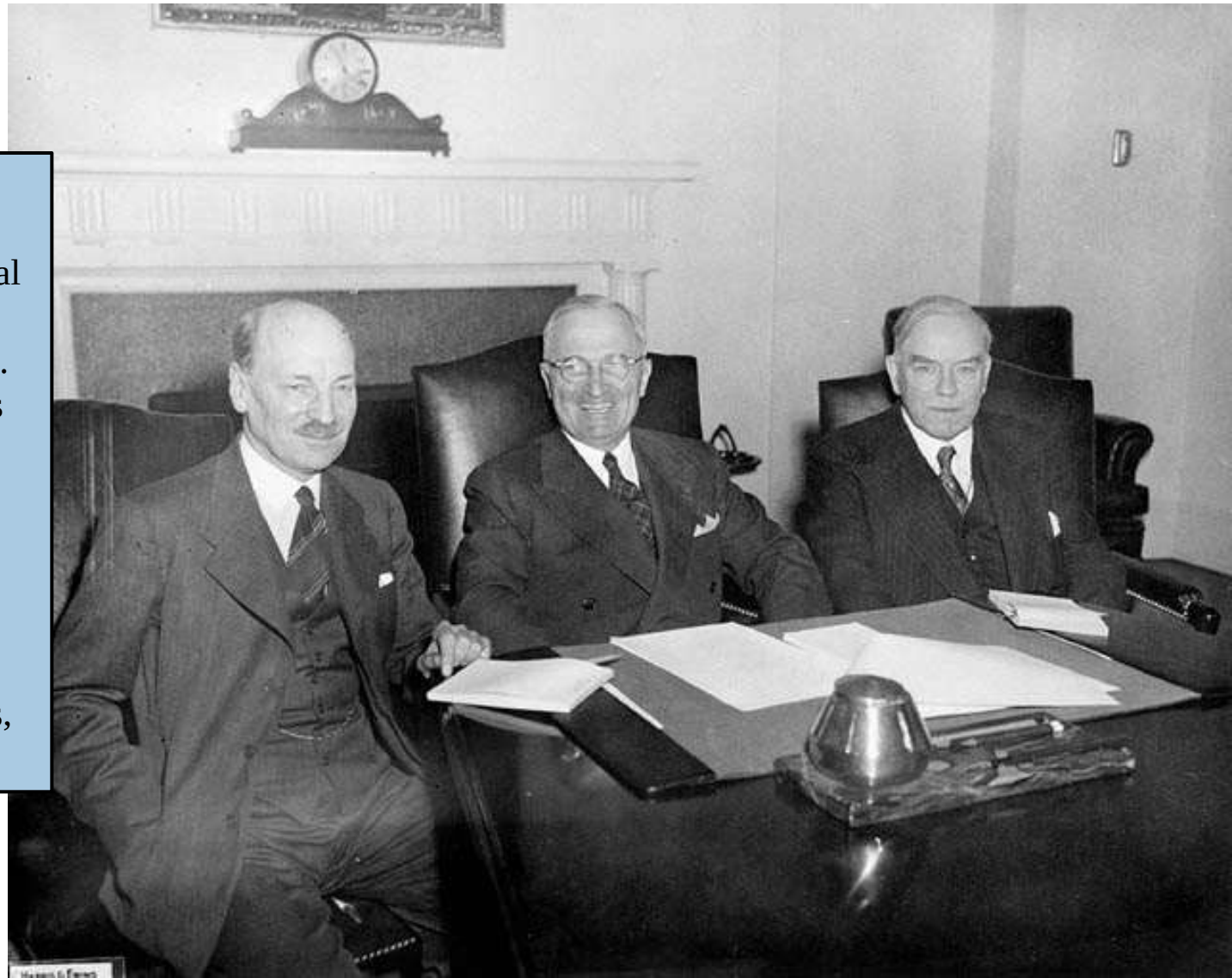
A plant worker covers his shoes to reduce contamination at Chalk River (November 1947)

Following a joint military decision between Ottawa and Washington to build a reactor in 1944, the Chalk River plant was conceived as the most efficient means of producing plutonium using heavy water. Even the employees' lockers are designated "active" or "inactive" according to the radioactivity level of their clothes.

Chris Lund, National Film Board, Library and Archives Canada

President Harry Truman and Rt. Hons. Clement Attlee and W. L. Mackenzie King concluding atom bomb talks (12-15 November 1945, Washington, DC)

When the U.S. army took over the atom bomb effort in 1942, it cut off its original British partners. Collaboration with the U.K. and Canada was restored as a result of the Quebec Accord in August 1943. However, in 1946, the U.S. **Atomic Energy Act** mandated exclusive U.S. control of nuclear weapons and all civilian applications, as of January 1st, 1947.



Harris and Ewing, Library and Archives Canada

The World After Hiroshima (2)

- In North America, while much of the world lay in ruins or struggled to survive from day to day, the aftermath of World War II was marked by increasing prosperity
- Both victory in the war and prosperity in peacetime were commonly attributed to science and technology, allowing Vannevar Bush (*Science—The Endless Frontier*) to argue for the government funding of basic scientific research as well as military and medical R&D

By the end of World War II, 37% of U.S. GDP was devoted to defence (in 1945). This was reduced to 7.4% in 1947.

To recapitulate (3)

- Identify three (3) Canadian sites that were part of the Manhattan District project and their main role.
- Were the United States the first country to create a research council during World War I?
- Identify two (2) arguments used by Vannevar Bush to claim that the U.S. government should fund basic and applied research after World War II.
- Were Great Britain and Canada full partners of the U.S. when the Manhattan District project led to the bombings of Hiroshima and Nagasaki?
- What was technoscientific about the development of nuclear weapons?

The Rise of Technoscience

- After World War II, even the United States did not feel the need to invest in more research, believing they, along with their allies, would enjoy a monopoly on the atomic bomb for decades to come
- Until 1948, the United States did not renew the wartime financing of research, leaving such financing to older agencies and to organisms such as the *Office of Naval Research*
- This made for a rude awakening when the USSR set off its first nuclear bomb in 1949, and even more so when Sputnik was lofted into space in 1957

The Heirs of Von Braun (1)

- After WWII, the victors came away with German rocket scientists or their material, or both
- In the USSR, space travel had been passionately defended by Konstantin Tsiolkovsky in the early 20th century

The R11 rocket (1949)

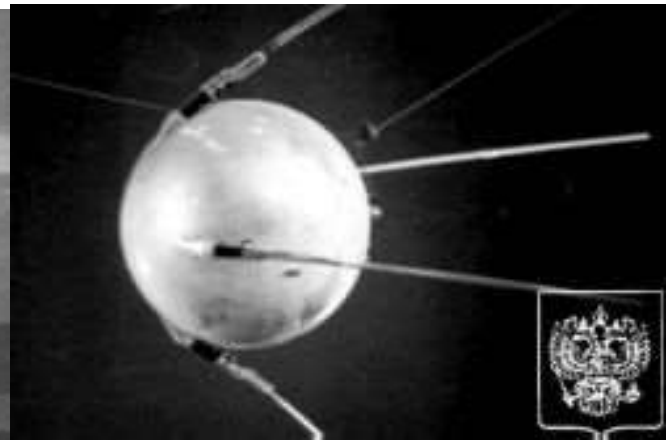
The R1B rocket, clearly modeled on the Nazi V2

Russian State Archive
of Scientific and Technical Documentation

The Heirs of Von Braun (2)

- While Wernher von Braun, the head of the Nazi rocket programme, went to the U.S., the USSR recovered enough
- In 1957, the Soviet space programme was able to launch Sputnik into space

Yu. A. Gagarin at the mathematics exam of the Saratov Industrial and Pedagogical Technical College (1952)



Russian State Archive
of Scientific and Technical Documentation

Gagarin in the Vostok capsule (April 1961)

Russian State Archive of Scientific and Technical Documentation

To the Moon...

- Back from orbit, Gagarin is received by Khrushchev in Moscow (April 14th, 1961)
- On May 5th, 1961, Wernher von Braun oversees the launch into space of Alan Shepard aboard Freedom 7

Russian State Archive
of Scientific and Technical Documentation

NASA

Space as a new battleground...

