TELEPHONE NUMBERS AND FAX NUMBERS TO THE NOBEL PRIZE WINNERS 1995

Physics:

926

Professor Martin L. Perl
Stanford Linear Accelerator Center — Tel:(415) 723 2300
Stanford University — Tel:(415) ~~280~~ 2652 (Perl´s office)
Stanford CA 94305 — Fax:(415) 926 4001

Professor Frederick Reines
Department of Physics
University of California at Irvine — Tel: (714) 824 7036
Irvine, CA 92717 — Fax: (714) 824 2174
Mrs.Sylvia Reines

Chemistry

Professor F. Sherwood Rowland
Department of Chemistry
University of California — Tel: (714) 824 6016
Irvine, CA 92717 — Fax: (714) 824 2905
Mrs Joan Rowland

Professor Mario Molina
Department of Earth Atmospheric
and Planetary Sciences
MIT 54 - 1312 — Tel: (617) 253 5081
Cambridge, MA 02139 — Fax: (617) 258 6525
Mrs.Luisa T. Molina

Physiology or Medicine:

Professor Eric F. Wieschaus
Department of Molecular Biology
Princeton University — Tel:(609) 258 5383
Princeton NJ 08544 — Fax:(609) 258 1547
Mrs Gertrud Shupbach

Professor Edward B. Lewis
Division of Biology
California Institute of Technology — Tel:(818) 395 4941
156-29 Pasadena CA 91125 — Fax:(818) 449 0756
Mrs Pamela Lewis

Economic Sciences

Professor Robert E. Lucas, Jr
Department of Economics
University of Chicago
1126 East 59th Street — Tel:(312) 702 8179
Chicago, IL 60637 — Fax:(312) 702 8490
Ms. Nancy Stokey

THE WHITE HOUSE

WASHINGTON

OFFICE OF THE FIRST LADY

phone 202-456-6266
fax 202-456-6244

TO Kim

FROM Madge

FAX # 6-6235

PHONE #

OF PAGES (including cover)

COMMENTS Kim - This is a better list of #'s for the Nobel's. I just got it from the Swedish embassy.

OSTP

Office of Science and Technology Policy
Executive Office of the President
Washington, D.C. 20500

SCIENCE DIVISION

FAX TRANSMITTAL SHEET

DATE: November 8, 1995

TO: Madge Henning

ORGANIZATION: First Lady's Office

PHONE:

FAX: 6-6244

FROM: Lisa Duffey

PHONE: 202/456-6130

FAX: 202/456-6027

NUMBER OF PAGES INCLUDING COVER PAGE: 8

SPECIAL INSTRUCTIONS:

As requested.

Edward B. Lewis
1995 Nobel Prize for Physiology or Medicine - Co-recipient (Wieschaus, Nüsslein-Volhard)
Thomas Hunt Morgan Professor of Biology, Emeritus
California Institute of Technology

Nobel citation: for their discoveries concerning the genetic control of early embryonic development.

Through pioneering studies of the fruit fly spanning several decades, Dr. Lewis laid the foundation for most of what is known today about the evolution, structure and function of genes that control the body plan of all higher organisms. Dr. Lewis discovered the bithorax complex, a cluster of master regulatory genes that controls how certain body regions of the fly develop, thus providing new insight into the evolution of animals and the development of a single cell into a complex organism.

Lewis investigated how genes could control the further development of individual body segments into specialized organs. He found that the genes were arranged in the same order on the chromosomes as the body segments they controlled. The first genes in a complex of developmental genes controlled the head region, genes in the middle controlled abdominal segments while the last genes controlled the posterior ("tail") region.

1947 Wieschaus - Princeton } fruit fly
1918 Lewis - Cal Tech

1937 Lucas - economics

Molina - PCAST member } Chem - environment ozone
1927 - Rowland UC Irvine

1927 Perl - Stanford } physics discovered new particles
1918 Reines - UC Irvine

Robert E. Lucas, Jr.
1995 Nobel Prize for Economic Sciences
John Dewey Distinguished Service Professor of Economics
University of Chicago

Nobel citation: for having developed and applied the hypothesis of rational expectations, and thereby having transformed macroeconomic analysis and deepened our understanding of economic policy.

Dr. Lucas' work in macroeconomics led to the rational expectations theory that has revolutionalized the field. The model states that individuals will make decisions about their economic futures based on their past experiences and the rational expectations of the outcomes of their choices, thus altering or nullifying the economic policies of the government. Today, our economists are better informed and less likely to trust government policies to affect change in the nation's economy.

Mario J. Molina
1995 Nobel Prize for Chemistry - Co-recipient (Rowland, Crutzen)
Lee and Geraldine Martin Professor of Environmental Sciences
Massachusetts Institute of Technology

Nobel citation: for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.

In 1974, Dr. Rowland and Dr. Molina were the first scientists to warn the world that chlorofluorocarbons were damaging the Earth's protective ozone layer. More recently, Dr. Molina's laboratory research demonstrated the vital role that heterogeneous processes play in activating chlorine on the surfaces of ice crystals in the polar regions, converting benign chlorine compounds into chemicals that can destroy ozone. He was then the first to propose and demonstrate in the laboratory that the reaction of the chlorine monoxide radical with itself was one of the key chemical processes responsible for the formation of the spring-time Antarctic ozone hole. This work has led to national and international regulations on the production and use of halocarbons, thus reducing the threat of skin cancer for millions of light-skinned people around the world.

Martin L. Perl
1995 Nobel Prize for Physics - Co-recipient (Reines)
Professor of Physics
Stanford Linear Accelerator Center, Stanford University

Nobel citation: for the discovery of the tau lepton.

Dr. Perl is honored for the 1975 discovery of the tau lepton, an elementary particle that alerted physicists to the existence of a third quark-lepton family, which includes the bottom quark discovered in 1976 and the top quark verified in 1995. The tau lepton is a superheavy, unstable cousin of the electron.

Frederick Reines
1995 Nobel Prize for Physics - Co-recipient (Perl)
Distinguished Professor of Physics, Emeritus
University of California, Irvine

Nobel citation: for the detection of the neutrino.

Dr. Reines' research career has been centered on elementary particle physics and astrophysics, specifically the properties and interactions of neutrinos. Many of the discoveries related to neutrinos have been made by Dr. Reines or resulted from his efforts. Examples include the first detection of neutrinos produced in the atmosphere, investigations into neutrino oscillations, and the co-discovery of neutrinos emitted from a supernova.

Frank Sherwood Rowland
1995 Nobel Prize for Chemistry - Co-recipient (Molina, Crutzen)
Donald Bren Research Professor of Chemistry
University of California, Irvine

Nobel citation: for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.

In 1974, Dr. Rowland and Dr. Molina were the first scientists to warn the world that chlorofluorocarbons were damaging the Earth's protective ozone layer. More recently, Dr. Rowland was the first scientist to use ground-based observational data to demonstrate that ozone was being depleted in the northern hemisphere, and he played a major role in identifying the likely chemical processes that destroy ozone in the Antarctic. This work has led to national and international regulations on the production and use of halocarbons, thus reducing the threat of skin cancer for millions of light-skinned people around the world. In addition, Dr. Rowland's studies have also identified an increasing trend in the atmospheric concentration of methane, leading to a better quantification of it's important role in global warming.

Eric F. Wieschaus
1995 Nobel Prize for Physiology or Medicine - Co-recipient (Lewis, Nüsslein-Volhard)
Professor, Department of Molecular Biology
Princeton University

Nobel citation: for their discoveries concerning the genetic control of early embryonic development.

Dr. Wieschaus, with Christiane Nüsslein-Volhard, identified and classified key genes in the fruit fly important to the formation of body segments and the final body plan. The genes studied by Dr. Wieschaus and his co-recipients have vital functions in the early development stages of embryos, including the formation of the body axis, the polarity of the embryo, the segmentation of the body, and the specialization of individual segments into different organs. Practical results of this work involve the explanation of congenital malformations in humans.

November 9, 1995

RECEPTION IN HONOR OF THE 1995 AMERICAN NOBEL LAUREATES

DATE:	**November 15, 1995**
LOCATION:	**State Floor**
TIME:	**2:00 PM**
FROM:	**Madge Henning**

I. PURPOSE

To honor the seven Americans who are recipients of the Nobel Prize for 1995.

II. BACKGROUND

Seven of the eleven 1995 Nobel Prize Recipients are Americans this year. The prizes are annually awarded in the following fields: **Physics, Chemistry, Medicine or Physiology, Economics, Literature and Peace.**

The Nobel Prize, initially awarded in 1901, is generally considered to be the world's highest civic honor. Alfred Nobel, the Swedish industrialist and inventor of dynamite, created the prize and designated his estate to be used to fund the awards.

The prize in **Economics** has only been awarded since 1968, when it was established by the Bank of Sweden in memory of Alfred Nobel.

Six of the seven American Nobel Laureates will be in attendance. There are only two categories in which Americans did not solely or jointly win the prize: Literature and Peace. This year's Literature Prize was won by ???. The Peace Prize was awarded to ???.

