Mitogenetic Rays

2

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2.1 Introduction: On the History of Mitogenesis

Ultraweak photon emission (UPE) from biological systems was predicted (Gurwitsch 1911, 1922) and first observed (Gurwitsch 1923) by a distinguished Russian biologist Alexander Gurwitsch. The main particularity of his work, which was both succsessful and posed serious problems, was that the UPE was detected with biological, but not physical, detectors. The "biological detector" (plant meristem, microbial or tissue culture) demonstrated higher rate of cell proliferation when put in optical contact with a UPE source, called "inductor." This phenomenon was termed "mitogenetic effect" (MGE) and was soon attributed to ultraviolet UPE due to its ability to propagate only straightly in uniform media, disappear if the two interacting objects were separated with any material opaque in the UV (including glass), and preserve when they were separated with quartz, while being chemically isolated (Gurwitsch 1924a; Reiter and Gabor 1928b) (see below). Thus, the term "mitogenetic radiation" (MGR) was suggested (Gurwitsch 1924a), which was actively used for more than 30 years, and was later considered inexact by the author (Gurwitsch and Gurwitsch 1999), because of its connection with phenomena not related to mitogenesis:

1. Besides tissues and cultures with high mitosis rate, MGR was observed for excited muscles and nerves (Siebert 1928a; Anikin 1926); stressed, dying, or resorbed tissues (Blacher and Bromley 1931; Gurwitsch and Gurwitsch 1948, 1959); and some chemical reactions (Wolff and Ras 1932; Potozky 1932; Braun 1934). The authors concluded that "the ability to emit ultraweak ultraviolet rays is an extremely common property of most chemical processes, regardless of whether it is a simple oxidation of inorganic substances in a test tube, or splitting of complex protein bodies in a living organism" (Rodionov and Frank 1934).
2. Besides stimulation of mitoses, MGR could cause quite different effects in the recipient object: mitotic suppression (Acs 1933), decrease of nerve conduction (Gurwitsch 1937), increase of permeability of plant cell walls (Potozky 1936), appearance of malformations in embryo development (Magrou 1932), etc.

The biological way of "detecting" UPE, initially suggested due to the very role the UPE was presumed to play in the living organisms, appeared extremely problematic for the whole field and doubtful in the eyes of many researchers. Its main disadvantages were obvious subjectiveness and laborious methods of observation, vulnerable to subtle deviations from the procedure. At the same time, as physiology and molecular biology were actually in their infancy, the procedure itself was usually described rather vaguely (e.g., "20-hour-old yeast culture on wort agar" without any information on its physiological state or medium content), and experimental details and results were frequently alternating with explanations and reflections on the topic. It was probably due to this uncertainty that many authors experienced periods of unexplained irreproducibility of their results, which later gave way to periods of sustained success.

The materials and methods of some "early works" were partially cleared up in Rahn (1936) and Gurwitsch (1968) and, nowadays, analyzed in Volodyaev and Beloussov (2015) and Volodyaev et al. (2021) (see also Part V).

Having once tried to reproduce MGE and failed (Volodyaev et al. 2013) and determined to put an end to this topic for ourselves, one of us (IV), together with the late Lev Beloussov, plunged into thorough reading of the "old literature" on MGE. Unexpectedly, we found so many

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important methodical details that we had missed, that our main conclusion happened to be the following: "if the mitogenetic effect existed, under our experimental conditions, it was sure not to manifest." That is, we had done everything *not* to confirm the effect, only because we had not paid enough attention to methodical details of the early works.

Though detailed methodical recommendations had been given in Gurwitsch (1929) and Reiter and Gabor (1928b), most of the "negative works" we managed to get and study (Hollaender and Claus 1937; Taylor and Harvey 1931; Kreuchen and Bateman 1934; Richards and Taylor 1932; Quickenden and Tilbury 1985; Quickenden et al. 1989) also contained critical deviations from these methods, that would have guaranteed their failure in MGE verification. Our experience in this area, together with both positive and negative works, analyzed from methodical viewpoint is given in Chap. 20, and also in Volodyaev and Beloussov (2015).

At the same time, the biological method of "UPE detection" appeared extremely sensitive, as it let the authors discover UPE as weak as 10–1000 photons/s^{-1} cm^{-2}, 15 years before the first stable success in its physical detection (Barth 1936; Barth 1937; Grebe et al. 1937; Audubert 1938), and 30–40 years before what is presently considered its proof (Colli and Facchini 1954; Vladimirov and Litvin 1959; Tarusov et al. 1961).