Alan Shepard, his wife, and his mother with president John F. Kennedy at the White House on May 6th, 1961 (NASA)

- The ability to put a Sputnik or a Gagarin in orbit was also the ability to launch a nuclear warhead at another continent
- The United States began to fear they had let the USSR take a dangerous lead

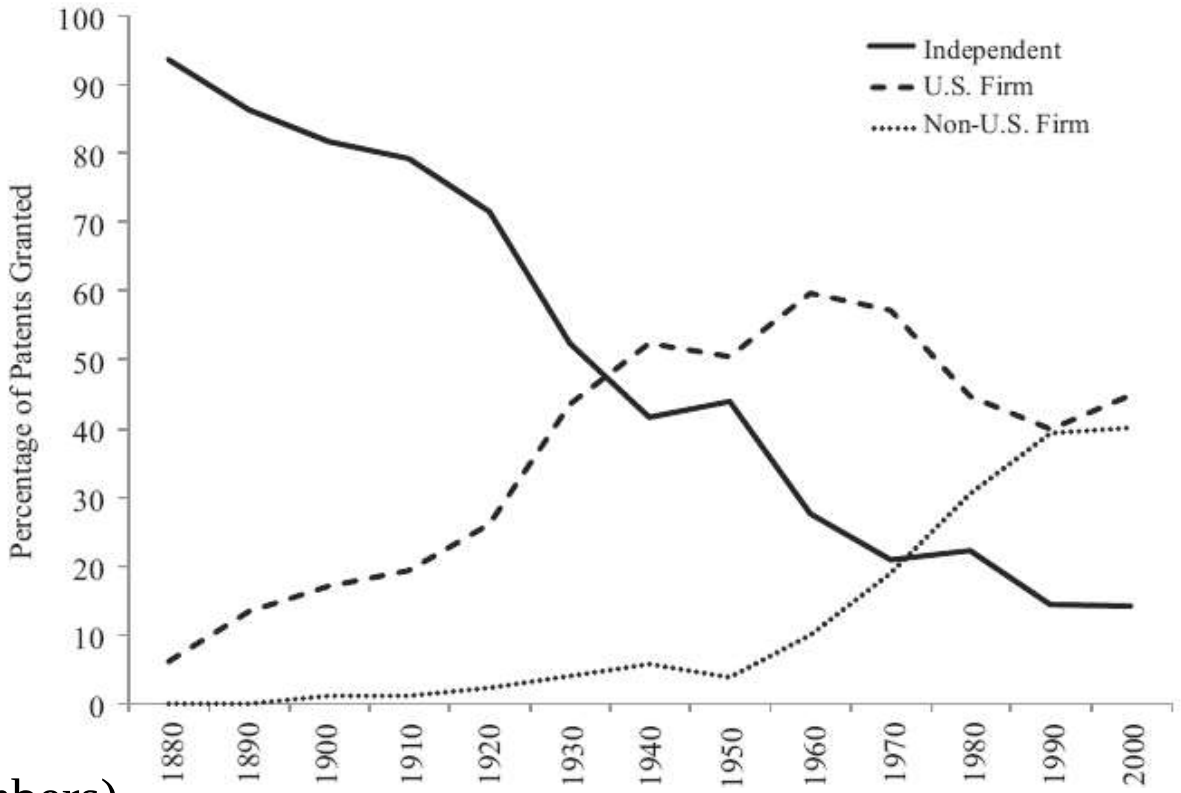
… and science as a weapon

- In 1950, the **National Science Foundation** was set up in the United States to support basic research expected to yield practical benefits
- However, the NSF only accounted for a minor fraction of government support for research
- A larger fraction came from the **Department of Defense** and two allied agencies, **NASA** and the **Department of Energy** (formerly the Atomic Energy Commission)
- The remainder came from the **National Institutes of Health**

Tom Nicholas, "The Role of Independent Invention in U.S. Technological Development, 1880-1930", *Journal of Economic History* **70**, Number 1 (March 2010).

From independent to corporate to government invention…

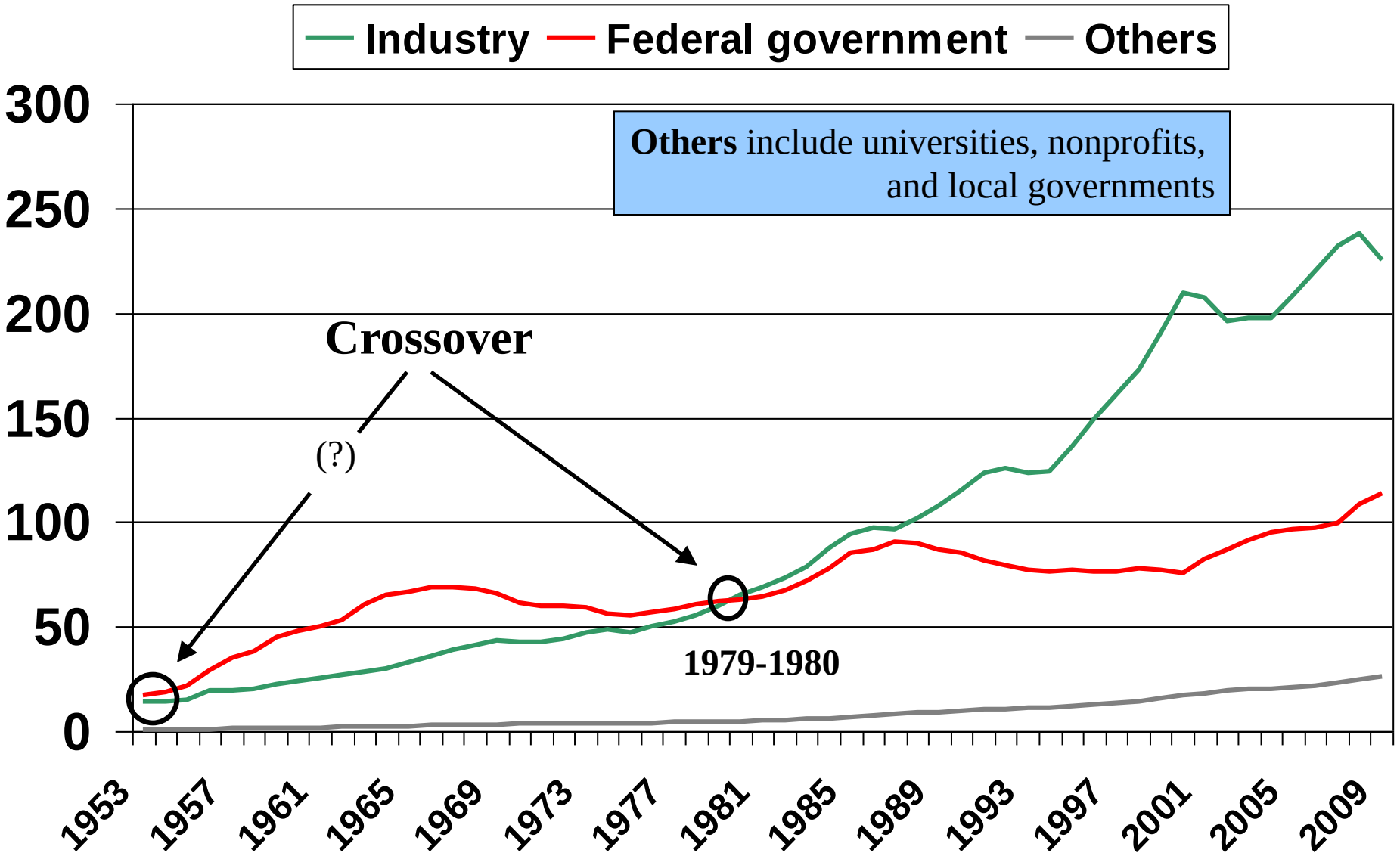
- By 1930, the inventions of corporate research laboratories take over from the output of individuals
- By 1950, the independent inventor is no longer a major player
- By 1953, the government funds most R&D



(U.S. patent numbers)