This year the Nobel Prize was awarded to Americans in:

<u>Physics</u> jointly to:
Frederick Reines U. of California-Irvine

• For the detection of the neutrino

Martin Perl Stanford
• For the discovery of the tau lepton

<u>Chemistry</u> jointly to:
Mario Molina MIT

and
F. Sherwood Rowland — Univ. of California, Irvine

•For their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone

Physiology or Medicine jointly to:
Edward B. Lewis — Cal Tech
and
Eric Wieschaus — Princeton

•For for their discoveries concerning the genetic control of early embryonic development

Economic Sciences to:
Robert J. Lucas — University of Chicago

•for having developed and applied the hypothesis of rational expectations, and thereby having transformed macroeconomic analysis and deepened our understanding of economic policy.

A congratulatory letter was sent from the President in early October when the Prizes were announced.???

III. PARTICIPANTS

The President (option to drop by)

The Vice President

Mrs. Clinton

American Nobel Laureates and their guests

Henrik Liljegren, Swedish Ambassador to the United States and wife, Nil

Dr. John Gibbons, Assistant to the President for Science and Technology

Harold Varmus, Director NIH (a previous Nobel recipient)

Approximately 180 leaders in the science community including scientists from the public sector, government researchers, University Presidents, previous Nobel Laureates, patrons of science, Science press
??????

IV. SEQUENCE OF EVENTS

Provided by the Social Secretary's Office

V. PRESS PLAN

Open Press

VI. REMARKS

EMBASSY OF SWEDEN
WASHINGTON

TELEFAX Page 1 (5)

Date	File
October 10, 1995	

TO: Ms Melanne Verveer
The White House
Office of the First Lady
Fax: (202) 456 6244

FROM: Ambassador Henrik Liljegren
Embassy of Sweden

RE: American Nobel Prize winner

Here is the information we have received from Sweden on the Nobel Prize winner in Economic Sciences for 1995.

Sincerely

Congratulations again -
is December 1st still
our target
date for
a possible event?

Henrik Liljegren
Ambassador

engelska

Information

The Sveriges Riksbank (Bank of Sweden) Prize in Economic Sciences in Memory of Alfred Nobel

The Royal Swedish Academy of Sciences has decided to award the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel, 1995, to

Professor **Robert E. Lucas, Jr.**, University of Chicago, USA, *for having developed and applied the hypothesis of rational expectations, and thereby having transformed macroeconomic analysis and deepened our understanding of economic policy.*

Rational Expectations Have Transformed Macroeconomic Analysis and Our Understanding of Economic Policy

Robert Lucas is the economist who has had the greatest influence on macroeconomic research since 1970. His work has brought about a rapid and revolutionary development: Application of the rational expectations hypothesis, emergence of an equilibrium theory of business cycles, insights into the difficulties of using economic policy to control the economy, and possibilities of reliably evaluating economic policy with statistical methods. In addition to his work in macroeconomics, Lucas's contributions have had a very significant impact on research in several other fields.

Rational Expectations

Expectations about the future are highly important to economic decisions made by households, firms and organizations. One among many examples is wage formation, where expectations about the inflation rate and the demand for labor in the future strongly affect the contracted wage level which, in turn, affects future inflation. Similarly, many other economic variables are to a large extent governed by expectations about future conditions.

Despite the major importance of expectations, economic analysis paid them only perfunctory attention for a long time. Twenty years ago, it was not unusual to assume arbitrarily specified or even static expectations, for example that the expected future price level was regarded as the same as today's price level. Or else adaptive expectations were assumed, such that the expected future price level was mechanically adjusted to the deviation between today's price level and the price level expected earlier.

Instead, rational expectations are genuinely forward-looking. The rational expectations hypothesis means that agents exploit available information without making the systematic mistakes implied by earlier theories. Expectations are formed by constantly updating and reinterpreting this information. Sometimes the consequences of rational expectations formation are dramatic, as in the case of economic policy. The first precise formulation of the rational expectations hypothesis was introduced by John Muth in 1961. But it did not gain much prominence until the 1970s, when Lucas extended it to models of the aggregate economy. In a series of path-breaking articles, Lucas demonstrated the far-reaching consequences of rational expectations formation, particularly concerning the effects of economic policy and the evaluation of these effects using econometric methods, that is, statistical methods specifically adapted for examining economic relationships. Lucas also applied the hypothesis to several fields other than macroeconomics.

KUNGL.
VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES
Box 50005, S 104 05 Stockholm, Sweden
Tel: +46 8 673 95 25, fax: +46 8 15 56 70

10 October 1995

Internet:http://www.kva.se

The Phillips Curve Example

The change in our understanding of the so-called Phillips curve is an excellent example of Lucas's contributions. The Phillips curve displays a positive relation between inflation and employment. In the late 1960s, there was considerable empirical support for the Phillips curve; it was regarded as one of the more stable relations in economics. It was interpreted as an option for government authorities to increase employment by pursuing an expansionary policy which raises inflation. Milton Friedman and Edmund Phelps criticized this interpretation and claimed that the expectations of the general public would adjust to higher inflation and preclude a lasting increase in employment: Only the short-run Phillips curve is sloping, whereas the long-run curve is vertical. This criticism was not quite convincing, however, because Friedman and Phelps assumed adaptive expectations. Such expectations do in fact imply a permanent rise in employment if inflation is allowed to increase over time. In a study published in 1972, Lucas used the rational expectations hypothesis to provide the first theoretically satisfactory explanation for why the Phillips curve could be sloping in the short run but vertical in the long run. In other words, regardless of how it is pursued, stabilization policy cannot systematically affect long-run employment. Lucas formulated an ingenious theoretical model which generates time series such that inflation and employment indeed seem to be positively correlated. A statistician who studies these time series might easily conclude that employment could be increased by implementing an expansionary economic policy. Nevertheless, Lucas demonstrated that any endeavor, based on such policy, to exploit the Phillips curve and permanently increase employment would be futile and only give rise to higher inflation. This is because agents in the model adjust their expectations and hence price and wage formation to the new, expected policy. Experience during the 1970s and 1980s has shown that higher inflation does not appear to bring about a permanent increase in employment. This insight into the long-run effects of stabilization policy has become a commonly accepted view; it is now the foundation for monetary policy in a number of countries in their efforts to achieve and maintain a low and stable inflation rate.

The short-run sloping and long-run vertical Phillips curve illustrates the pitfalls of uncritically relying on statistically estimated so-called macroeconometric models to draw conclusions about the effects of changes in economic policy. In a 1976 study, introducing what is now known as the "Lucas critique", Lucas demonstrated that relations which had so far been regarded as "structural" in econometric analysis were in fact influenced by past policy. Two decades ago, virtually all macroeconometric models contained relations which, on closer examination, could be shown to depend on the fiscal and monetary policy carried out during the estimation period. Obviously then, the same relations cannot be used in simulations designed to predict the effect of another fiscal or monetary policy. Yet this was exactly how the models were often used.

The Lucas critique has had a profound influence on economic-policy recommendations. Shifts in economic policy often produce a completely different outcome if the agents adapt their expectations to the new policy stance. Nowadays, when evaluating the consequences of shifts in economic-policy regimes – for example, a new exchange rate system, a new monetary policy, a tax reform or new rules for unemployment benefits – it is more or less self-evident to consider changes in the behavior of economic agents due to revised expectations.

How could researchers avoid the mistakes forewarned by the Lucas critique? Lucas's own research provided the answer by calling for a new research program. The objective of the program was to formulate macroeconometric models such that their relations are not sensitive to policy changes; otherwise, the models cannot contribute to a reliable assessment of economic-policy alternatives. It is easy to formulate this principle: the models should be "equilibrium models" with rational expectations. This means that all important variables should be determined within the model, on the basis of interaction among rational agents who have rational expectations and operate in a well-specified economic environment. In addition, the models should be formulated so that they only incorporate policy-independent parameters (those coefficients which describe the relations of the models). This, in turn, requires sound microeconomic foundations, i.e., the individual agents' decision problems have to be completely accounted for in the model. The parameters are then estimated using econometric methods developed for this purpose. Interesting attempts to derive and estimate such models have subsequently been made in several different areas, such as the empirical analysis of investment, consumption and employment, as well as of asset pricing on financial markets. The program can be difficult to implement in practice, however, and not all attempts have been successful.

A Large Following

Lucas formulated powerful and operational methods for drawing conclusions from models with rational expectations. These methods provided the means for rapid development of macroeconomic analysis and eventually became part of the standard toolbox. Without them, the outcome of the rational expectations hypothesis would have been limited to general insights into the importance of expectations instead of clear-cut statements in specific situations. Rational expectations have now been accepted as the natural basis for further studies of expectation formation with respect to limited rationality, limited computational capacity and gradual learning.