Notwithstanding lack of general recognition of MGE, and complete mistrust of some researchers, one has to admit that the basic data on MGE were actually never refuted in later works and seemingly do not contradict them. Moreover, many results and conclusions of early works were proven later or appeared to have curious parallels in what is known now: the phenomenon of UPE from biological systems (see Part IV), free-radical processes as its source (see Part III), the existence of peptide tumour markers in blood (see Chap. 23), etc. These facts command respect to early experiments and attract interest to their broader revisiting and thorough investigation at the up-to-date level. With this in mind, we now aim to go through a brief, yet evidence-based summary of the history of MGE research, and come to some general discussion closer to the end of the book (Chaps. 20, 21, 22, and 23).

2.2 A Brief History of the Mitogenetic Research

Here, we briefly describe the history of mitogenetic radiation, in a concise form, with illustrations from the now almost inaccessible original works.

2.2.1 1910s–1923 – Before the Beginning

2.2.1.1 A.G. Gurwitsch's Reflections on the Factors Inducing Mitosis and Organizing Its Temporal Orderliness in Tissues. His Concept of Two Mitotic Factors: "Factor of Cell Readiness" and "Initiation Factor"

In Russia, the 10s–20s of the twentieth century are associated with global historical upheavals: participation in the First World War, two revolutions, and the Civil War. A famous histologist and morphologist, a world-famous scientist, A.G. Gurwitsch received invitations from leading world universities, including personal offers from Wilhelm Ru to replace him in his position. Yet, he remained in Russia.

In 1918, he left the ruined Petrograd to the newly founded Taurida University in Simferopol, where he was to spend very fruitful years, among the great scientists V.I. Vernadsky, V.A. Obruchev, S.I. Metalnikov, and V.I. Palladin and his outstanding pupils A.A. Lyubishchev, G.M. Frank, and others.

Here, during extensive histological observations, A.G. Gurwitsch discovered the following pattern. While neighboring cells in a tissue or embryo can divide independently (Fig. 2.1a), several nuclei surrounded by a single membrane – in multinucleated cells (Fig. 2.1a, b) or syncytia (Fig. 2.1c, d) – always divide synchronously (Gurwitsch 1926).

This observation led the author to formulate his "two-factor theory of mitosis." According to this, in order to start mitosis, the cell requires two independent factors:

1. The endogenous "readiness factor" – meaning all the processes of synthesis <and replication> that must be completed in advance (Gurwitsch 1926)
2. The exogenous "initiation factor" – an external impulse that must somehow affect the cell membrane and trigger the (already prepared) mitosis in all the nuclei surrounded by it (Gurwitsch 1926)

The "readiness factor" was obvious even at that time (long before the DNA discovery), while the search for the hypothetical "initiation factor" prompted A.G. Gurwitsch to the following experiments.

2.2.1.2 Experiments Indirectly Confirming the Existence of the "Initiation Factor" and the Two-Factor Theory of Mitosis. Rationale That the "Initiation Factor" Should Be Radiation

A.G. Gurwitsch obtained the first indirect evidence for the existence and possible nature of the initiation factor in experiments with onion roots (*Allium cepa*). If an onion