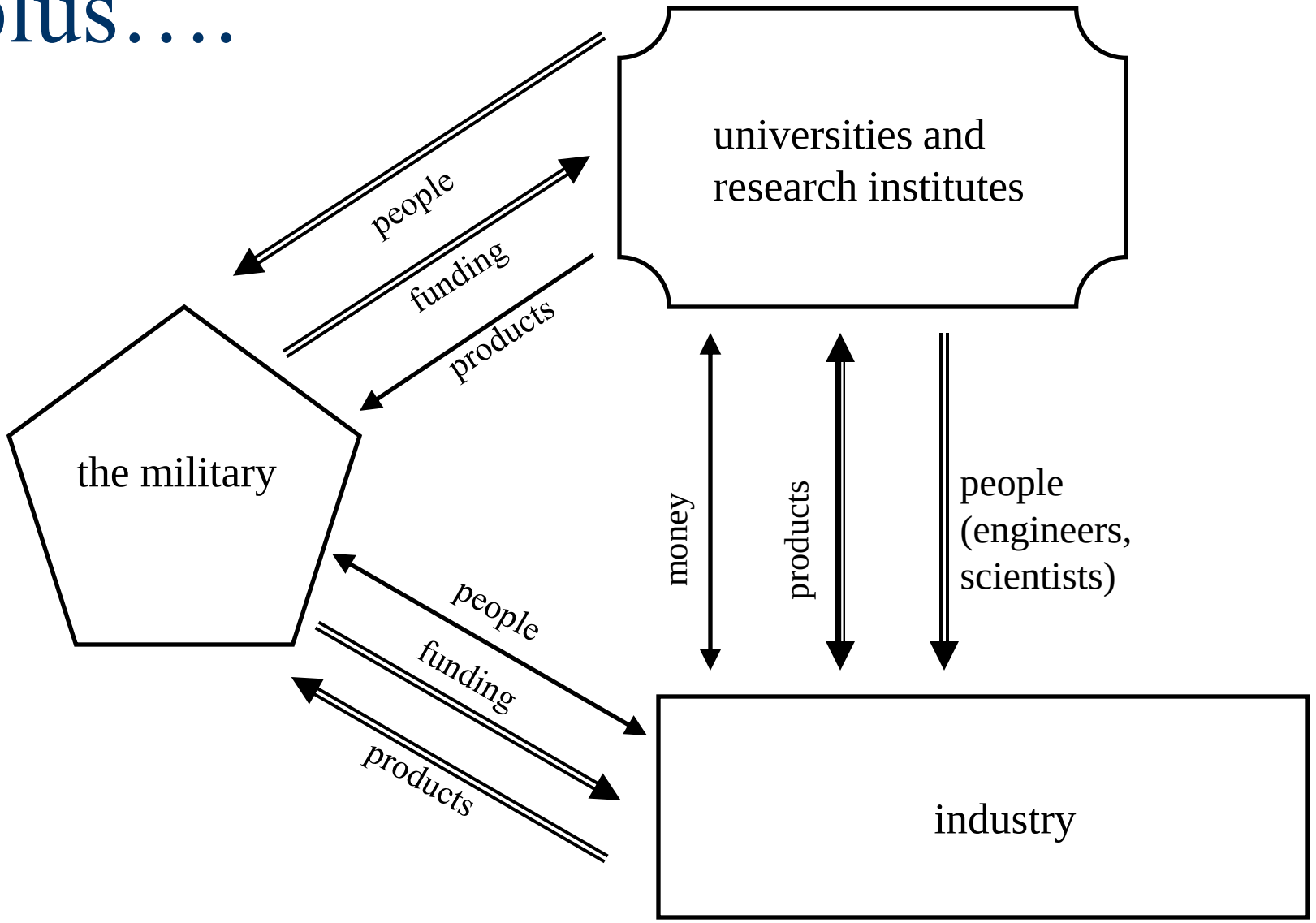
United States: R&D funding

(1953-2009, total expenditures, billions of constant 2005 dollars)



Science and Engineering Indicators, 2012

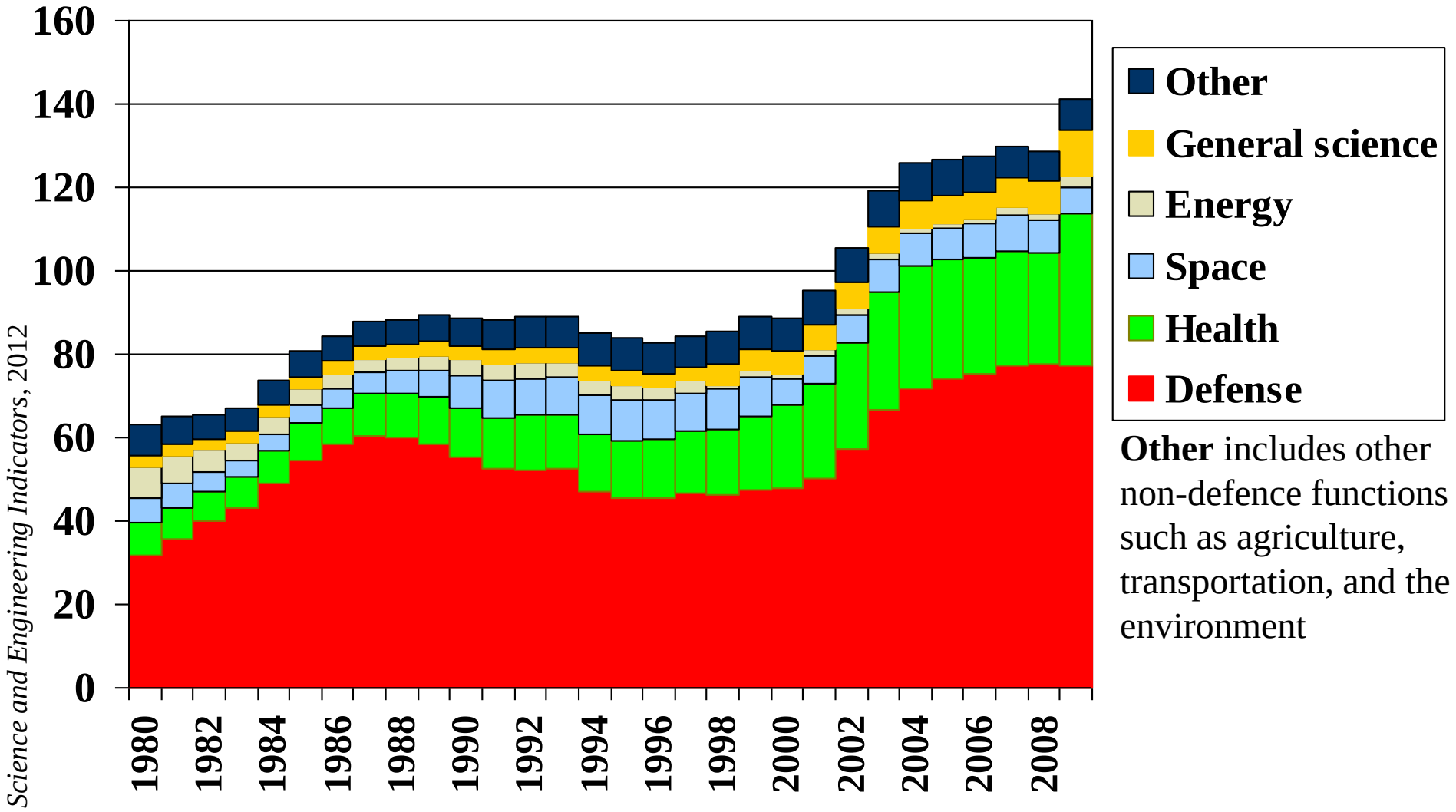
The "Military-Industrial" Complex, plus….



Even today…

U.S. R&D budget

(government funding by budget function, fiscal years, billions of constant 2005 dollars)



Other includes other non-defence functions such as agriculture, transportation, and the environment

Science and Engineering Indicators, 2012

To recapitulate (4)

- Why did U.S. R&D expenditures for defense dip after 1989?
- Why was the tight embrace of the military and industry criticized by president Eisenhower, for one, in 1961?
- Why was the collaboration of university researchers with the military and industry criticized by some as early as the 1960s?
- What two (2) historical events drove the U.S. government to start backing basic and applied research in peacetime?
- Between 1930 and 1940, what sector accounted for most inventions and R&D in the United States?

Privatizing and Outsourcing Research

- 1980: Bayh-Dole Act (USA) — universities and small businesses (large corporations after 1983) retain title to federally-funded inventions/discoveries and can negotiate exclusive licences for them
- Rationale: inventions require outside financing for further development (in 2001, 45% of inventions were at the “proof of concept” stage; only 12% were ready for practical use before licencing)
- Other U.S. laws during the 1980s facilitated the partnering of private and public entities, with corporations capturing the benefits of innovations
- Consequences: (i) the decline of the in-house corporate research laboratory, (ii) the rise of private financing