Lucas has established new areas of research. After his pioneering work on the Phillips curve, the so-called equilibrium theory of business cycles has become an extensive and dynamic field, where the effects of real and monetary disturbances on the business cycle have been carefully examined. The equilibrium theory of business cycles initially relied on the assumption of completely flexible prices and immediate adjustment to equilibrium on goods and labor markets with perfect competition. However, Lucas's methodological approach is not incompatible with sticky prices and various market failures such as imperfect competition and imperfect information. Nevertheless, these frictions and imperfections should not be introduced in an arbitrary way, but should be explained as a result of rational agents' decisions and interaction in a well-specified choice situation. Interpreted in this way, Lucas's methodological approach has been accepted by nearly all macroeconomists. Indeed, the greatest advances in modeling frictions and market imperfections seem to have been made precisely when this methodological approach has been followed.

Lucas's pioneering work has created an entirely new field of econometrics, known as rational expectations econometrics. There, the rational expectations hypothesis is used to identify the most efficient statistical methods for estimating economic relations where expectations are the key components. A number of researchers have subsequently made important contributions to this new field.

How could researchers avoid the mistakes forewarned by the Lucas critique? Lucas's own research provided the answer by calling for a new research program. The objective of the program was to formulate macroeconometric models such that their relations are not sensitive to policy changes; otherwise, the models cannot contribute to a reliable assessment of economic-policy alternatives. It is easy to formulate this principle: the models should be "equilibrium models" with rational expectations. This means that all important variables should be determined within the model, on the basis of interaction among rational agents who have rational expectations and operate in a well-specified economic environment. In addition, the models should be formulated so that they only incorporate policy-independent parameters (those coefficients which describe the relations of the models). This, in turn, requires sound microeconomic foundations, i.e., the individual agents' decision problems have to be completely accounted for in the model. The parameters are then estimated using econometric methods developed for this purpose. Interesting attempts to derive and estimate such models have subsequently been made in several different areas, such as the empirical analysis of investment, consumption and employment, as well as of asset pricing on financial markets. The program can be difficult to implement in practice, however, and not all attempts have been successful.

A Large Following

Lucas formulated powerful and operational methods for drawing conclusions from models with rational expectations. These methods provided the means for rapid development of macroeconomic analysis and eventually became part of the standard toolbox. Without them, the outcome of the rational expectations hypothesis would have been limited to general insights into the importance of expectations instead of clear-cut statements in specific situations. Rational expectations have now been accepted as the natural basis for further studies of expectation formation with respect to limited rationality, limited computational capacity and gradual learning.

Lucas has established new areas of research. After his pioneering work on the Phillips curve, the so-called equilibrium theory of business cycles has become an extensive and dynamic field, where the effects of real and monetary disturbances on the business cycle have been carefully examined. The equilibrium theory of business cycles initially relied on the assumption of completely flexible prices and immediate adjustment to equilibrium on goods and labor markets with perfect competition. However, Lucas's methodological approach is not incompatible with sticky prices and various market failures such as imperfect competition and imperfect information. Nevertheless, these frictions and imperfections should not be introduced in an arbitrary way, but should be explained as a result of rational agents' decisions and interaction in a well-specified choice situation. Interpreted in this way, Lucas's methodological approach has been accepted by nearly all macroeconomists. Indeed, the greatest advances in modeling frictions and market imperfections seem to have been made precisely when this methodological approach has been followed.

Lucas's pioneering work has created an entirely new field of econometrics, known as rational expectations econometrics. There, the rational expectations hypothesis is used to identify the most efficient statistical methods for estimating economic relations where expectations are the key components. A number of researchers have subsequently made important contributions to this new field.

Other Contributions

In addition to his work in macroeconomics, Lucas has made outstanding contributions to investment theory, financial economics, monetary theory, dynamic public economics, international finance and, most recently, the theory of economic growth. In each of these fields, Lucas's studies have had a significant impact; they have launched new ideas and generated an extensive new literature.

Further reading

The Royal Swedish Academy of Sciences (1995), *The Scientific Contributions of Robert E. Lucas, Jr.* Internet: http://www.kva.se

Lucas, R.E. (1972), *Expectations and the Neutrality of Money*, Journal of Economic Theory 4, 103-124.

Lucas, R.E. (1976), *Econometric Policy Evaluation: A Critique*. Carnegie-Rochester Conference Series on Public Policy 1, 19-46.

Lucas, R.E. (1981), *Studies in Business-Cycle Theory*, MITPress, Cambridge, MA.

Lucas, R.E. (1987), *Models of Business Cycles*, 1985 Yrjö Jahnsson Lectures, Basil Blackwell, Oxford.

Lucas's achievements are described at greater length in Royal Swedish Academy of Sciences (1995). His two best-known publications are Lucas (1972) and (1976). The research he carried out during the 1970s is compiled in Lucas (1981). A relatively easily accessible account of his views on business-cycle theory may be found in Lucas (1987).

*****

Robert E. Lucas, Jr. was born in 1937 in Yakima, Wahington, USA. He received his Ph.D. in economics from the University of Chicago in 1964. He began as Assistant Professor of Economics in 1963 at Carnegie-Mellon University, where he became Associate Professor in 1967 and Professor of Economics in 1970. Since 1975, he has held a professorship in Economics at the University of Chicago. He is Second Vice-President of the Econometric Society, a Fellow of the American Academy of Arts and Sciences and a member of the National Academy of Sciences.

Professor Robert E. Lucas, Jr.
Department of Economics
University of Chicago
1126 East 59th Street
Chicago, IL 60637
USA

EMBASSY OF SWEDEN
WASHINGTON

TELEFAX

Page 1 (13)

Date	File
October 11, 1995	

TO: Ms Melanne Verveer
The White House
Office of the First Lady
Fax: (202) 456 6244

FROM: Ambassador Henrik Liljegren
Embassy of Sweden

RE: American Nobel Prize winners

Here is the information we have received from Sweden on the Nobel Prize winners in Physics and Chemistry for 1995.

Sincerely

Wow!

Henrik Liljegren
Ambassador

Address
1501 M Street, NW
Washington, D.C. 20005
USA

Telephone
(202)467-2600

Telefax
(202)467-2699

Cable
Svensk

engelska

Information

For further information please contact:
The Royal Swedish Academy of Sciences
Information Department, Box 50005, S-104 05 Stockholm, Sweden
Tel. +46-(0)8-673 95 25, fax: +46-(0)8-15 56 70

The Royal Swedish Academy of Sciences has decided to award the 1995 Nobel Prize in Physics for **pioneering experimental contributions to lepton physics**

with one half to

Martin L. Perl, Stanford University, Stanford, California, USA
for the discovery of the tau lepton

and with one half to

Frederick Reines, University of California, Irvine, California, USA
for the detection of the neutrino.

Discoveries of two of nature's sub-atomic particles rewarded

Mankind seeks his place in nature. He endeavours to find answers to philosophical and physical questions alike. The home of mankind, the Universe, was created in a Big Bang. "What does this Universe consist of?" – "What are the smallest constituents of the Universe and what are their properties?" – "What can they tell us of the history of the Universe and of its future?" etc. This year's laureates have in this search made lasting contributions: They have discovered two of nature's most remarkable subatomic particles.

Martin L. Perl and his colleagues discovered, through a series of experiments between 1974 and 1977, at the Stanford Linear Accelerator Center (SLAC) in the USA, that the electron has a relative some 3 500 times heavier, which is called the tau.

Frederick Reines made pioneering contributions during the 1950s together with the late Clyde L.Cowan, Jr., which led to their being able to demonstrate experimentally the existence of the antineutrino of the electron.

Martin Perl's discovery of the tau was the first sign that a third "family" of fundamental building blocks existed. Some years later a further building block was discovered – one of the family's two quarks, the bottom quark. Not until 18 years later was its other quark, the top quark, discovered. The existence of the third family is very important for physicists' confidence in the present theoretical model for understanding the properties of nature's smallest constituents. This is called the standard model. Without a third family, the model would have been incomplete and unable to admit what is termed the Charge and Parity (CP) violation, a violation of a fundamental principle of symmetry which, among other things, regulates particle decay (Nobel Prize to Cronin and Fitch 1980). If a fourth family of quarks and leptons is discovered, this may mean that the standard model must be revised and more extensive reconstruction within elementary-particle physics commenced.

Frederick Reines' and Clyde L. Cowan's first observation of neutrinos was a pioneering contribution that opened the doors to the region of "impossible" neutrinoexperiments. Nowadays we are attempting to capture neutrinos in cosmic radiation that may originate in the sun or in supernovas (exploding stars). Because of the reluctance of neutrinos to react with atomic nuclei and thus allow themselves to be captured, very large detector volumes are required for these experiments. While Reines and Cowan in the 1950s managed with about half a cubic metre of water in their detector, large-scale experiments in the 1990s use many thousand cubic metres. Some experiments have even used surrounding sea or ice as their detector volume.

