Curriculum C, - 7 pages incl. Description of Physics Papers. Personal 58 M incl. Rupp

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M

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BIOGRAPHICAL DATA AND LIST OF
PUBLICATIONS OF LEO SZILARD FROM
1922 to 1946

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investigate the energy threshold for a photo disintegration of beryllium X-rays. This was done jointly with six other authors. The threshold for photo-neutrons from beryllium was determined by varying the voltage of an X-ray tube and was found to be somewhere about 1.5 and well below 2 m.e.v. This information was partially responsible for inducing Bethe to revise the accepted mass of He and thereby to resolve the paradox of the stability of beryllium. Our paper was published in 1934:

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After the discovery of fission by Hahn and Strassman, I found, jointly with Walter Zinn, that fast neutrons are emitted in the fission process and that their number is about two per fission. The neutron emission in the fission of uranium was discovered independently, and about the same time, by Halban, Joliot and Kovarsky, and By Anderson and Fermi. This discovery revealed that

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Curriculum C2 – 6 pages
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Curriculum C3 — 6 page after 1955

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Curric. C3

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Curriculum G3 — 6 pages after 1955

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Beginning of Biology 1) [D3] 1

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~~18~~ 19 - 2)	Aaron Novick and Leo Szilard -	VIRUS STRAINS OF IDENTICAL PHENOTYPE BUT DIFFERENT GENOTYPE. Science, January 12, 1951, Vol. 113, No. 2924, pp. 34-55.
~~17~~ 18 -3)	Aaron Novick and Leo Szilard -	EXPERIMENTS WITH THE CHEMOSTAT ON SPONTANEOUS MUTATIONS OF BACTERIA. Proceedings of the NATIONAL ACADEMY OF SCIENCES. Vol. 36, No. 12, pp. 706-719, December, 1950.
17 ~~16~~ - 4)	Aaron Novick and Leo Szilard -	DESCRIPTION OF THE CHEMOSTAT. Science, December 15, 1950. Vol. 112, No. 2920, pp. 715-716.
~~19~~ 20 - 5)	Aaron Novick and Leo Szilard -	EXPERIMENTS ON SPONTANEOUS AND CHEMICALLY INDUCED MUTATIONS OF BACTERIA GROWING IN THE CHEMOSTAT. Cold Spring Harbor Symposia on Quantitative Biology. Vol. XVI, 1951. 337-343
21 ~~20~~ -6)	Aaron Novick and Leo Szilard -	ANTI-MUTAGENS. Nature, Vol. 170, p. 926, November 29, 1952.
~~21~~ 22 - 7)	A. Novick and Leo Szilard -	EXPERIMENTS WITH THE CHEMOSTAT ON THE RATES OF AMINO ACID SYNTHESIS IN BACTERIA. Dynamics of Growth Processes. Princeton University Press, pp. 21-32, 1954.
~~22~~ 23 - 8)	Maurice S. Fox and Leo Szilard -	A DEVICE FOR GROWING BACTERIAL POPULATIONS UNDER STEADY STATE CONDITIONS. Journal of General Physiology 39, p. 261-6, 1955.

The first of these papers (1) investigates a phenomenon discovered by A. Kelner after the war, who showed that bacteria "killed" by ultra-violet light can be revived by shining visible light on them. Experiments designed to analyze the phenomenon are described in this paper; they lead to the conclusion that the ultra-violet light produces a "poison" which can be inactivated by light and that this "poison", if present when, subsequent to irradiation, the bacteria divide, will cause both death and mutations.

The second paper (2) describes the discovery that, when a bacterium is infected simultaneously with two related viruses which differ from each other both in genotype and phenotype, the virus population emerging from the bacterium contains a class of viruses which have the genotype of one and the phenotype of the other.

The papers Nos. 3 to 7 describe a new way of studying bacteria by maintaining a bacterial population in a stationary (exponentially growing) state indefinitely and controlling the growth rate by controlling the rate of supply of an essential growth factor. An apparatus is described in these papers which will conveniently accomplish this and which is designated as the Chemostat.

In studying mutations in bacteria or the formation of adaptive enzymes in bacteria inaccurate, and therefore misleading, results are frequently obtained by studying bacterial cultures in flasks in which the number of bacteria increases exponentially and today the use of the Chemostat appears to be indispensable.

In the papers Nos. 3 to 6, the Chemostat is used in the study of mutations. It turns out that the rate at which mutations occur in a growing bacterial population under the conditions studied is not proportional to the rate at which cell division occurs, rather the mutation rate is constant per unit time independent of the rate at which the culture is growing. There is found one group of compounds, all purine derivatives, of which caffein is one, which greatly increases the mutation rate without having an appreciable killing effect on the bacteria.

There is another group of compounds described in these papers, all of them ribosides of purines which in small quantities will completely counteract the action of the above mentioned purine type mutagens and also reduce the rate of spontaneous mutations.