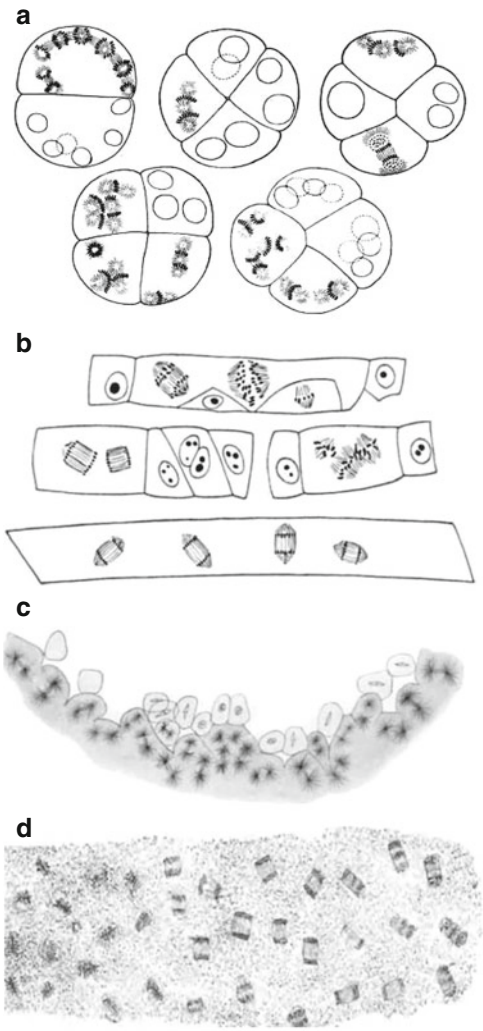

Fig. 2.1 Observations that led A.G. Gurwitsch to the "two-factor theory of mitosis": (**a**) Synchronous mitoses of nuclei in one blastomere; asynchronous mitoses in different blastomeres (*Sea urchin* embryos). (**b**) Synchronous mitoses in multinucleated cells (*Ricinus* root). (**c**, **d**) Synchronous mitoses in syncytia (**c** – *Belone acus* periblast, **d** – *Fritillaria imperialis* embryo sac). (Adapted from Gurwitsch (1926). Copyright 1926, with permission from Springer Nature)

root was separated from the bulb, or the bulb was narcotized or killed with local boiling, the mitoses in the onion root meristem were suppressed. Yet, even a small viable piece of the sole remaining on the root base, was enough to maintain mitoses in the root meristem (Gurwitsch 1926). Thus, cell division in the onion root meristem required a certain external impulse, apparently coming from the bottom of the bulb.

On the physical nature of the "initiation factor," Gurwitsch considered two possible alternatives:

1. A chemical ligand, sensed by membrane receptors
2. A kind of radiation, sensed by a "mosaic" of membrane-associated receivers by means of resonant absorption (the question how such a radiation could spread in the tissue was addressed later – see below)

In a series of histological observations on longitudinal sections of onion roots, the author showed that the probability of detecting a meristem cell in the state of mitosis decreases linearly with its length and exponentially increases with its distance from the bottom of the bulb (Gurwitsch 1923). Interpreting this pattern, through a complex chain of reasoning (Gurwitsch 1926), he concluded that the initiation factor should be resonantly acting on something spatially distributed in the membrane and suggested it to be a kind of radiation.

2.2.1.3 The First Experimental Evidence in Favour of the Radiant Nature of the Initiation Factor

The first attempts to test the hypothesis that the initiation factor is radiant, were carried out on frog cornea (apparently *Rana temporaria*). It was known that a wound applied to the corneal epithelium stimulates mitosis in the surrounding tissue. Varying the size and type of wound, Gurwitsch obtained the following results (Gurwitsch 1923):

- A burn wound, applied to the cornea led to suppression of mitoses in the nearest cells (quite soon) and stimulation of mitoses 3–4 days later.
- Too strong wounds gave only suppression.
- Accurate linear cuts had no effects on the cornea, but they "screened" a part of it from the mitosis-stimulating influence of the burn wound (Fig. 2.2), "as if the initiation factor were linearly spreading through the tissue."

The author's conclusions from the results were as follows (Gurwitsch 1926):

1. The existence of the initiation factor is indirectly confirmed; its (additional) source in the tissue is the wound surface;
2. The initiation factor propagates linearly in the medium, i.e., apparently, is radiation (the critical question how such a radiation could spread in the tissue was addressed much later – see below).

Thus, the "two-factor theory of mitoses" was preliminary considered right, and the initiation factor was supposed to be some kind of radiation. This brought the author to his famous "Grundversuch" – "onion experiment."

2.2.2 1923–1928 – Discovery and First Surge of Interest in MGE and MGR

2.2.2.1 The First Observation of Mitogenetic Effect on Onion Roots and the Surge of Interest in the Newly Found Phenomenon

After obtaining preliminary data, indirectly supporting the existence and radiant nature of the initiation factor, Gurwitsch turned to direct experimental verification of this hypothesis. For this, he needed to create conditions under which the hypothetical induction factor would be partially irradiated beyond the biological system and could affect another one, in which (if it was competent) the frequency of mitoses should increase (Gurwitsch 1923).