KUNGL. VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

11 October 1995

Internet: http://www.kva.se

Nature's building blocks and their family structure
The smallest of nature's structures to have been studied so far are twelve types of **matter particles** - *six quarks* and *six leptons*. They each have their anti-particle, a sort of "mirror image" of the particle. (The name of a particle also includes its anti-particle.) As well as these quarks and leptons, there are other types of subatomic particles called **force particles**, since they are responsible for three of our known forces, *strong force, electromagnetic force* and *weak force*. Gravitational forces operate outside the scope of these. The most essential difference between quarks and leptons is that leptons are not affected by the strong force.

A remarkable property of matter particles is that they exhibit "family affiliation". They come in three families, each consisting of two quarks and two leptons (Fig. 1). In many ways the three families behave as copies of one another. "Is there a fundamental principle to justify the existence of just three families?" is one of the unanswered questions of physics.

The quarks of the first family are "up quarks" and "down quarks". Its lepton members are the electron and the electron-neutrino. The two quarks build protons and neutrons, which in turn form atomic nuclei and hence over 99% of all the earth's matter. The small remainder is electrons. The electron-neutrino can be imagined very roughly as an electron deprived of charge and mass. Whether an insignificant amount of mass nevertheless remains, is another unanswered question. It was this electron-neutrino that Reines and his colleague Cowan, both then employed at the Los Alamos Scientific Laboratory, managed to capture.

The discovery of the tau
During the 1960s many research groups were carrying out experiments one aim of which was to discover new charged particles, including new leptons. One approach was to search for the new particles in the products of decay of the particles that were available, e.g. kaons. Another way was to attempt to produce them in an accelerator, e.g. in collisions between high-energy electrons and a target. Martin Perl was a member of a team performing such an experiment at SLAC in 1966, but no new charged leptons were found. In 1973 a new machine started operation at SLAC – an electron-positron collider called SPEAR. A collider such as this is a lepton-hunter's dream since the mechanism for possible production of new charged leptons (X^+, X^-) is simple and easy to interpret:

$$\text{electron} + \text{positron} \rightarrow X^+ + X^-$$

The SPEAR collider offered Perl an exceptional opportunity to continue his earlier hunt for new leptons, this time in a new and earlier inaccessible energy region of about 5 GeV (5 thousand million electron volts). After only a year came the first hint that something exciting was in the offing – something that could be signalling the production of a new type of lepton. The next year Perl and his co-workers published the first results. But a few more years were to pass before they could be certain that they had in fact discovered a lepton. The new lepton was designated with the Greek letter tau, standing for the first letter of the word triton, third.

	leptons		quarks	
family 1	e	ν_e	u	d
family 2	μ	ν_μ	c	s
family 3	τ	ν_τ	t	b

Fig. 1. The elementary particles of the standard model – a new periodic system. The figure represents a Triton.

Perl's and co-workers' experiment

The experiment recorded frontal collisions between electrons and their antiparticles, positrons. A large cylindrical detector placed in a magnetic field surrounded the collision area. The detector consisted of many components including a number of wire spark chambers together with shower counters constructed of lead scintillators and a few proportional chambers. The first indication of a possible new phenomenon was that the research team observed 24 events of the type

electron + positron → electron + antimuon + i.p.

or

electron + positron → positron + muon + i.p.

where i.p. stands for invisible particles; those that left no trace in the detector. Thus only one electron (or positron) and an antimuon (or muon) with the opposite sign on its charges were detected. Applying the law of conservation of energy, Perl and his co-workers found that they had produced at least two invisible particles.

One possible interpretation of these events was that a pair of heavy leptons, later termed tau particles, had been produced first:

electron + positron → tau + antitau

But these were expected to decay very rapidly and the observed electrons and muons were therefore interpreted as products of decay from reactions:

tau → electron (or muon) + neutrinos

antitau → antimuon (or positron) + neutrinos

The invisible particles were neutrinos, which with their notorious lack of sensitivity to their surroundings disappeared without visible trace (Fig. 2). However they made themselves felt when the energy balance was to be accounted for. They had taken with them a respectable proportion of the energy (cf. below).

Perl's and co-workers' hypothesis was tested in a new series of observations over many years. It gradually became clear that the tau had passed the test and thereby met all the possible requirements of a heavier relative to the electron and the muon. Like these, the tau also has its very own neutrino – the tau neutrino.

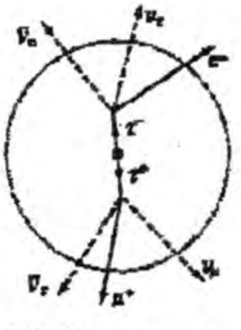

Fig. 2. Interpretation of a typical electron-muon trace from the SPEAR detector. The two heavy leptons decay within millimetres of the point of collision and cannot be seen directly. The neutrinos are also invisible. Only the charged particles e and μ are detected.

Energy conservation law cue for neutrino's entrance

The neutrino hypothesis is some 40 years older. The neutrino "was born" as a hypothetical particle in a letter written in 1930 by Wolfgang Pauli (Nobel Prize 1945). At that time it was known that many atomic nuclei ended their lives by emitting an electron. This process, termed beta decay, caused researchers many headaches, among others that one of the sacred laws of physics – the law of conservation of energy – appeared not to apply. To restore order in the statute book of physics Pauli offered what he called a "desperate solution" – the nucleus did not emit the electron alone. It was accompanied by another subatomic particle which lacked electrical charge and reacted very little with its environment. The small particle, which came to be called the neutrino, took part of the energy with it and disappeared without trace into nothingness. The energy balance proved to be as expected as long as account was taken of the proportion the neutrino had removed.

Pauli thought he had done "a frightful thing", as he called it, by proposing a particle that could never be discovered. It took three decades and the ingenuity of Reines and Cowan to bring the neutrino to light.

The discovery of the neutrino

Pauli's neutrino hypothesis may have been "frightful" but it was also extremely attractive. It saved the energy conservation law and simultaneously solved many other riddles.The neutrino hypothesis was used by Enrico Fermi (Nobel Prize 1938) in a masterly manner to formulate a theory for one of the natural forces, *the weak force*. This splendid theory lent great credibility to the hypothesis that the neutrino is created simultaneously with the electron every time a nucleus disintegrates through beta decay. But how to produce conclusive proof that the neutrino existed? Researchers Hans Bethe (Nobel Prize 1967) and Rudolf Peierls had evaluated the probability of stopping neutrinos produced in the beta decay of radioactive nuclei and found that it was so minimal that a target several light years thick would be needed to capture these neutrinos efficiently. When the first nuclear reactors were built during the 1940s, Fermi was one of those who realised that the reactors could serve as intensive neutrino sources. It was estimated that the reactors would be able to give a neutrino flow of about 10^{12}-10^{13} per second and cm^2. This was many orders of magnitude greater than what was obtained from radioactive sources.

In 1953 Reines and Cowan proposed a reactor experiment to capture neutrinos. The reaction to be studied was

antineutrino + proton → neutron + positron.

Despite the great intensity of the neutrinos the reactor delivered, such a low counting speed was expected for this reaction that the attempt appeared to be bordering on the impossible. Reines and Cowan realised the importance of detecting both the neutron and the positron to reduce the risk of erroneous interpretation. After a first trial at the Hanford reactor, Reines and Cowan went to work at the Savannah River Plant.

The target in the Reines-Cowan experiment consisted of approximately 400 litres of water containing cadmium chloride placed between large liquid scintillation detectors. The course of events for the reaction sought is as follows (cf. formula above): The neutrino collides with a proton in the water and creates a positron and a neutron. The positron is slowed down by the water and destroyed together with an electron (matter meets antimatter), whereupon two photons (light particles) are created. These are recorded simultaneously in the two detectors (Fig. 3). The neutron also loses velocity in the water and is eventually captured by a cadmium nucleus, whereupon photons are emitted. These photons reach the detectors a microsecond or so later than those from the destruction of the positron and give proof of neutrino capture.

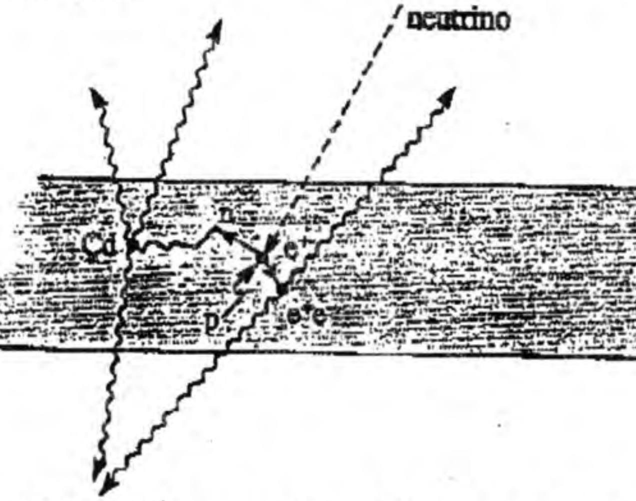

Fig. 3. Schematic picture of the neutrino detector of Reines and Cowan (see explanation in text).