In paper No. 7, the Chemostat is used to study the biosynthesis of amino acids in bacteria and the regulatory mechanisms which are involved in it. The biosynthetic apparatus of the bacteria respond to amino acid concentrations in the medium, which are exceedingly low. For instance, a bacterium which can make arginine and will do so if there is no arginine in the medium, will stop making arginine if an arginine concentration of 10^{-9} ga/ce is maintained in the medium in the Chemostat. (Novick and Szilard - unpublished.)

One way of studying such regulatory mechanisms is based on the use of a mutant which is blocked in the synthesis of an amino acid -- in our case Tryptophane -- and which pours out into the medium a "precursor" of that amino acid. Paper No. 7 utilizes such a mutant. In the absence of Tryptophane in the medium, a precursor of Tryptophane is poured out by the mutant into the medium at a rate which is independent of the growth rate of the bacteria. In the presence of Tryptophane this "precursor" is <u>not</u> poured out by the bacteria. It is conceivable that this indicates a general phenomenon of regulation through a negative feed-back of the final product at one of the <u>early</u> steps of the metabolic pathway leading to Tryptophane.

In paper No. 8, there is described a device called a breeder. In this device bacteria may be grown in a continuous flow of nutrient. The flow of the nutrient is controlled by the turbidity of the bacterial culture and the growth is not limited by a growth factor, as is the case in the "Chemostat."

This device was developed in order to study mutations in bacteria under conditions of growth at the maximal rate, and such study was carried out by Maurice S. Fox.

24 the Aging Process
~~22.~~ Szilard, Leo. On the Nature of ~~Ageing.~~ Proc. Nat. Acad. Sci. U. S., ~~1959~~, 45: 30-45. (Jan) 1959

26. ~~23.~~ Szilard, Leo. The Control of the Formation of Specific Proteins in Bacteria and in Animal Cells. Proc. Nat. Acad. Sci. U. S., 1960, 46: 277-292.

27. ~~24.~~ Szilard, Leo. The Molecular Basis of Antibody Formation. Proc. Nat. Acad. Sci. U. S., 1960, 46: 293-302.

25. Leo Szilard "A Theory of Aging"
Nature, 184 : 957 - 958,
(Sept 26) 1959
Reply to Letter to Editor

28. Leo Szilard "Dependence of the Sex Ratio at Birth on the Age of the Father"
Nature 186 : 649 - 650

Leo Szilard

29. Proc. Ntl. Ac. Sc. 51 : 1092-1099
Memory and Recall (June) 1964
by L.S.

Transl ④ 30. Behav. Sc. 9 : 301 - 310, (Oct) 1964
of "On the Decrease of E.)"

Curriculum C   duplicate   Personal 58

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In October 1946, I was appointed to my present position as a full professor on the regular staff of the University of Chicago.

BIOGRAPHICAL DATA AND LIST OF PUBLICATIONS OF LEO SZILARD FROM 1922 to 1946

I obtained my doctor's degree in Physics at the University of Berlin in 1922. My dissertation showed that the second law of thermodynamics permits to draw conclusions on the laws that control thermodynamic fluctuations. This dissertation was published in 1925.

(1) Zeitschrift für Physik, 1925, p.753, 32.

Subsequently I worked for about two years with H. Mark at the Kaiser Wilhelm Institute für Faserstoffchemie in Berlin Dahlem. Our work on the anomalous scattering of X-rays in crystals and on the polarization of X-rays by reflection on crystals, resulted in two papers:

(2) Zeitschrift für Physik, 1925, p.688, 33.

(3) Zeitschrift für Physik, 1926, p.743, 35.

Subsequently I was, for three years, Assistant at the Institute für Theoretische Physik at the University of Berlin (Director Prof. Max von Laue).

During this period I investigated the apparent decrease in entropy in a system in which variables that are subject to thermodynamic fluctuations are "observed", and used to control operations. This led me to the recognition of the connection between "entropy" and "information" and a theorem which now forms part of "modern information theory". The resulting papers were accepted as Habilitationschrift at the University of Berlin and I was appointed Privatdozent für Physik. This paper was published in 1929:

(4) Zeitschrift für Physik, 1929, p.840, 35.

When my three year term as Assistant at the Institute für Theoretische Physik ended I received a Forschungsstipendum for one year and worked on problems of quantum theory. This work did not result in any published paper.

In the meantime jointly with Professor Albert Einstein I thought of a method of pumping liquid metals through tubes through the action of a moving magnetic field on electric currents induced by this field in the liquid metal. The German General Electric Co. (A.E.G.) wanted to develop a pump based on this principle and for about three years -- until 1932 -- I acted as a consultant to them for this development. (This principle found at last its practical application in America after the introduction of atomic reactors in 1942.)