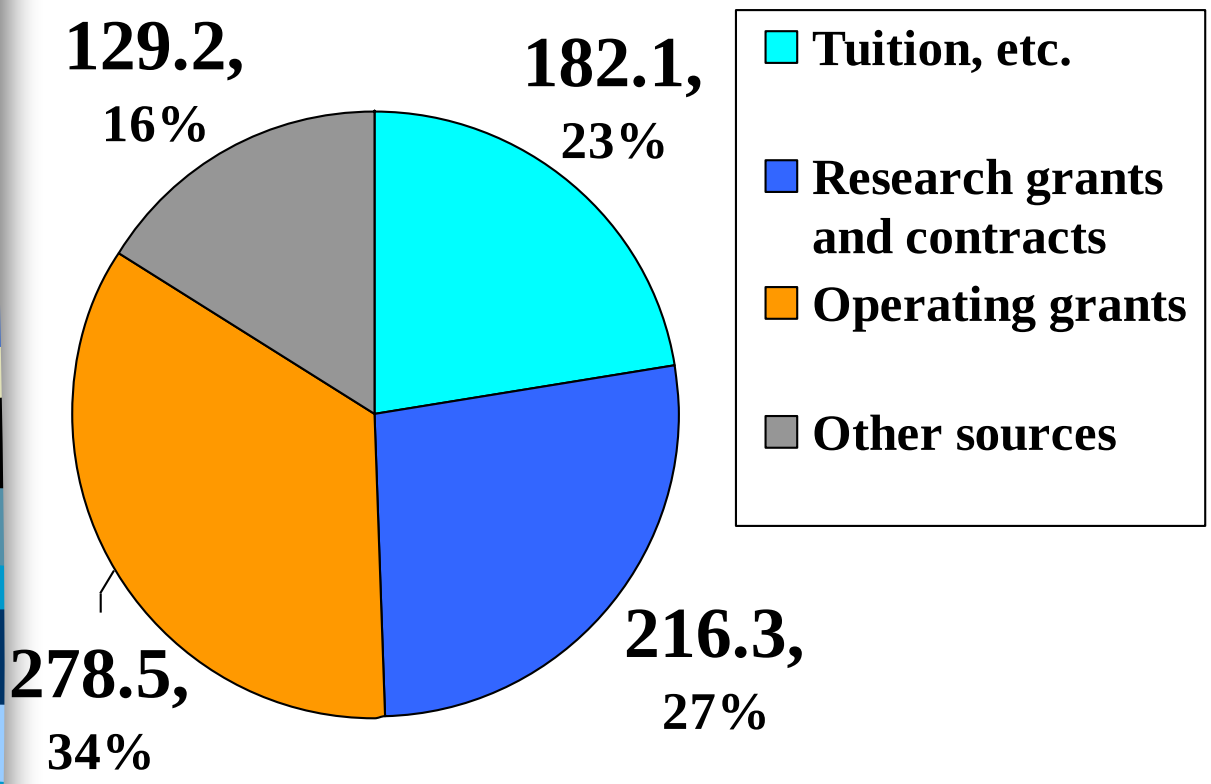
Scientists and Engineers in the Canadian and U.S. Economies

Employment shares (% of individuals classified as)	1980-1981	1990-1991	2000-2001
Scientists and engineers	**2.3**	**3.0**	**4.5**
Science and engineering-related workers	**7.5**	**8.7**	**9.0**
Scientists and engineers	**2.6**	**3.3**	**4.5**
Science and engineering-related workers	**7.1**	**8.0**	**9.1**
Income shares (% of paid earnings received by)			
Scientists and engineers	**4.2**	**5.2**	**7.7**
Science and engineering-related workers	**9.3**	**11.3**	**12.2**
Scientists and engineers	**5.1**	**6.5**	**8.5**
Science and engineering-related workers	**7.3**	**9.0**	**10.7**

Desmond Beckstead and Guy Gellatly, "Innovation Capabilities: Science and Engineering Employment in Canada and the United States", Statistics Canada # 11-622-MIE

Research at the University of Ottawa

Revenues 2006-2007 (in millions)

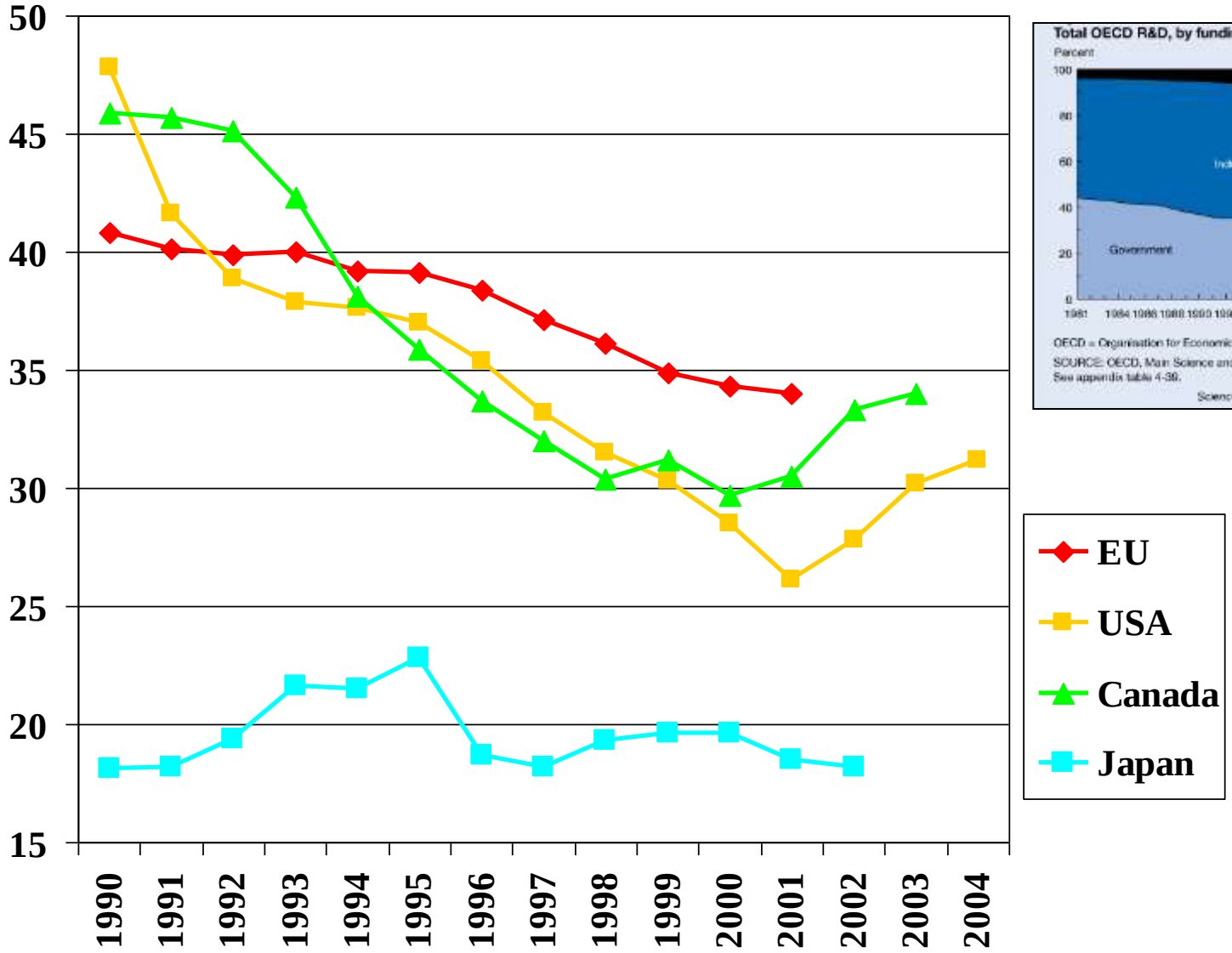


Year	Inventions in progress
2000	**7**
2001	**13**
2002	**14**
2003	**25**
2004	**31**
2005	**44**

Grants from national funding agencies in 2006-2007
CIHR: $38.3M NSERC: $14.6M SSHRC: $8.6M