There were struggles with the low counting speed and high background. During the experiment a few events were recorded per hour. Nevertheless Reines and Cowan succeeded in a feat considered to border on the impossible: They had raised the neutrino from its status as a figure of the imagination to an existence as a free particle.

EMBASSY OF SWEDEN
WASHINGTON

TELEFAX Page 1 (8)

Date	File
October 9, 1995	

TO: Ms Melanne Verveer
The White House
Office of the First Lady
Fax: (202) 456 6244

FROM: Ambassador Henrik Liljegren
Embassy of Sweden

RE: American Nobel Prize winners

Here is the information we have recieved from Sweden on the Nobel Prize winners in Physiology or Medicine for 1995.

Sincerely

Congratulations!

Henrik Liljegren
Ambassador

Address
1501 M Street, NW
Washington, D.C. 20005
USA

Telephone
(202)467-2600

Telefax
(202)467-2699

Cable
Svensk

NOBELFÖRSAMLINGEN
KAROLINSKA INSTITUTET

Press Release October 9, 1995

The Nobel Assembly at the Karolinska Institute has today decided to award the Nobel Prize in Physiology or Medicine for 1995 jointly to

Edward B. Lewis, Christiane Nüsslein-Volhard and Eric F. Wieschaus

for their discoveries concerning
"the genetic control of early embryonic development"

Summary

The 1995 laureates in physiology or medicine are developmental biologists who have discovered important genetic mechanisms which control early embryonic development. They have used the fruit fly, *Drosophila melanogaster*, as their experimental system. This organism is classical in genetics. The principles found in the fruit fly, apply also to higher organisms including man.
Using *Drosophila* Nüsslein-Volhard and Wieschaus were able to identify and classify a small number of genes that are of key importance in determining the body plan and the formation of body segments. Lewis investigated how genes could control the further development of individual body segments into specialized organs. He found that the genes were arranged in the same order on the chromosomes as the body segments they controlled. The first genes in a complex of developmental genes controlled the head region, genes in the middle controlled abdominal segments while the last genes controlled the posterior ("tail") region. Together these three scientists have achieved a breakthrough that will help explain congenital malformations in man.

What controls the development of the fertilized egg?

The fertilized egg is spherical. It divides rapidly to form 2, 4, 8 cells and so on. Up until the 16-cell stage the early embryo is symmetrical and all cells are equal. Beyond this point, cells begin to specialize and the embryo becomes asymmetrical. Within a week it becomes clear what will form the head and tail regions and what will become the ventral and dorsal sides of the embryo. Somewhat later in development the body of the embryo forms segments and the position of the vertebral column is fixed. The individual segments undergo different development, depending on their position along the "head-tail" axis. Which genes control these events? How many are they? Do they cooperate or do they exert their controlling influence

Postadress/Postal address
The Nobel Assembly
Nobel Forum
Karolinska Institutet
Box 270
S-171 77 STOCKHOLM

Gatuadress/Visiting address
Solnavägen 1 (Byggnad/Building Doktorsringen 1)
STOCKHOLM

Telefon/Phone
46-8-33 39 31
Fax 46-8-32 93 68

Telegram
nobelkl

independently of each other?

This year's laureates have answered several of these questions by identifying a series of important genes and how they function to control the formation of the body axis and body segments. They have also discovered genes that determine which organs that will form in individual segments. Although the fruit fly was used as an experimental system, the principles apply also to higher animals and man. Furthermore, genes analogous to those in the fruit fly have been found in man. An important conclusion is that basic genetic mechanisms controlling early development of multicellular organisms have been conserved during evolution for millions of years.

Brave decision by two young scientists

Christiane Nüsslein-Volhard and Eric Wieschaus both finished their basic scientific training at the end of the seventies. They were offered their first independent research positions at the European Molecular Biology Laboratory (EMBL) in Heidelberg. They knew each other before they arrived in Heidelberg because of their common interest: they both wanted to find out how the newly fertilized *Drosophila* egg developed into a segmented embryo. The reason they chose the fruit fly is that embryonic development is very fast. Within 9 days from fertilization the egg develops into an embryo, then a larvae and then into a complete fly.

They decided to join forces to identify the genes which control the early phase of this process. It was a brave decision by two young scientists at the beginning of their scientific careers. Nobody before had done anything similar and the chances of success were very uncertain. For one, the number of genes involved might be very great. But they got started. Their experimental strategy was unique and well planned. They treated flies with mutagenic substances so as to damage (mutate) approximately half of the *Drosophila* genes at random (saturation mutagenesis). They then studied genes which, if mutated would cause disturbances in the formation of a body axis or in the segmentation pattern. Using a microscope where two persons could simultaneously examine the same embryo they analyzed and classified a large number of malformations caused by mutations in genes controlling early embryonic development. For more than a year the two scientists sat opposite each other examining *Drosophila* embryos resulting from genetic crosses of mutant *Drosophila* strains. They were able to identify 15 different genes which, if mutated, would cause defects in segmentation. The genes could be classified with respect to the order in which they were important during development and how mutations affected segmentation. *Gap* genes (Fig 1) control the body plan along the head-tail axis. Loss of gap gene function results in a reduced number of body segments. *Pair rule* genes affect every second body segment.

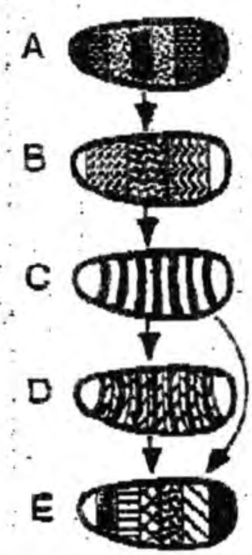

Fig. 1. Regions of activity in the embryo for the genes belonging to the gap, pair-rule, and segment-polarity groups. The gap genes start to act in the very early embryo (A) to specify an initial segmentation (B). The pair-rule genes specify the 14 final segments (C) of the embryo under the influence of the gap genes. These segments later acquire a head-to-tail polarity due to the segment polarity genes.

loss of a gene known as "even-skipped" results in an embryo consisting only of odd numbered segments. A third class of genes called segment polarity genes affect the head-to-tail polarity of individual segments.
The results of Nüsslein-Volhard and Wieschaus were first published in the English scientific journal Nature during the fall of 1980. They received a lot of attention among developmental biologists and for several reasons. The strategy used by the two young scientists was novel. It established that genes controlling development could be systematically identified. The number of genes involved was limited and they could be classified into specific functional groups. This encouraged a number of other scientists to look for developmental genes in other species. In a fairly short time it was possible to show that similar or identical genes existed also in higher organisms and in man. It has also been demonstrated that they perform similar functions during development.

The fly with the extra pair of wings

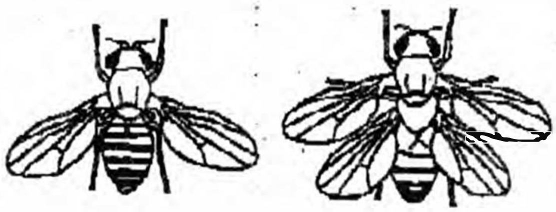

Fig. 2. Comparison of a normal and a four-winged fruit fly. The third thoracic segment has developed as a duplicate of the second due to a defective homeotic gene. In the normal fly only the second segment develops wings.

Already at the beginning of this century geneticists had noted occasional malformations in *Drosophila*. In one type of mutation the organ that controls balance (the halteres), was transformed into an extra pair of wings (Fig. 2). In this type of bizarre disturbance of the body plan, cells in one region behave as though they were located in another. The Greek word homeosis was used to describe this type of malformations and the mutations were referred to as homeotic mutations.
The fly with the extra pair of wings interested Edward B. Lewis at the California Institute of Technology in Los Angeles. He had, since the beginning of the forties, been trying to analyze the genetic basis for homeotic transformations. Lewis found that the extra pair of wings was due to a duplication of an entire body segment. The mutated genes responsible for this phenomenon were found to be members of a gene family (*bithorax*-complex) that controls segmentation along the anterior-posterior body axis (Fig. 3). Genes at the beginning of the complex controlled anterior body segments while genes further down the genetic map controlled more posterior body segments (the colinearity principle). Furthermore, he found that the regions controlled by the individual genes overlapped, and that several genes interacted in a complex manner to specify the development of individual body segments. The fly with the four wings was due to inactivity of the first gene of the *bithorax* complex in a segment that normally would have produced the halteres, the balancing organ of the fly (Fig 3). This caused other homeotic genes to respecify this particular segment into one that forms wings.
Edward Lewis worked on these problems for decades and was far ahead of his time. In 1978 he summarized his results in a review article and formulated theories about how homeotic genes interact, how the gene order corresponded to the segment order along the body axis, and how the individual genes were expressed. His pioneering work on homeotic genes induced other scientists to examine families of

analogous genes in higher organisms. In mammalians, the gene clusters first found in *Drosophila* have been duplicated into four complexes known as the *HOX* genes. Human genes in these complexes are sufficiently similar to their *Drosophila* analogues they can restore some of the normal functions of mutant *Drosophila* genes.