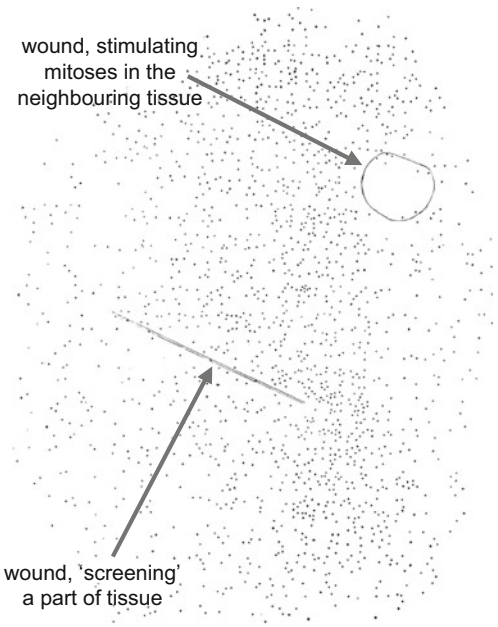

Fig. 2.2 Spatial distribution of mitoses (dots) in *frog* cornea (*Rana temporaria*) after applying a round burn wound ("stimulating mitoses in the surrounding tissue") and a "linear, most accurate" wound ("screening a part of tissue from the influence of the round wound"). (Adapted from Gurwitsch (1923). Copyright 1923, with permission from Springer Nature)

The onion root was chosen as the first ("inductor") object, because in it (see above) the radiation was supposedly propagated from the bottom of the bulb to the tip and, therefore, could be partially radiated into the space. The onion root was also chosen as the second ("recipient") object, because, in the absence of obvious defects, the "perfectly straight root" is radially symmetric and, according to the author, the difference in the number of mitoses between any two halves of any transverse cut does not exceed 3%.

The experimental design and photograph of the setup are shown in Fig. 2.3 (the roots mutual position was precisely controlled with adjusting microscrews and a horizontal microscope).

The cross-sectional diagram of the control and induced onion roots in the induction region is shown in Fig. 2.4. The difference in the number of mitoses between the two halves of the root is shown in Fig. 2.5 (a – induced root, b – control, noninduced root). One can see considerably more mitoses in the induced half of the recipient root, and no difference in the control.

Thus, the presence of an inductor root near the division zone of the recipient root led to a stable effect: stimulation of mitoses in the induced half of the recipient. This phenomenon proved the existence of the initiation factor and was called the "mitogenetic effect" (MGE).

Soon, the MGE was confirmed by other authors (for a review, see (Reiter and Gabor 1928b)), not only on onion roots but also on other objects. However, its physical nature still required verification.

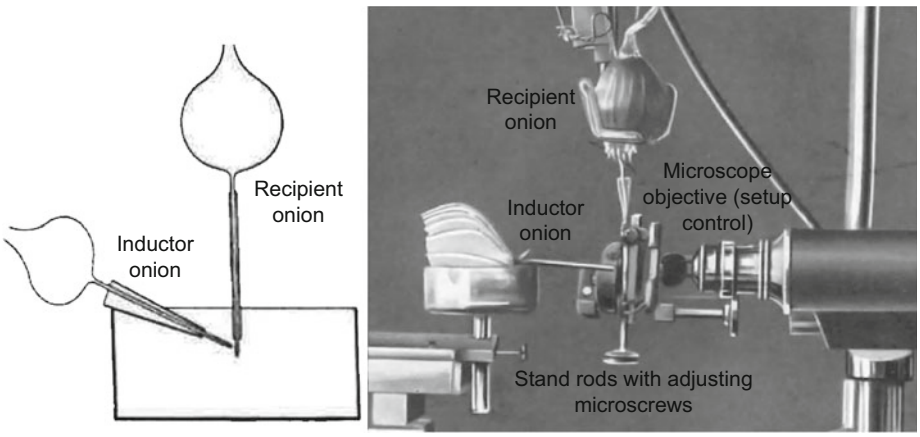

Fig. 2.3 "Onion experiment" for detecting the supposed initiation factor. (**a**) Scheme of experimental setup. (Adapted from Gurwitsch (1926). Copyright 1926, with permission from Springer Nature). (**b**) Photo of experimental setup. (Adapted from Gurwitsch (1923). Copyright 1923, with permission from Springer Nature)

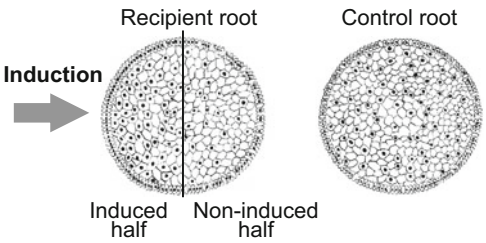

Fig. 2.4 Results of the "Onion experiment" for detecting the supposed initiation factor. A scheme of the cross-section of intact (control) and induced (recipient) onion roots after the experiment; mitoses marked. The number of mitoses at the "induced" half is definitely higher than at the "noninduced" half. (Adapted from Reiter and Gabor (1928a) and Gurwitsch and Gurwitsch (1932). Copyright 1932, with permission from Springer Nature)