Government share of R&D

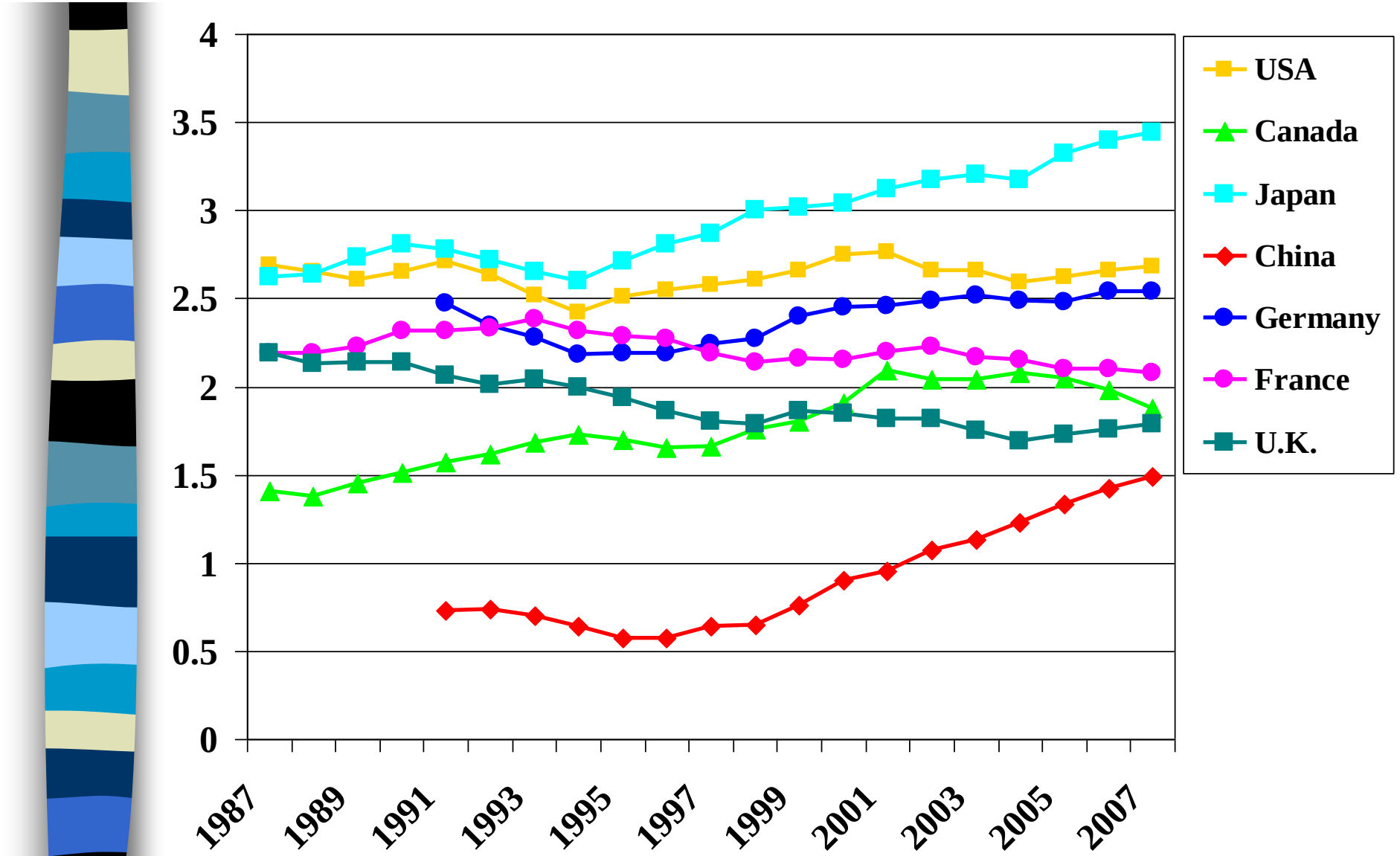
(% of gross expenditures in dollars converted with purchasing power parities)



Science and Engineering Indicators, 2006

R&D share of gross domestic product

(expenditures converted into U.S. dollars using purchasing power parities or equivalent)



Science and Engineering Indicators, 2010

The Prelude to "Atoms for Peace"

- Even the death of Stalin in 1953 did not abate the low-level hostilities (Cold War) that opposed the Atlantic Alliance and the Communist world
- In 1949, the USSR first tested an atomic bomb of its own (a fission device)
- In 1952, the USA tested a hydrogen bomb (a fusion device), matched in 1955 by the USSR
- In 1952, the United Kingdom detonated in Australia its first atomic bomb (a fission design), going on to test its own thermonuclear device in May 1957

The Context to "Atoms for Peace"

Robert Kraus, *The New Yorker*, 31/08/1957

- In 1954, a thermonuclear test at Bikini produces fallout that kills within days one crewman aboard a Japanese fishing ship downwind; many others are contaminated
- By 1957, the accelerating pace of nuclear tests and "advances" leads scientists like Linus Pauling and many others to campaign for a limitation of tests
- Even the United States worries about nuclear proliferation. On December 8, 1953, president **Dwight D. Eisenhower** addresses the United Nations with a new proposal

“Atoms for Peace” — Speech Highlights (1)

- “In size and variety, the development of atomic weapons has been no less remarkable. The development has been such that atomic weapons have virtually achieved conventional status within our armed services. In the United States, the Army, the Navy, the Air Force, and the Marine Corps are all capable of putting this weapon to military use.”
- “But the dread secret, and the fearful engines of atomic might, are not ours alone. In the first place, the secret is possessed by our friends and allies, Great Britain and Canada, whose scientific genius made a tremendous contribution to our original discoveries, and the designs of atomic bombs.”

“Atoms for Peace” — Speech Highlights (2)

- “The United States would seek more than the mere reduction or elimination of atomic materials for military purposes. It is not enough to take this weapon out of the hands of the soldiers. It must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace.”
- “The Governments principally involved, to the extent permitted by elementary prudence, to begin now and continue to make joint contributions from their stockpiles of normal uranium and fissionable materials to an international Atomic Energy Agency.”

“Atoms for Peace” — Speech Highlights (3)

- “The more important responsibility of this Atomic Energy Agency would be to devise methods where by this fissionable material would be allocated to serve the peaceful pursuits of mankind. Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world.”

After “Atoms for Peace”

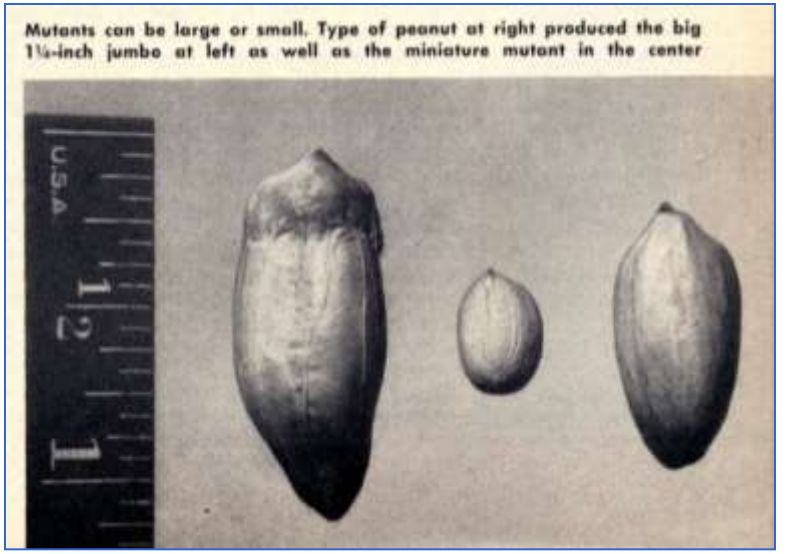
- In July 1955, Arco (Idaho) is the first city powered by electricity produced by a nuclear plant
- In August 1955, the first UN International Conference on Peaceful Uses of Atomic Energy is held in Geneva
- On October 1, 1957, the UN establishes the International Atomic Energy Agency
- On October 4, 1957, the USSR launches Sputnik
- After the collapse of the 1960 Paris peace summit (U-2 incident) and the 1962 Cuban missile crisis, many peace movements (including the Voice of Women in Canada, founded in 1960) felt compelled to campaign for initiatives such as the Limited Test Ban Treaty (at a time when nuclear weapons were too often tested aboveground)

Atomic farms, and more…

When cobalt slug is hoisted inside pipe at right, this field becomes saturated with potent gamma rays

The New Age of "ATOMIC CROPS"

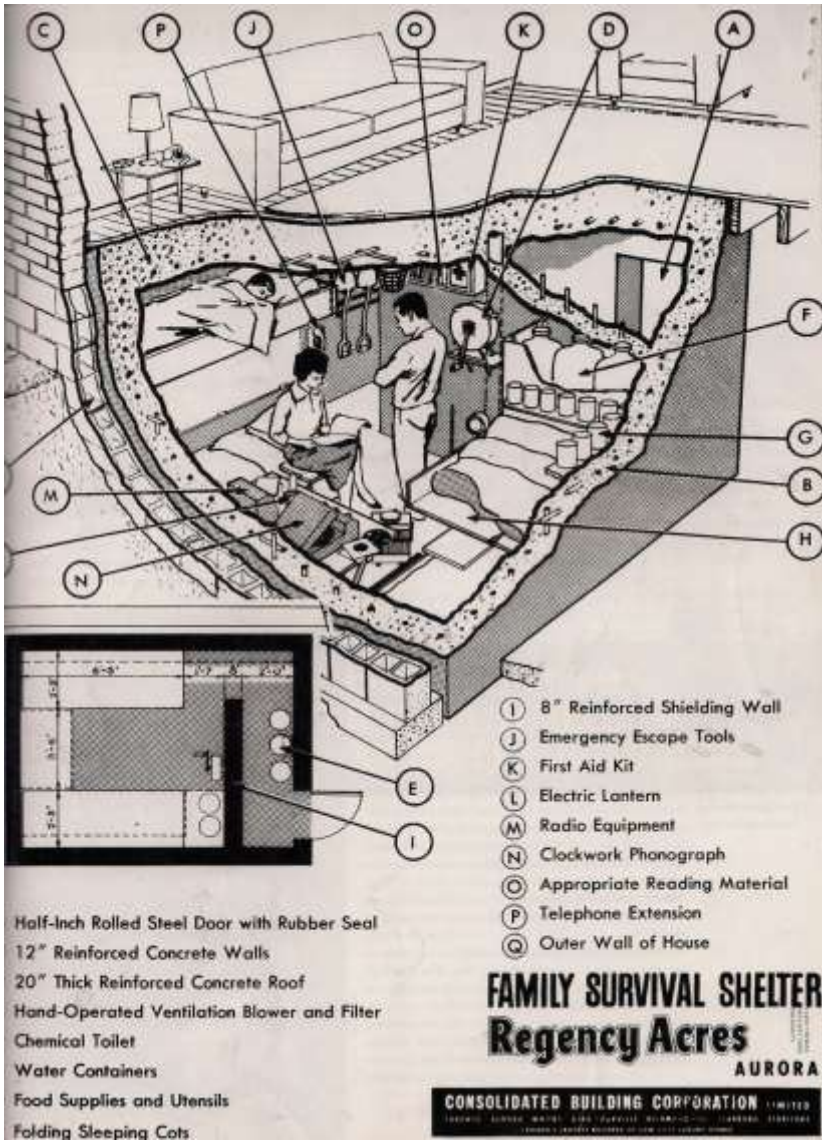
Between 1961 and 1973, 28 nuclear bombs were detonated by the U.S. as part of Operation Plowshare, which sought to apply Peaceful Nuclear Explosions (PNE) to useful ends, including oil extraction, mining, canal and harbour building, and other forms of earth removal.