The individual genes within the four HOX gene families in vertebrates occur in the same order as they do in *Drosophila*, and they exert their influence along the body axis (Fig 3 D-F) in agreement with the colinearity principle first discovered by Lewis in *Drosophila*. More recent research has suggested that the segments where shoulders and the pelvis form is determined by homeotic genes.

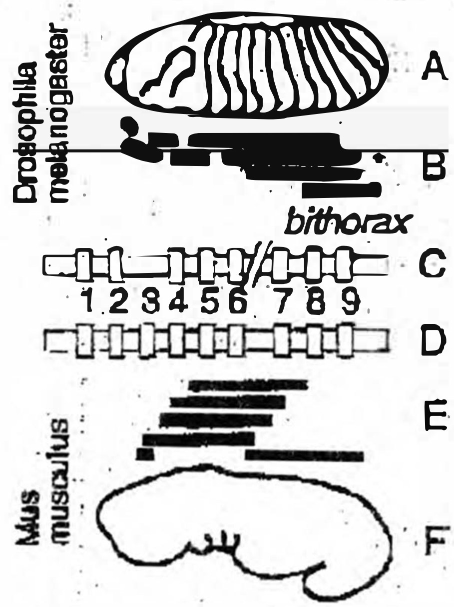

Fig. 3. The principle of colinearity in Drosophila (A-C) and mouse (Mus musculus, D-F) embryos. The horizontal bars indicate in which areas the homeotic genes 1-9 are active along the body axis. Gene 1 is active in the head region (left in A and F, respectively); gene 9 is active in the tail region (right). Gene 7 of the bithorax complex was inactive in the fly with four wings. The bar showing its normal range of activity is indicated with an asterisk.

Congenital malformations in man

Most of the genes studied by Nüsslein-Volhard, Wieschaus and Lewis have important functions during the early development of the human embryo. The functions include the formation of the body axis, i.e. the polarity of the embryo, the segmentation of the body, and the specialization of individual segments into different organs. It is likely that mutations in such important genes are responsible for some of the early, spontaneous abortions that occur in man, and for some of the about 40% of the congenital malformations that develop due to unknown reasons. Environmental factors such as very high doses of vitamin A during early pregnancy are also known to disturb the regulation of HOX-genes, thus inducing severe congenital malformations. Mutations have in some cases been found in human genes related to those described here for Drosophila. A human gene related to the *Drosophila* gene *paired* will cause a condition known as Waardenburg's syndrome. It is a rare disease which involves deafness, defects in the facial skeleton and altered pigmentation of the iris. Another developmental gene mutation causes a complete loss of the iris, a condition known as aniridia.

Literature
Lewis, E.B. (1978) A Gene Complex Controlling Segmentation in Drosophila. Nature 276, 565-570
Nüsslein-Volhard, C., Wieschaus, E. (1980). Mutations Affecting Segment Number and Polarity in Drosophila. Nature 287, 795-801
McGinnis, W., Kuziora, M. (1994). The Molecular Architects of Body Design. Scientific American 270, 36-42
Lawrence, P. The Making of a Fly. Blackwell Scientific Publications. Oxford 1992.
The Molecular Biology of the Cell. Eds Alberts, B. et al, 3rd edition pp 1077-1107. Garland Publishing, New York 1994.

CHRISTIANE NÜSSLEIN - VOLHARD, born October 20th, 1942, Magdeburg, Germany

Address: Max-Planck-Institut für Entwicklungsbiologie, Abt. Genetick, Spemannstr. 35, 72076 Tübingen, Germany

Academic Education:

1962-1964	Johann-Wolfgang-Goethe-Universität, Frankfurt/Main, Germany, (Biology, Physics, Chemistry)
1964-1968	Eberhard-Karls-Universität, Tübingen, Germany, Diplom in Biochemistry
1973	PhD (Dr rer nat) in Biology (Genetics), University of Tübingen

Appointments and Professional Activities:

1969-1974	Max-Planck-Institut für Virusforschung, Tübingen, Diplom- and PhD thesis, thesis supervisor Dr Heinz Schaller, Research associate
1978-1980	Head of group, European Molecular Biology Laboratory (EMBL), Heidelberg
1981-1985	Groupleader in the Friedrich-Miescher -Laboratorium der Max-Planck-Gesellschaft, Tübingen
1985 -	Scientific member of the Max-Planck-Society and Director at the Max-Planck-Institut für Entwicklungsbiologie (Developmental Biology), Genetics Division, Tübingen

Fellowships and awards:

1975-1976	Postdoctoral fellow (EMBO fellowship) laboratory of Professor Dr Walter Gehring, Biozentrum, Basel
1977	Postdoctoral fellow (DFG fellowship) laboratory of Professor Dr Klaus Sander, University of Freiburg
1986	Leibnizpreis der Deutschen Forschungsgemeinschaft Franz-Vogt-Preis der Universität Giessen
1988	Brooks Lecturer, Harvard Medical School
1989	Carus-Medaille der Deutschen Akademie der Wissenschaften Leopoldina Halle, Carus-Preis der Stadt Schweinfurth, Honorary Professor, Universität Tübingen, Silliman Lecturer, Yale University
1990	Rosenstiel Medal, Brandeis University, ScD, Yale University, Mattia Award, Roche Institute, New Jersey
1991	Dr h.c. Utrecht University, Dr h.c. Princeton University, Dunham Lecturer, Harvard Medical School, Harvey Lecturer, Rockefeller University, Albert Lasker Medical Research Award, New York
1992	Prix Louis Jeantet de Médecine, Geneva, Otto Bayer Preis der Bayer AG, Leverkusen, Alfred Sloan Price of the General Motors Company, Gregor Mendel Medal of the Genetical Society, Great Britain, Otto Warburg Medal of the Deutsche Gesellschaft für Biochemie
1993	Dr h.c. Universität Freiburg , Dr h.c. Harvard University, Sir Hans Krebs Medal of the Federation of European Biochemical Societies, Theodor Boveri Preis der Gesellschaft Physico-Medica der Universität Würzburg, Ernst Schering Preis, Berlin, Bertner Award, Anderson Cancer Research Center, Houston, Texas, Sonneborn Lecturer, Indiana University
1994	Das Verdienstkreuz 1 Klasse des Verdienstordens der Bundesrepublik Deutschland

ERIC F. WIESCHAUS, born June 7, 1947

Address: Department of Molecular Biology, Princeton University, Princeton, NJ 08544, USA

Academic Education:

1969	BS, University of Notre Dame, South Bend, IN
1974	PhD, Yale University, New Haven, CT
1975-1978	Postdoctoral, University of Zürich, Switzerland

Appointments and Professional Activities:

1975-1978	Postdoctoral Fellow, Zoologisches Institut der Universität Zürich, with Dr Rolf Nöthiger
1976	EMBO short-term fellowship to the laboratory of Mme Gans, Laboratoire de Genetique Moleculaire CNRS, Gif-sur-Yvette, France
1977	Visiting Researcher, Laboratory of Peter Bryant, Center of Pathobiology, University of CA, Irvine
1978-1981	Group Leader, European Molecular Biology Laboratory, Heidelberg, West Germany
1981-1983	Assistant Professor of Biology, Princeton University
1983-1987	Associate Professor of Biology, Princeton University
1987 -	Professor, Princeton University

Fellowships and Awards:

1969	Graduated Magna cum laude, University of Notre Dame, South Bend IN
1974	John Spangler Niclaus Prize for the outstanding dissertation in experimental embryology, Yale University
1987	Scientific Advisor Council, Damon Runyon-Walter Winchell Cancer Fund
1986-	Advisor Council, Department of Biology/Biochemistry, Rice University, Houston, Texas

NOBELFÖRSAMLINGEN
KAROLINSKA INSTITUTET

October 9, 1995

NOBEL LAUREATES IN PHYSIOLOGY OR MEDICINE 1995

CURRICULA VITAE

EDWARD B. LEWIS, born May 20, 1918, Wilkes-Barre, Pennsylvania, USA

Address: Division of Biology, California Institute of Technology, 156-29, Pasadena, California 91125, USA

Academic Education:

1939	University of Minnesota, Minneapolis, B.A. (Biostatistics)
1942	California Institute of Technology, Pasadena, Ph.D. (Genetics)
1943	California Institute of Technology, M.S. (Meteorology)

Appointments and Professional Activities:

1947-48	Rockefeller Foundation Fellow, Cambridge University, Cambridge, UK
1948-49	Assistant Professor of Biology, California Institute of Technology
1949-56	Associate Professor of Biology, California Institute of Technology
1956-66	Professor of Biology, California Institute of Tehnology
1975-76	Guest Professor, Institute of Genetics, University of Copenhagen, Denmark
1966-88	Thomas Hunt Morgan Professor of Biology, Caltech
1988-	Thomas Hunt Morgan Professor of Biology, Emeritus, Caltech

Fellowships and Awards:

Honorary Doctor of Philosophy, University of Umeå, Umeå, Sweden, 1981
Thomas Hunt Morgan Medal of the Genetics Society of America, 1983
Gairdner Foundation International Award (Canada), 1987
Wolf Prize in Medicine (Israel), 1989
Lewis S. Rosenstiel Award in Basic Medical Research, 1990
National Medal of Science (USA), 1990
Honorary Member, The Genetical Society (UK), 1990
Albert Lasker Basic Medical Research Award, 1991
The Louisa Gross Horwitz Prize, 1992
Honorary Doctor of Science, University of Minnesota, 1993

Postadress/Postal address
The Nobel Assembly
Nobel Forum
Karolinska Institutet
Box 270
S-171 77 STOCKHOLM

Gatuadress/Visiting address
Solnavägen 1 (Byggnad/Building Doktorsringen 1)
STOCKHOLM

Telefon/Phone
46-8-33 39 31
Fax 46-8-32 03 65

Telegram
nobelki

engelska

Information

For further information please contact:
The Royal Swedish Academy of Sciences
Information Department, Box 50005, S-104 05 Stockholm, Sweden
Tel: +46-(0)8-673 95 25, fax: +46-(0)8-15 56 70

The Royal Swedish Academy of Sciences has decided to award the 1995 Nobel Prize in Chemistry to

Professor Paul Crutzen, Max-Planck-Institute for Chemistry, Mainz, Germany (Dutch citizen),
Professor Mario Molina, Department of Earth, Atmospheric and Planetary Sciences and Department of Chemistry, MIT, Cambridge, MA, USA and
Professor F. Sherwood Rowland, Department of Chemistry, University of California, Irvine, CA, USA

for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.

The ozone layer – the Achilles heel of the biosphere

The atmosphere surrounding the earth contains small quantities of ozone – a gas with molecules consisting of three oxygen atoms (O_3). If all the ozone in the atmosphere were compressed to a pressure corresponding to that at the earth's surface, the layer would be only 3 mm thick. But even though ozone occurs in such small quantities, it plays an exceptionally fundamental part in life on earth. This is because ozone, together with ordinary molecular oxygen (O_2), is able to absorb the major part of the sun's ultraviolet radiation and therefore prevent this dangerous radiation from reaching the surface. Without a protective ozone layer in the atmosphere, animals and plants could not exist, at least upon land. It is therefore of the greatest importance to understand the processes that regulate the atmosphere's ozone content.

Paul Crutzen, Mario Molina and Sherwood Rowland have all made pioneering contributions to explaining how ozone is formed and decomposes through chemical processes in the atmosphere. Most importantly, they have in this way showed how sensitive the ozone layer is to the influence of anthropogenic emissions of certain compounds. The thin ozone layer has proved to be an Achilles heel that may be seriously injured by apparently moderate changes in the composition of the atmosphere. By explaining the chemical mechanisms that affect the thickness of the ozone layer, the three researchers have contributed to our salvation from a global environmental problem that could have catastrophic consequences.

KUNGL.
VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

11 October 1995

Internet: http://www.kva.se

How this knowledge evolved

Ozone is formed in the atmosphere through the splitting of ordinary oxygen molecules (O_2) by ultra-violet radiation from the sun. The oxygen atoms thereby liberated react with the molecular oxygen according to :

$$O_2 + \text{uv-light} \rightarrow 2O$$
$$O + O_2 + M \rightarrow O_3 + M$$

where M is a random air molecule (N_2 or O_2).

The English physicist Sidney Chapman formulated in 1930 the first photochemical theory for the formation and decomposition of ozone in the atmosphere. This theory, which describes how sunlight converts the various forms of oxygen from one to another, explains why the highest contents of ozone occur in the layer between 15 and 50 km, termed the ozone layer (Fig. 1). Later measurements, however, showed appreciable deviations from Chapman's theory. The calculated ozone contents were considerably higher than the observed ones. Thus, there must be other chemical reactions contributing to the reduction of the ozone content. Some years later the Belgian Marcel Nicolet contributed important knowledge of how the decomposition of ozone was enhanced by the presence of the hydrogen radicals OH and HO_2.

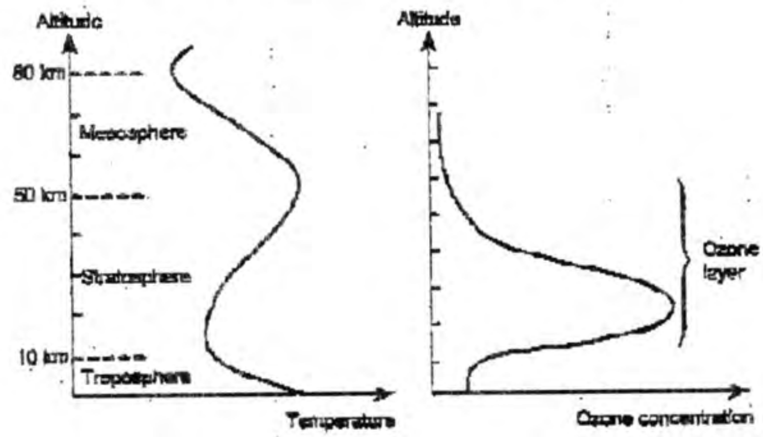

Fig. 1. Variation in temperature and ozone concentrationt up through the atmosphere

The scientist to take the next fundamental step towards a deeper understanding of the chemistry of the ozone layer was Paul Crutzen. In 1970 he showed that the nitrogen oxides NO and NO_2 react catalytically (without themselves being consumed) with ozone, thus accelerating the rate of reduction of the ozone content.

$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$
$$O_3 + \text{uv-light} \rightarrow O_2 + O$$

$$\text{Net result:} \quad 2O_3 \rightarrow 3O_2$$

These nitrogen oxides are formed in the atmosphere through the decay of the chemically stable nitrous oxide N_2O, which originates from microbiological transformations at the ground. The connection demonstrated by Crutzen between microorganisms in the soil and the thickness of the ozone layer is one of the motives for the recent rapid development of research on global biogeochemical cycles.

The first threat noted: supersonic aircraft

The power of nitrogen oxides to decompose ozone was also noted early by the American researcher Harold Johnston, who carried out extensive laboratory studies of the chemistry of nitrogen compounds. In 1971 he pointed out the possible threat to the ozone layer that the planned fleet of supersonic aircraft and supersonic travel (SST) might represent. These aircraft would be capable of releasing nitrogen oxides right in the middle of the ozone layer at altitudes of 20 km. Crutzen's and Johnston's work gave rise to a very intensive debate among researchers as well as among technologists and decision-makers. This was also the start of intensive research into the chemistry of the atmosphere which has made great progress during the past several years. (The subsequent cancellation of plans for a large SST fleet had other reasons than the environmental risks they involved.)

Spray cans and refrigerators damage the ozone layer

The next leap in our knowledge of ozone chemistry was in 1974, when Mario Molina and Sherwood Rowland published their widely noted *Nature* article on the threat to the ozone layer from chlorofluorocarbon (CFC) gases – "freons" – used in spray bottles, as the cooling medium in refrigerators and elsewhere and plastic foams. Molina and Rowland based their conclusions on two important contributions by other researchers:

- James Lovelock (England) had recently developed a highly sensitive device of measuring extremely low organic gas contents in the atmosphere, the electron capture detector. Using this he could now demonstrate that the exclusively man-made, chemically inert, CFC gases had already spread globally throughout the atmosphere.
- Richard Stolarski and Ralph Cicerone (USA) had shown that free chlorine atoms in the atmosphere can decompose ozone catalytically in similar ways as nitrogen oxides do.

Molina and Rowland realised that the chemically inert CFC could gradually be transported up to the ozone layer, there to be met by such intensive ultra-violet light that they would be separated into their constituents, notably chlorine atoms. They calculated that if human use of CFC gases was to continue at an unaltered rate the ozone layer would be depleted by many percent after some decades. Their prediction created an enormous attention. For the CFC gases were used in many technical processes and their very chemical stability and non-toxicity were thought to render them environmentally ideal. Many were critical of Molina's and Rowland's calculations but yet more were seriously concerned by the possibility of a depleted ozone layer. Today we know that they were right in all essentials. It was to turn out that they had even underestimated the risk.

Ozone content over Antarctica

Molina's and Rowland's report led to certain restrictions on CFC release during the late 1970s and early 1980s. Not until 1985, when the real shock came, was there any real urgency in the international negotiations on release restrictions. Then the Englishman Joseph Farman and his colleagues noted a drastic depletion of the ozone layer over the Antarctic, the "ozone hole" (Fig. 2). The depletion was, at least periodically, far greater than expected from earlier calculations of the CFC effect. The debate among researchers now intensified. Was this a natural climatic variation or was it chemical decomposition brought about by mankind? Thanks to pioneering research by many researchers, among them Crutzen, Molina and Rowland, as well as Susan Solomon and James Anderson, both from the USA, the picture has now cleared. The depletion is caused chiefly by ozone reacting chemically with chlorine and bromine from industrially manufactured gases.