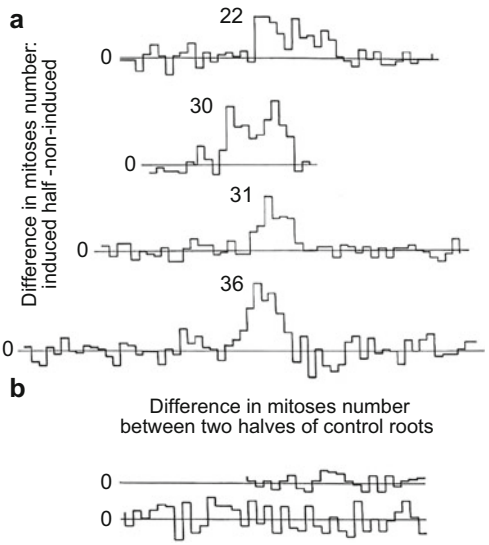

Fig. 2.5 Results of the "Onion experiment" for detecting the supposed initiation factor. Difference between the number of mitoses in two halves of the roots: (**a**) Recipient root: "induced" half–"noninduced" half (as the original figures contain no division values along axes, the numbers at plots were taken from the accompanying raw data tables). (**b**) Control (noninduced) onion root: random fluctuations around 0. (Adapted from Gurwitsch (1923). Copyright 1923, with permission from Springer Nature)

2.2.2.2 Evidence That MGE-Producing Factor Is Ultraweak Photon Emission in the UV Range; Appearance of the Term "Mitogenetic Radiation" (MGR)

In subsequent experiments, the authors turned to study the nature of the factor causing MGE (Gurwitsch 1924a; Reiter and Gabor 1928b; Frank 1929).

The MGE was preserved, when the inductor and the recipient were separated with quartz plates (Fig. 2.6), even when they were completely chemically isolated (Figs. 2.7 and 2.8). Separation of the inductor and the recipient with UV-opaque materials having various transparency windows

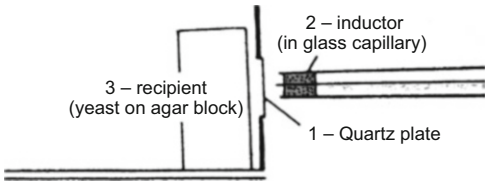

Fig. 2.6 Physical properties of mitogenetic effect: evidence that it is produced by UPE in the UV range. The inductor and the recipient are separated with quartz. (Adapted from Gurwitsch (1929). Copyright 1929, with permission from Elsevier)

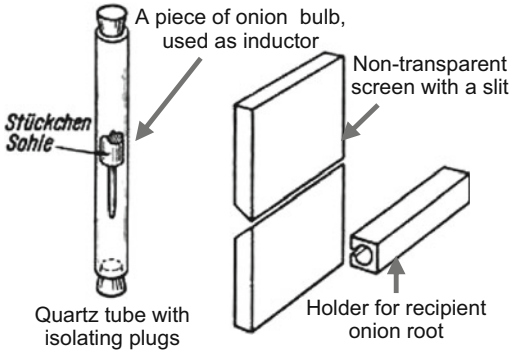

Fig. 2.7 Physical properties of mitogenetic effect: evidence that it is produced by UPE. The inductor is placed inside a quartz tube with isolating plugs. (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

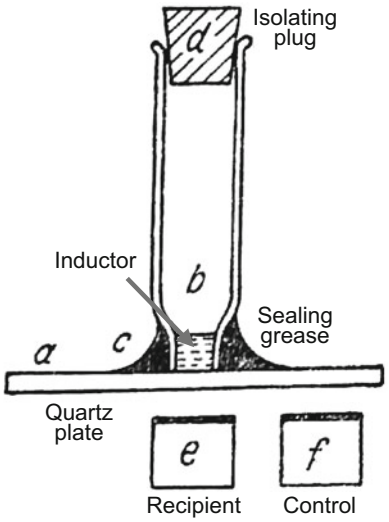

Fig. 2.8 Physical properties of mitogenetic effect: evidence that it is produced by UPE. The inductor is placed inside an isolated bottle with quartz bottom; the recipient is placed under the quartz bottom of the inductor; the control is placed next to the recipient. (Adapted from Blacher and Bromley (1931). Copyright 1931, with permission from Springer Nature)