Using radioactivity to induce useful mutations in crops was tried…
(*Popular Mechanics*, October-December 1958)

But also fallout shelters...

- To preserve the nuclear supremacy of the United States, nuclear war had to be survivable and nuclear weapons had to remain a rare commodity
- Basement or backyard shelters were sold as a way to defuse some of the fear roused by crises of brinkmanship, from the Korean War to the blockade of Cuba in 1961



Civil Defence Poster

- Dated to about 1954, this U.S. Civil Defense poster offered a checklist of items to keep at home in case of nuclear war
- It reflects the rising tide of worries and general anxiety about the possibility of a Third World War

(NARA 594366)

Early demonstration by members of "Canadian Voice of Women for Peace" in Ottawa (*c.* 1960-1963)

Library and Archives Canada

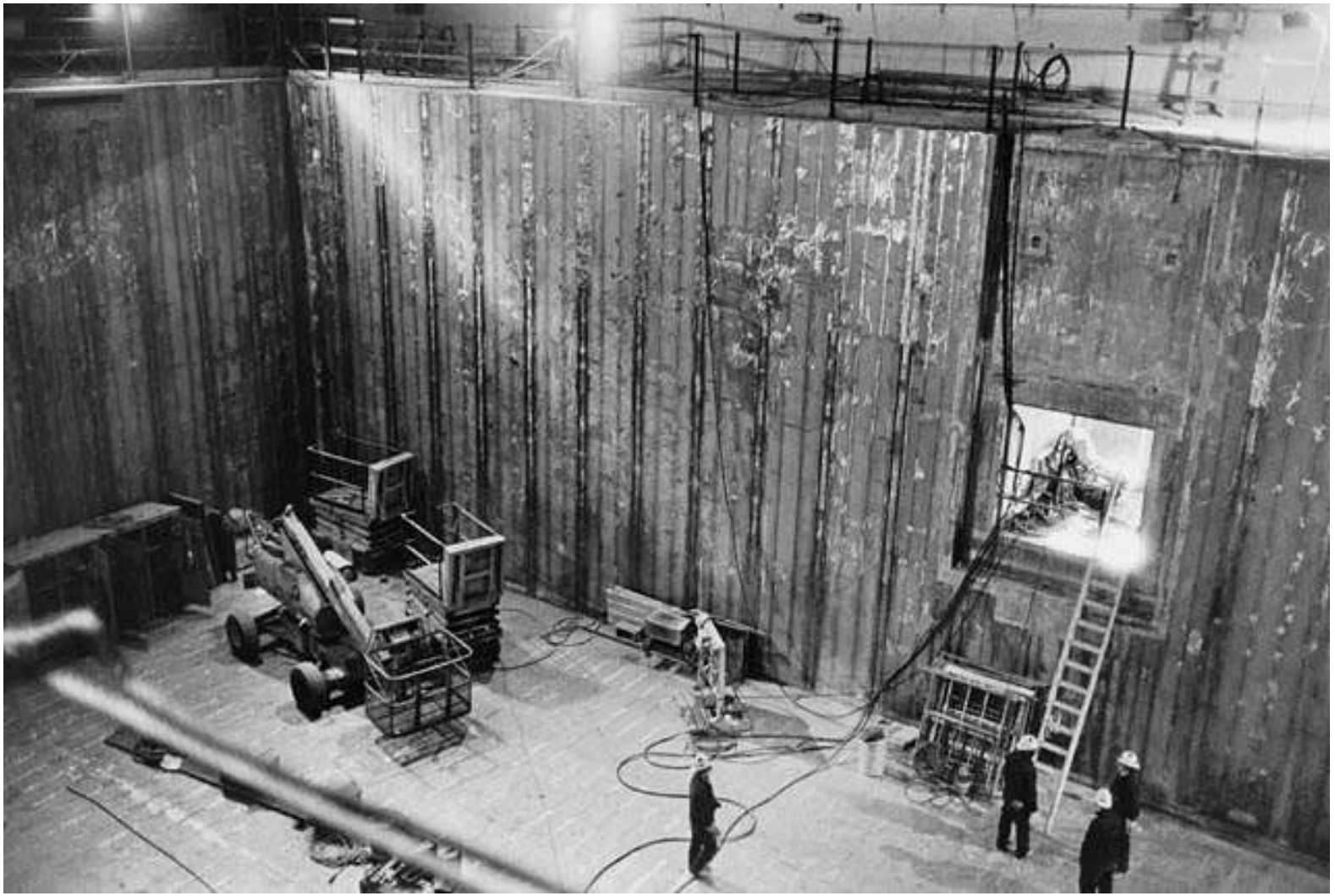
Nuclear Energy in Canada (1)

- Canada's first nuclear experiments began in 1940 in Ottawa
- In 1945, the ZEEP nuclear reactor at Chalk River (ON) was the first reactor outside the U.S. to go critical
- Canada pioneered cancer therapy with radioactive cobalt in 1951

Between 1954 and 1962, the CANDU nuclear reactor producing power for civilian use was developed. While highly reliable in early use, it proved to be prone to accelerated aging.

Gentilly-2 nuclear reactor, Gentilly, QC, 2013

Nuclear Energy in Canada (2)



Working with spent fuel at the Darlington nuclear power plant in 1986.

To recapitulate (5)

- What did the “Atoms for Peace” plan propose?
- What country’s space ambitions were helped by the former head of Nazi Germany’s rocket programme?
- Name two (2) concrete results of the effort to develop peaceful, civilian applications of nuclear technology.
- Identify the first three (3) countries involved in the nuclear arms race.
- In Canada and the United States, scientists and engineers are paid below-average wages: true or false?
- Give two consequences of the Bayh-Dole Act. Elaborate as needed.

Tupolev Tu-104

The Jetliner Age

- After the war, the initial experiments with jet planes led to jetliners that were streamlined—of course

The British De Havilland Comet was the first jet airliner to fly in July 1949, beating Canada's Avro Jetliner prototype by a few days. However, the U.S. Boeing 707 and Douglas DC-8, the French Caravelle, and the Russian Tupolev Tu-104 all enjoyed greater success in the late 1950s than the Comet, plagued with crashes. (The Avro Jetliner was cancelled before entering production, let alone service.)

- Between the menace of nuclear weapons and the promises of nuclear power, the future seemed open to all the possibilities of earlier times
- More and more, the dreams and designs of the first decades of the century were turned into actual buildings, airports, cars, highways, and machines

Better Living Through Chemistry

- For textiles: bleaches and dyes
- For explosives: guncotton, nitroglycerine, dynamite…
- For medicine: aspirin, synthetic morphine, sulfa drugs...
- For materials: celluloid, Bakelite, nylon...
- For agriculture: synthetic ammonia

When Chemists Were Gods...