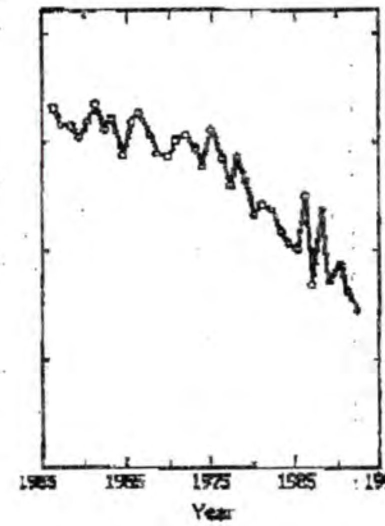

Fig. 2. Thickness of the ozone layer (mean monthly value for October) over Halley Bay, Antarctica. Note the drastic depletion since the end of the 1970s.

The surprisingly rapid depletion of the ozone layer over Antarctica could not be explained by transport processes or by gas phase chemical reactions. An alternative mechanism must exist which could accelerate the decomposition of ozone. Crutzen and colleagues identified this mechanism as chemical reactions on the surface of cloud particles in the stratosphere. Thus, the Antarctic ozone depletion appears to be connected with the extremely low prevailing temperatures, which lead to condensation of water and nitric acid to form "polar stratospheric clouds" (PSCs). The ozone-decomposing chemical reactions are greatly reinforced by the presence of cloud particles. This understanding has led to an exciting new branch of atmospheric chemistry: "heterogeneous" chemical reactions on particle surfaces.

The ozone layer and the climate

The ozone problem also has interesting connections with the issue of how mankind is affecting the climate. Ozone, like carbon dioxide and methane, is a greenhouse gas that contributes to high temperatures at the surface of the earth. (CFC gases have a similar effect). Model calculations have shown that the climate is specially sensitive to changes in the ozone content in the lower layers, the troposphere. Here the ozone content has increased markedly during the past century, chiefly because of the release of nitric oxide, carbon monoxide and gaseous hydrocarbons from vehicles and industrial processes and from the combustion of biomass in the tropics. The elevated ozone content in lower atmospheric layers is itself an environmental problem for the damage it can cause to crops and human health. Paul Crutzen has been the world's leading researcher in mapping the chemical mechanisms that determine the ozone content at these levels.

What can we expect in the future?

Thanks to our good scientific understanding of the ozone problem – and very largely to Crutzen, Molina and Rowland – it has been possible to make far-reaching decisions on prohibiting the release of gases that destroy ozone. A protocol on the protection of the ozone layer was negotiated under the auspices of the United Nations and signed in Montreal, Canada, in 1987. Under the latest tightening-up of the Montreal Protocol, the most dangerous gases will be totally banned from 1996 (developing countries have a few years' grace to introduce substitutes that do not harm the ozone layer). Since it takes some time for the ozone-destroying gases to reach the ozone layer we must expect the depletion, not only over Antarctica but also over parts of the Northern Hemisphere, to worsen for some years to come. Given compliance with the prohibitions, the ozone layer should gradually begin to heal after the turn of the century (Fig. 3). Yet it will take at least 100 years before it has fully recovered.

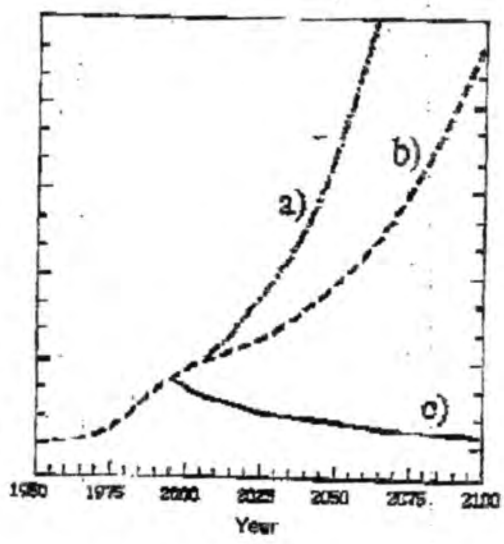

Fig. 3. Change in the chlorine content in the stratosphere up to the present and three different future scenarios: a) Without restrictions on release, b) Limitations according to the original Montreal Protocol of 1987 c) The release limitations now internationally agreed. (Chlorine content is a measure of the magnitude of ozone depletion.)

Further reading

Dotto, L. and Schiff, H. L. *The ozone war*, Doubleday, Garden City, New York, 1978.
Graedel, T. E. and Crutzen, P.J. *Atmosphere, climate and change*. Scientific American Library, 1995.
Gribbin, J., *The hole in the sky*, Corgi Books, London, 1988.
Rowland, F. S. and Molina, M. J., *Ozone depletion: 20 years after the alarm*, Chemical and Engineering News 72, 8-13, 1994.
Scientific assessment of ozone depletion 1994, WMO Report 37. World Meteorological Organization and United Nations Environment Programme, Geneva, 1995.
Toon, O. B. and Turco, R. P., *Polar stratospheric clouds and ozone depletion*, Scientific American 264, 68-74, 1991.
Wayne, R. P. *Chemistry of Atmospheres*, Oxford Science Publications, 1993.
WMO and the ozone issue, World Meteorological Organization, Report 778, 1992

****

Paul Crutzen was born in 1933 in Amsterdam. Dutch citizen. Doctor's degree in meteorology, Stockholm University, 1973. Member of the Royal Swedish Academy of Sciences, the Royal Swedish Academy of Engineering Sciences and Academia Europaea.

Professor Paul Crutzen
Max-Planck-Institute for Chemistry
P.O. Box 3060
D-55020 Mainz, Germany.

Mario Molina was born in 1943 in Mexico City, Mexico. PhD in physical chemistry, University of California, Berkeley. Member of the US National Academy of Sciences.

Professor Mario Molina
Department of Earth, Atmospheric and Planetary Sciences
MIT 54 - 1312
Cambridge MA 02139, USA

F. Sherwood Rowland was born in Delaware, Ohio, USA, 1927. Doctor's degree in chemistry, University of Chicago, 1952. Member of the American Academy of Arts and Sciences and of the US National Academy of Sciences, where he is currently Foreign Secretary.

Professor F. Sherwood Rowland
Department of Chemistry
University of California
Irvine CA 92717, USA

6(6) Physics

Further reading

Additional background material on the Nobel Prize for Physics 1995, The Royal Swedish Academy of Sciences, Internet: http://www.kva.se
Heavy Leptons, Martin L.Perl and William T.Kirk, Scientific American, March 1978.
Leptons -- what are they? Martin L. Perl, New Scientist, 22 February 1979.
The Neutrino, Frederick Reines and Clyde L. Cowan, Jr., Nature, 1 September 1956.
Neutrino Physics, Frederick Reines and Clyde L. Cowan, Jr., Physics Today, August 1957.
Spaceship neutrino, Christine Sutton, Cambridge University Press 1992, p. 37-44, 89-93.

*****

Martin L.Perl
Born 1927, New York, NY, USA. American citizen. Doctor's degree in physics 1955, Columbia University. Perl is a member of the National Academy of Sciences, USA.

Martin L. Perl, Professor
Stanford Linear Accelerator Center
Stanford University
Stanford, CA 94305
USA

Frederick Reines
Born 1918 Paterson, New Jersey, USA. American citizen. Doctor's degree in physics 1944, New York University. Reines is a member of the National Academy of Sciences, USA, and a foreign member of the Russian Academy of Sciences.

Frederick Reines, Professor
Department of Physics
University of California at Irvine
Irvine, CA 92717
USA

SCHEDULE PROPOSAL

TO:	Kim Tilley
FROM:	Melanne Verveer, Madge Henning
REQUEST:	The Vice President to participate in and make remarks at an event honoring the 7 American 1995 Nobel Laureates.
PURPOSE:	To honor the 7 Americans who are receiving Nobel prizes this year. Outreach to the Hispanic and scientific community.
BACKGROUND:	This administration has honored the Laureates for the last two years, in 1993 with a tea and in 1994 with a reception. Last year the Vice President and the First Lady participated. This year one of the winners is of Hispanic origin. The office of Public Liaison would like to use this occasion to do outreach to the Hispanic community. OSTP would contribute the names of the scientific community to be invited. We have also been told that the Vice President personally knows two of this year's Laureates.
DATE:	November 15 afternoon
LOCATION:	East Room, reception in the State Dining Room
DURATION:	1 hour ??

EMBASSY OF SWEDEN
WASHINGTON

TELEFAX

Page 1 (2)

Date	File
October 19, 1995	

TO: Ms Madge Henning
456 6244

FROM: Elisabeth Wild-Nordlund
Ambassador's office

RE: List of fax numbers

Dear Ms Henning,

Nancy asked me to fax you the list of fax numbers to the Nobel Prize winners.

Regards

Elisabeth

Address
1501 M Street, NW
Washington, D.C. 20005
USA

Telephone
(202)467-2600

Telefax
(202)467-2699

Cable
Svensk