While acting as a consultant to the A.E.G., I collaborated with Dr. Rupp on experiments relating to the polarization of electrons. The results were published in "Die Naturwissenschaften", but they are probably wrong. All photographic films were developed by Rupp, even those which I exposed myself, and the pictures might well have been faked. At the time it did not occur to me to entertain a suspicion of this kind.

In 1932 my interest shifted to nuclear physics and I moved to the Harnack House in Berlin Dahlem with the thought of taking up some experimental work in one of the Kaiser Wilhelm Institutes there. I discussed the possibility of doing experiments in nuclear physics with Miss Lisa Meitner in the Kaiser Wilhelm Institute für Chemie, but before we reached a final conclusion one way or the other, the political situation in Germany became tense and it seemed advisable to delay a final decision.

I was still at the Harnack House at the time of the Reichstagsbrand in March 1933 but soon thereafter went to England. The laws promulgated by the National Socialist Government barred me from holding a University position in Germany by virtue of my "non-Aryan" descent, and I remained in England until 1938.

I began my work in nuclear physics in the summer of 1934 as guest of St. Bartholomew's Hospital in London. There, together with Chalmers, I developed a method (Szilard Chalmers separation) for the concentration of radioactive elements produced by neutrons. This method is used if a radioactive element has to be separated from the bulk of the stable element from which it is produced and with which it is chemically isotopic. This work was published in 1934:

(5) "Chemical Separation of the Radioactive Element from its Bombarded Isotope in the Fermi Effect" -- Szilard and Chalmers. Nature, p.462, 134, 1934.

Together with Chalmers I found that Gamma Rays from radium eject neutrons from beryllium. These photoneutrons of beryllium are of low energy. (In 1939 when I investigated with Zinn whether uranium emits neutrons in the fission process, the use of these slow photo neutrons as a primary neutron source made it possible for us to distinguish the fast neutrons emitted in the fission process from the primary neutrons.) The discovery of the photoneutrons from beryllium was published in 1934:

(6) "Detecting Neutrons Liberated from Beryllium by Gamma Rays," Szilard and Chalmers, Nature, p.494, 134, 1934.

In 1934 it was generally believed that the mass of the beryllium atom was sufficient to permit its spontaneous disintegration into two alpha particles and a neutron. Since such spontaneous disintegration did not occur it seemed important to

investigate the energy threshold for a photo disintegration of beryllium X-rays. This was done jointly with six other authors. The threshold for photo-neutrons from beryllium was determined by varying the voltage of an X-ray tube and was found to be somewhere about 1.5 and well below 2 m.e.v. This information was partially responsible for inducing Bethe to revise the accepted mass of He and thereby to resolve the paradox of the stability of beryllium. Our paper was published in 1934:

(7) "Liberation of Neutrons from Beryllium by X-rays" --jointly with a group of six others. Nature, p.880, 134, 1934.

Working with Chalmers I found that indium, which has only two isotopes, shows three radioactive periods when nombarded by neutrons. This was the first case of isomerism found among the artificial radioactive elements, and we recognized its importance. Subsequently, it was possible for me to show [see (11)] that one period is due to an excited indium nucleus which is isomeric with the stable idium nucleus 115. Our results obtained in 1934 were published in 1935:

(8) "Radioactivity Induced by Neutrons" -- Szilard and Chalmers. Nature, p.96, 135, 1935.

In June 1935 I accepted a research fellowship at the Clarendon Laboratory, Oxford.

Working at the Clarendon Laboratory, I discovered that if a slow neutron beam is filtered by cadmium, in order to remove the thermal neutrons, the residual neutrons show strong resonance absorptions at low energies in various elements. I was able to estimate the energy region at which these resonances occurred and to state that the resonance energy can be determined by observing

the absorption of the neutrons in boron or lithium. This work was published in 1935:

(9) "Absorption of Residual Neutrons".
Nature, p. 136, 1935.

Working at the Clarendon Laboratory jointly with Griffiths, I investigated the Gamma Ray emission that occurs when slow neutrons are absorbed by odd elements. This work was published in 1937:

(10) "Gamma Rays Excited by Capture of Neutrons".
Griffiths and Szilard, Nature, p.323, 139, 1937.

In January 1938 I went to the U. S. on a visiting basis under a new arrangement with the Clarendon Laboratory. While I was there, I received an offer of a lectureship in nuclear physics at Oxford University. In September 1938 I declined this offer, resigned from Clarendon Laboratory, and shifted my residence to New York.

In 1938, using the Rochester cyclotron, I found that one of the radioactive periods of indium which Chalmers and I had previously discovered was due to the nuclear excitation of the stable isotope 115. This conclusion reached jointly with Goldhaber and Hill, we published in 1939:

(11) "Radioactivity Induced by Nuclear Excitation" --
Szilard, Goldhaber and Hill, Physical Revue, p.47, 55, 193.

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