- Practical applications of chemical discoveries may go back to the development of bleach
- The discoveries of **William Perkin** (aniline) and others in the nineteenth century led to the development of a true chemical industry
- The fortune reaped by **Alfred Nobel** for his invention of dynamite (nitroglycerine stabilized with *kieselguhr*) allowed him to fund the Nobel Prizes
- By 1911, **Fritz Haber** and **Carl Bosch** develop a process for the synthesis of ammonia, a key ingredient of fertilizers and explosives
- By the 1930s, the DuPont de Nemours company used as its slogan, “Better Things for Better Living through Chemistry”

The latest fashions in 1885

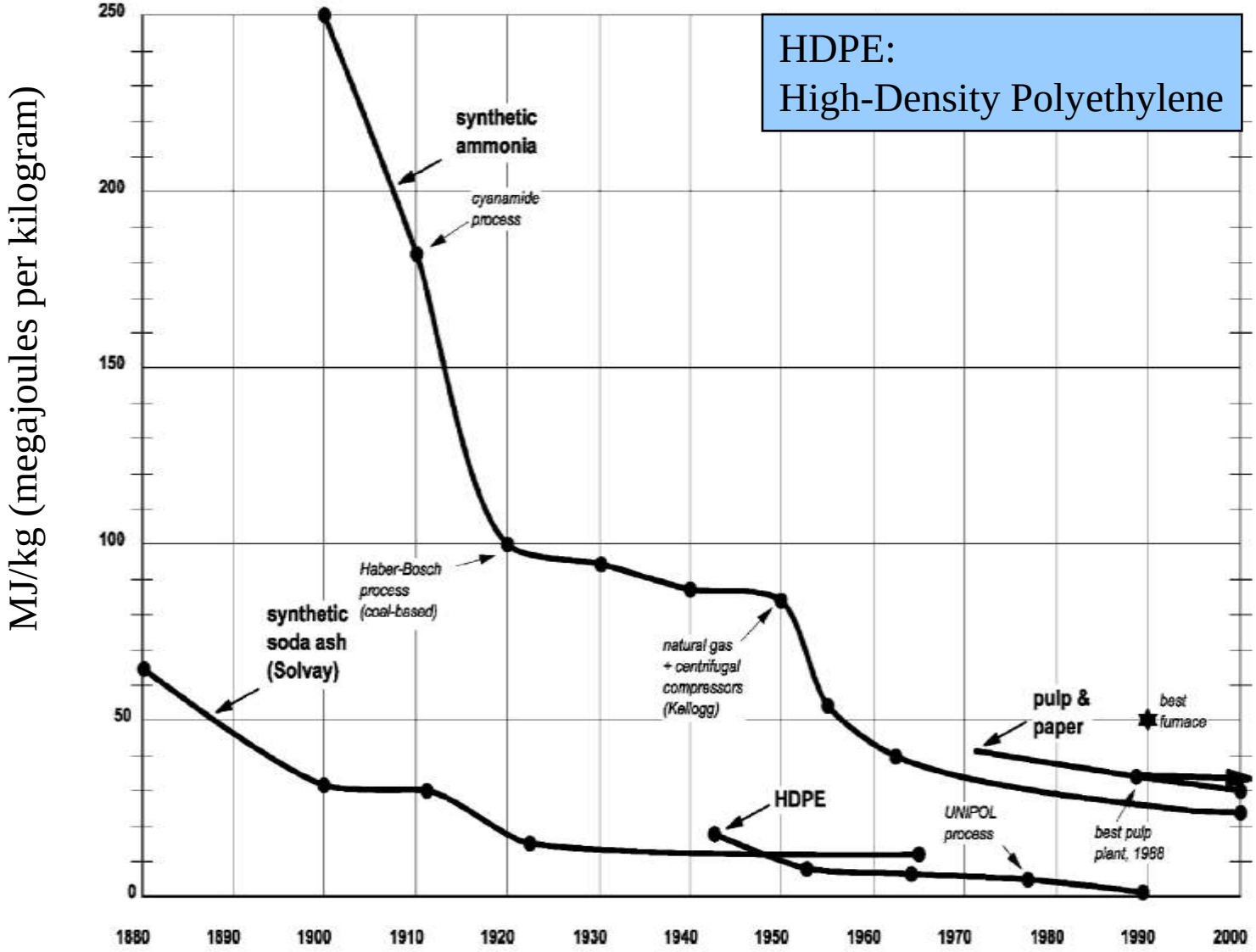
Note the soft mauve of the dress and curtains, presumably produced with Mauveine, the first aniline dye obtained by William Perkin. The 1890s were termed the Mauve Decade by Thomas Beer in 1926.

*

Art by Jules David (1808-1892), for *Le Moniteur de la Mode*

Library and Archives Canada

Some Energy-Intensive Industrial Processes (U.S., 1880-2000)



Cited by: Robert U. Ayres, Leslie W. Ayres, and Benjamin Warr, *Energy* (March 2003)

Ammonia storage at the Welland Chemical Plant (April 1941)

While chemistry and chemical engineering had played a role in World War I, the scale of production during World War II was unprecedented, and much of it was organized by the government.

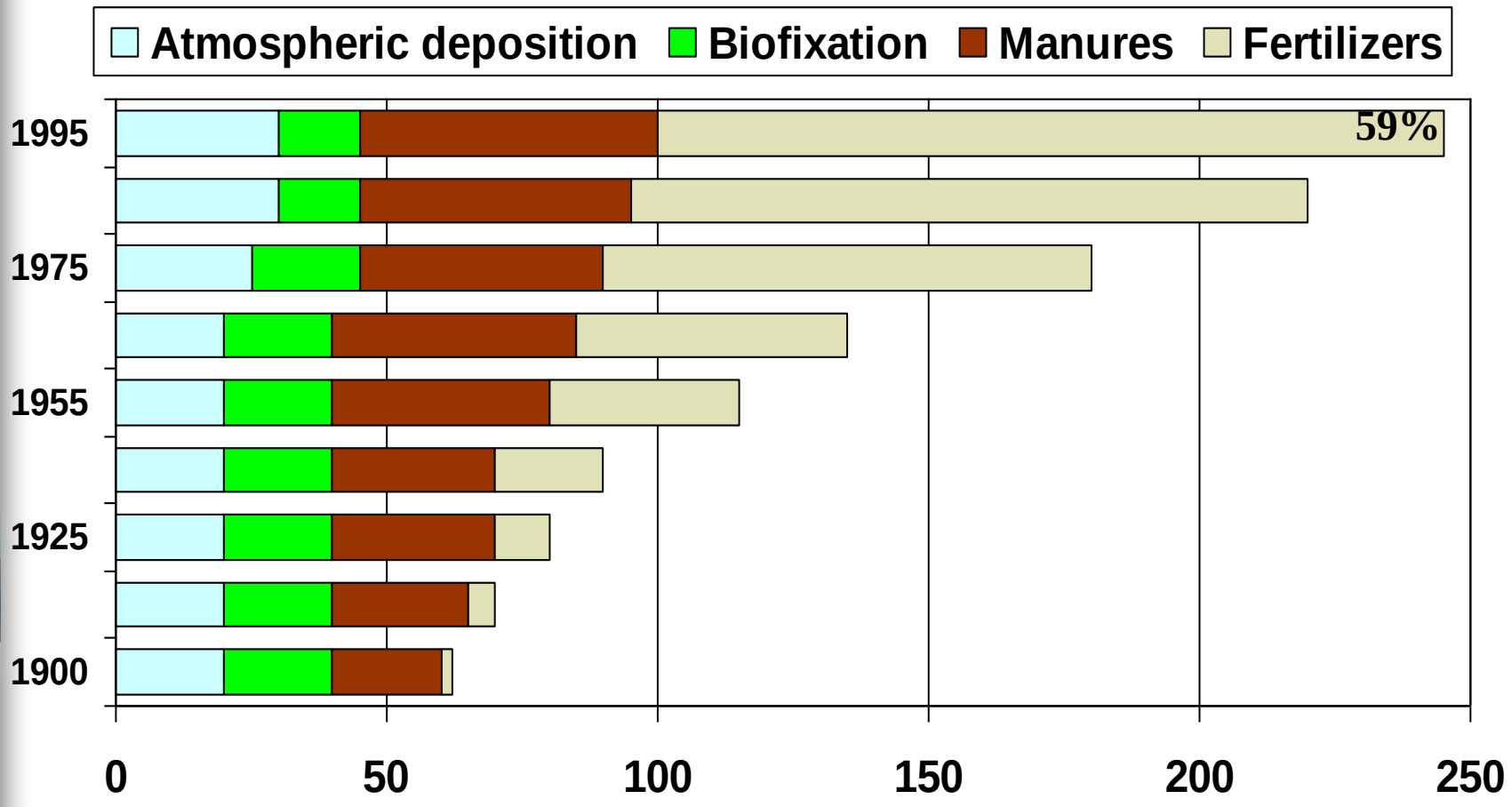
National Film Board, Library and Archives Canada

Barrels of ammonium nitrate in Trail, BC (April 1943)