(glass, wood, gelatin etc.) led to complete disappearance of MGE. Straightforward propagation (Fig. 2.7), reflection in UV mirrors (mercury and others) (Figs. 2.9 and 2.10) and

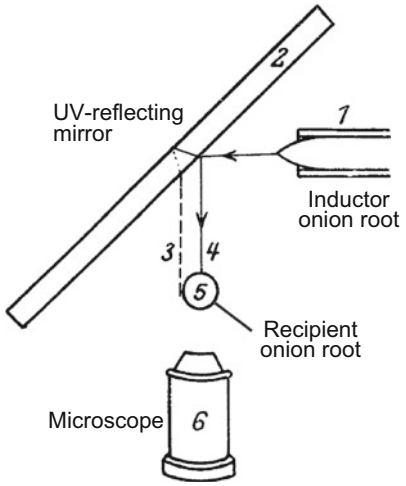

Fig. 2.9 Physical properties of mitogenetic radiation: reflection in mirrors. Experimental setup from Gurwitsch (1926). (Adapted from Gurwitsch (1926). Copyright 1926, with permission from Springer Nature)

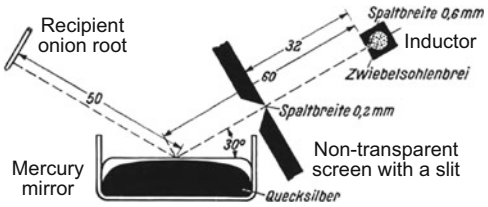

Fig. 2.10 Physical properties of mitogenetic radiation: reflection in mirrors. (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

UV-like refraction in quartz prisms (Fig. 2.11) also corroborated the conclusion that the acting factor should be electromagnetic radiation belonging to the UV range (Gurwitsch 1926, 1929; Reiter and Gabor 1928b). Later, it was also confirmed by observation of MGE produced by weak UV radiation from artificial sources (see below and Chap. 20) and spectral analysis of MGE-inducing radiation from both biological and physical sources (see below and Chap. 21). A.G. Gurwitsch called this radiation mitogenetic (MGR).

2.2.2.3 Search for and Discovery of Other Inductors, Recipients, and Noninductors of MGE

As the existence of the initiation factor was supposed universal (Gurwitsch 1926), experiments on obtaining MGE began to be carried out at different objects and in different combinations. Below is a short list of recipients, inductors, and noninductors – those objects that didn't cause any MGE in the recipient (for more details on the conditions for obtaining the effect and requirements for objects, see Chap. 20).

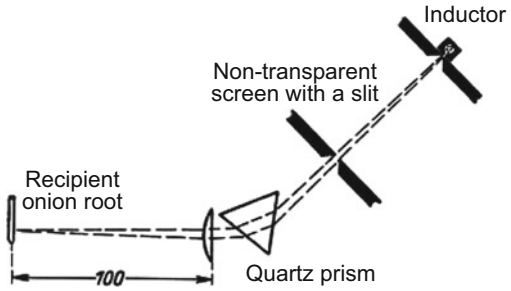

Fig. 2.11 Physical properties of mitogenetic radiation: refraction in quartz prisms. (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

- **Recipients** – yeast (Siebert 1930; Baron 1926), bacterial cultures (Wolff and Ras 1931b; Sewertzowa 1928), corneal epithelium of frogs, tritons, rats (Gurwitsch and Anikin 1928)
- **Inductors** – yeast (Baron 1926), bacteria (Sewertzowa 1928; Acs 1931), eggs and embryos of different species (Magrou et al. 1929; Gurwitsch 1924d), blood (Sorin 1926; Potozky and Zoglina 1929), malignant tumours (Siebert 1928b; Gurwitsch and Gurwitsch 1928; Reiter and Gabor 1928b)
- **Noninductors** – blood of cancer patients (Gurwitsch and Salkind 1929; Siebert 1930; Gesenius 1930), internal organs of adult animals (Gurwitsch and Gurwitsch 1932), nongrowing or slowly growing cultures (Gurwitsch and Gurwitsch 1932)

Also, a number of works have shown MGE at interaction of organisms of different taxa (Siebert 1928a; Gurwitsch and Gurwitsch 1924), as well as "nonmitogenetic effects" of MGE: influence of growing bacterial cultures on embryo growth, teratosis, etc. (Magrou 1932; Wolff and Ras 1934).