Richard Wright, National Film Board, Library and Archives Canada

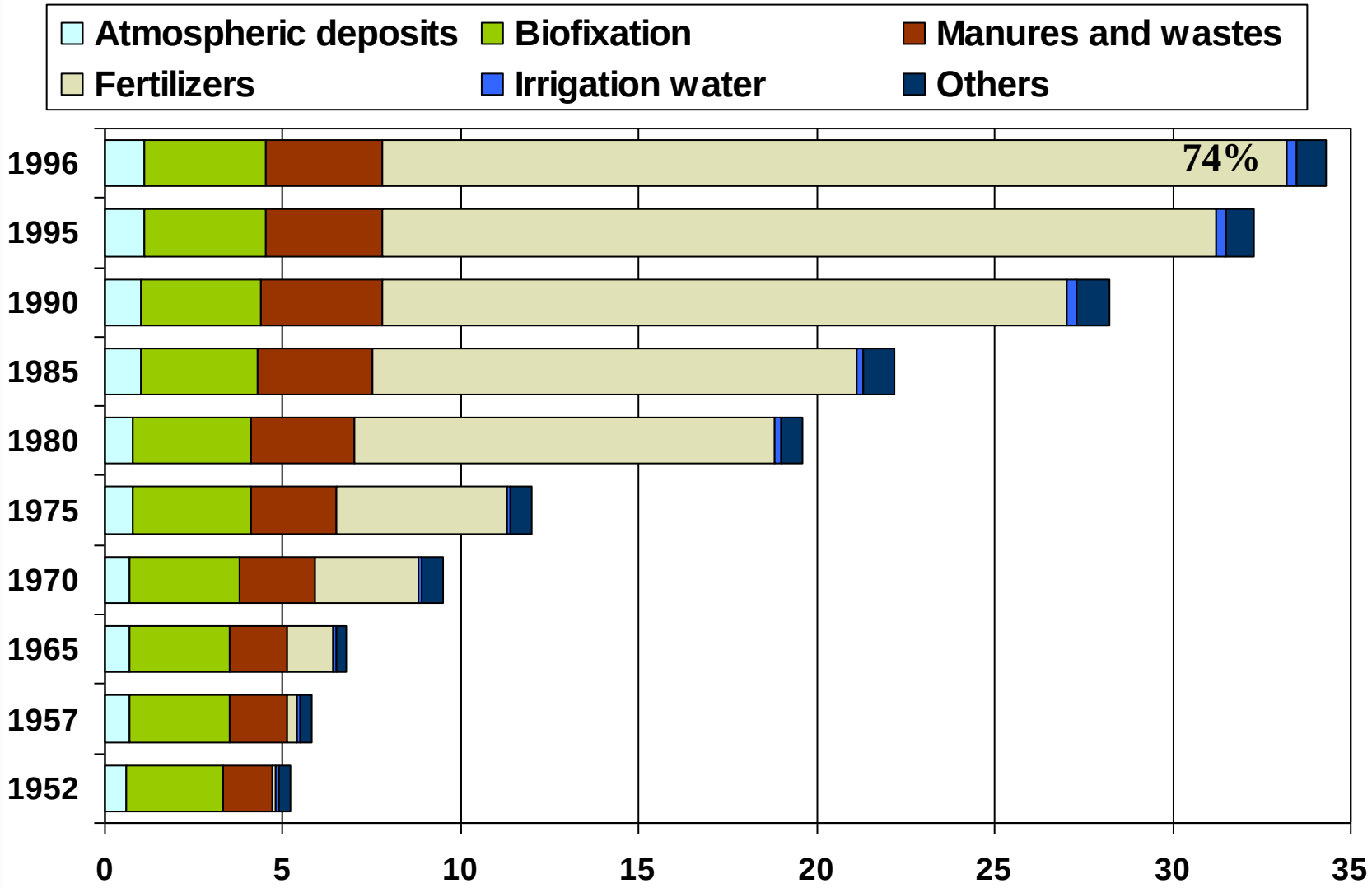
The Consolidated Mining and Smelting Company of Canada produced ammonium nitrate for use in depth charges, bombs, and other explosives.

Nitrogen sources in German agriculture (kg N/ha)



Atmospheric deposition: the nitrogen molecule (N_2) is split by lightning (etc.) and rain washes ammonia into the soil. / Biofixation: bacteria (incl. symbiotic ones) convert the air's nitrogen into ammonia or nitrates usable by crops.

Nitrogen sources in Chinese agriculture (Mt N)

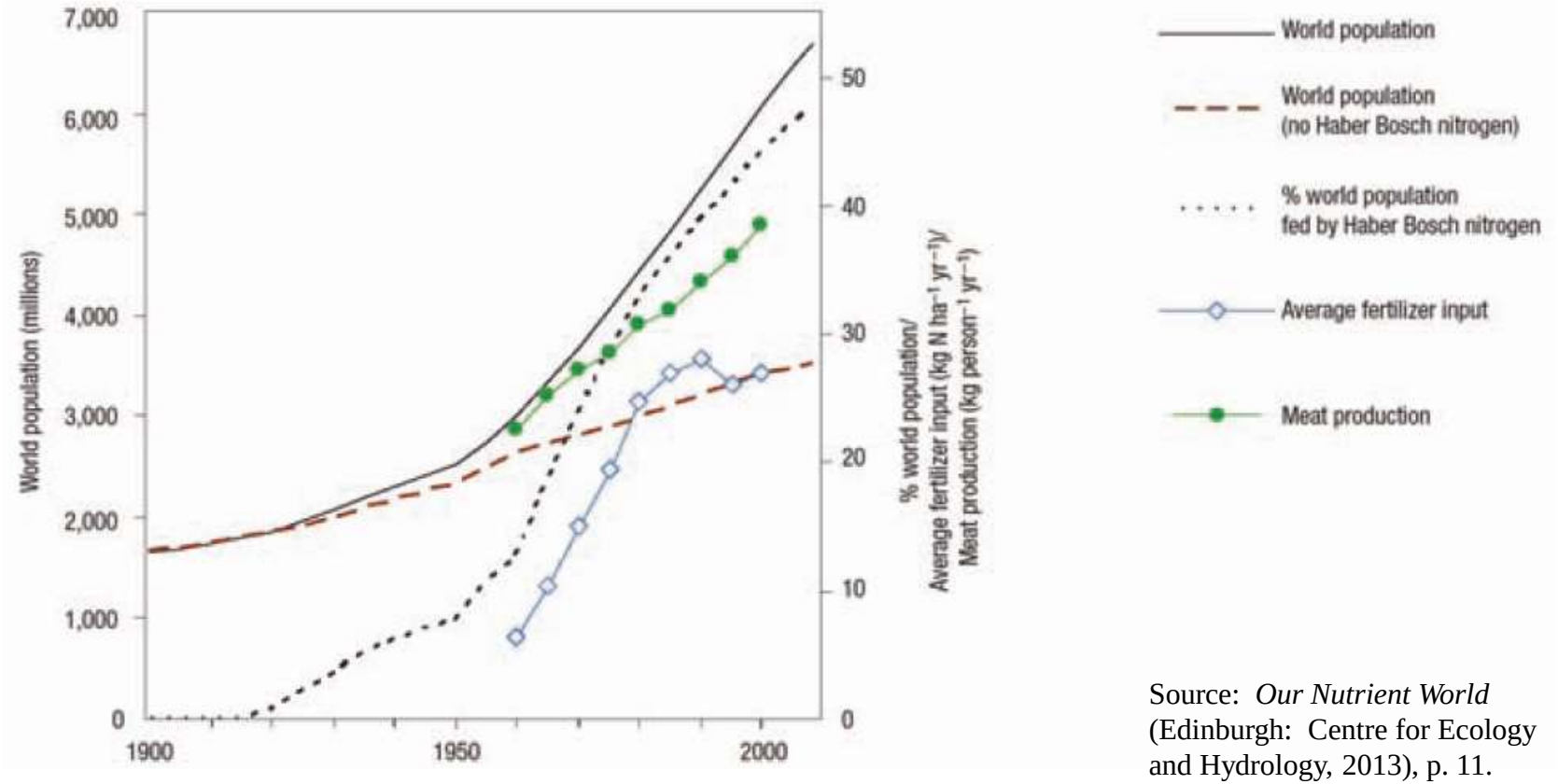


Nitrogen inputs in the global agroecosystem *c.* 1995 (Mt N/a)

	Minimum		Mean	*Fraction*		Maximum
Seeds	2		2	*1,1%*		2
Atmospheric deposition	18		20	*11,8%*		22
Irrigation water	3		4	*2,4%*		5
Crop residues	12		14	*8,3%*		16
Animal manures	16		18	*10,7%*		20
Biofixation	25		33	*19,5%*		41
Fertilizers	75		78	*46,2%*		80
TOTALS	151		169			186

Source: Vaclav Smil, *Enriching the Earth*, 2004

The global impact of the Haber-Bosch process today: Chemistry feeds half the world



Source: *Our Nutrient World* (Edinburgh: Centre for Ecology and Hydrology, 2013), p. 11.

To recapitulate (6)

- What two (2) main products could be produced more cheaply when the Haber-Bosch process was perfected?
- What chemical discovery sparked the birth of the first large-scale chemical industry?
- What Canadian company beat out almost all others in perfecting a jet-propelled airliner?
- What proportion (approximately) of the human population could not be fed today without the Haber-Bosch process?
- What five (5) areas benefited from significant new chemical discoveries by the early 20th century?