Therefore, MGE appeared not species-specific and not associated with any highly-specific signals, "dictating to a cell or tissue what to do." On the contrary, it turned out more like a "nonspecific primitive yes/no signal, triggering the recipient to start the process, determined by the other context."

2.2.2.4 Spread of Work on MGE and MGR

Initially after MGE discovery, its study was conducted only by a narrow circle of A.G. Gurwitsch's close associates in Taurida University – his wife L.D. Gurwitsch (1924b, c) and daughter N.A. Gurwitsch (1924d), G.M. Frank (1925), S.J. Salkind (1925) and a few others. Their leaving for Moscow with appointment of A.G. Gurwitsch to the post of the Histology Department head, Moscow University (1924), gave rise to development of this small group into an advanced scientific school on mitogenesis.

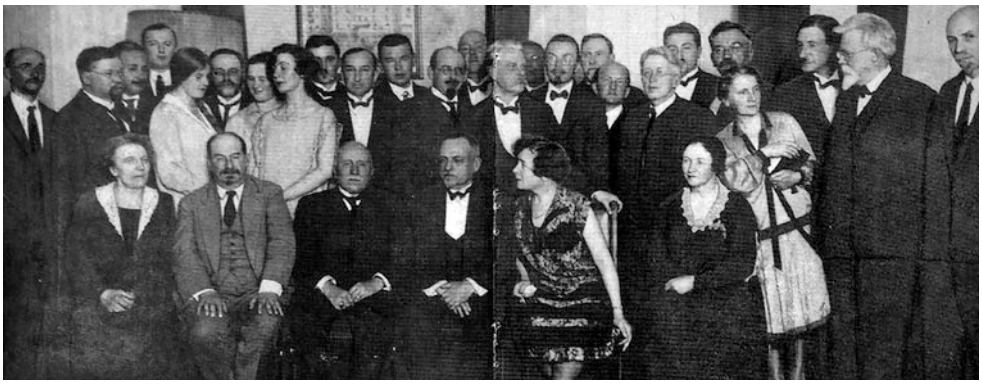

Fig. 2.12 "Days of Soviet Science" in Berlin (1927). Sitting: 1st – C. Vogt, 2nd – A.V. Lunacharsky, 3rd – F.G. Schmidt-Ott, 4th – N.A. Semashko, 5th – M.P. Koltsova, 6th – wife of A.A. Borisyak. Standing: 1st – A.G. Gurwitsch, 2nd – P. P. Lazarev, 3rd – A. Einstein, 6th –A.F. Samoilov, 10th – A.I. Abrikosov, 12th – Ambassador of USSR in Germany N.N. Krestinsky, 13th – A.Ye. Fersman, 14th–N.K. Koltsov, 16th – A.V. Palladin, 17th – V.N. Ipatyev, 19th – A.A. Borisyak, 20th – L.Ya. Brusilovsky, 21st – A.Ye. Chichibabin, 23rd – P.M. Nikiforov, 24th – V.I. Vernadsky, 25th – I.I. Schmalgausen. (From the personal archive of A.G. Gurwitsch, with the permission of his heirs)

Later, this problem attracted interest of various scholars around the world. A brilliant talk of A.G. Gurwitsch at the "Days of Soviet Science" in Berlin (1927), participated by A. Einstein, V.I. Vernadsky, and other outstanding people (see Fig. 2.12), stimulated further dissemination of knowledge about MGR and research spreading. At this time, several teams started their works on MGR, including the groups of J. Magrou (The Pasteur Institute, Paris), W.W. Siebert (The Medical Clinic of Berlin University, now Charité), A.F. Ioffe (State Physical-Technical Radiology Institute, now Ioffe Physical-Technical Institute, St. Petersburg), D. Gabor (Siemens&Halske AG, now Siemens AG, Berlin). Research by the physicist D. Gabor (later Nobel laureate) and the physician T. Reiter, and their monograph on MGE (Reiter and Gabor 1928b) had a strong impact on the field.

Also the first critical papers by H. Guttenberg (1928a, b) and his pupil B. Rossmann (Rossmann 1928) from Botanical Institute of Rostock University were published (their arguments and counter-critique see in Chap. 20).

Altogether, during the period of 1923–1928, the scope of works on MGE comprised verification of MGE;, proofs of ultraviolet radiation as its mediator; wide diversification of the known biological inductors, noninductors, and recipients; and development of experimental methods.

2.2.3 1928–1938 – "The Golden Age of MGR"

2.2.3.1 Advancement of MGR Research

The next decade witnessed a burst of activity and significant progress in MGR research. "Nothing among biological works from your country attracts so much attention of scientific world as your works" – wrote A. Bethe, Director of the Institute of Physiology, Frankfurt am Main University, in his letter to A.G. Gurwitsch in 1930 (Gavrish 2003). From 1929 to 1938, Gurwitsch was 11 times nominated for the Nobel Prize for his works on MGE and once failed to get just two votes to the prize (Nobel Prize Nomination Database).

The heated international discussion of that period was accompanied by multiple verifications of all key experiments in authoritative laboratories. MGR study was a fundamentally interdisciplinary field and attracted well-known experts in biology, physics, chemistry, physiology, and medicine. For instance, a phamous physicist S.I. Vavilov summed up the results of an outstanding chemist R. Audubert as the final proof of A.G. Gurwitsch's findings (Gurwitsch and Gurwitsch 1948) (see Chap. 21).

The development of interest to MGE and MGR led to series of works by various authors in the USSR, the United States, Germany, France, the Netherlands, Italy, and other countries. The most extensive research was conducted in the USSR (Moscow, Leningrad) and in Germany (Berlin, Frankfurt am Main); significant contribution was made by the groups of the microbiologist L.K. Wolff (Utrecht University, Netherlands) and the bacteriologist O. Rahn (Cornell University, USA). The total number of publications on these topics was more than 1000 (e.g., the dissertation of Moissejewa on MGR (Moissejewa 1960) contains more than 1000 references), including several dozen books and more than 50 publications in "top journals" (e.g., at least a dozen in Nature (Braun 1934; Copisarow 1932; Gurwitsch 1933; Gurwitsch and Gurwitsch 1939; Gurwitsch et al. 1965; Heinemann 1934; Prokofiewa 1934; Wolff and Ras 1934; Hill 1933; Bateman 1934; Gates 1929; Anonim 1937).

At the same time, although many of these publications confirmed the results of Gurwitsch (Reiter and Gabor 1928a; Tuthill and Rahn 1933; Ferguson and Rahn 1933; Wolff and Ras 1931b; Loos 1930), some other authors didn't succeed in

obtaining MGE and published negative works (Taylor and Harvey 1931; Moissejewa 1931a, b; Rossmann 1928). According to the assessment (Maxia 1940), "...Several hundreds of confirming results coming from different countries... <were> opposed by barely a couple of dozen reports of negative results" (cited from Gurwitsch and Gurwitsch (1999)).

There was also a number of false-positive papers inevitable for such a surge of interest. The most detailed critical analysis of publications on MGE was presented in a series of papers by A. Hollaender (Hollaender and Schoeffel 1931; Hollaender and Claus 1935, 1937; Hollaender 1936, 1939; Hollaender and Duggar 1938). It is worth mentioning that being the most consistent critic of false-positive papers on MGE, he clearly stated that "we cannot believe that the phenomenon should be relegated to the limbo of an ignominious past, merely on the ground that some of the evidence presented by possibly overenthusiastic supporters is inconsistent" (Hollaender and Claus 1935). Moreover, he didn't claim MGE generally false even after his own failure to observe this effect (Hollaender and Claus 1937) (though later this work appeared the most crucial for the whole area). A. Gurwitsch also was indignant at plenty of emerged negative and positive publications with fundamental methodical errors (Gurwitsch and Gurwitsch 1999).

Among the critical papers of this period, the analytical reviews (Hollaender 1936; Bateman 1935) can be recommended as the most thorough ones.

A detailed analysis of critical works is given later in Chaps. 20 and 21. Here, we give only a summary assessment of the reliability of the results on onion roots, conducted in Schwemmle (1929) (Fig. 2.13). In all experiments analyzed by the author, the difference in the number of mitoses between two halves of control roots fell into the area of the calculated error, while the difference in the number of mitoses between the induced and noninduced sides of the recipient root exceeded the limits of this region. The author concluded that results of MGE experiments on onion roots are reliable (Schwemmle 1929).

Besides verification of onion experiments, there was intensive further development of yeast (Tuthill and Rahn 1933; Baron 1930; Gurwitsch and Gurwitsch 1934) and bacterial (Ferguson and Rahn 1933; Wolff and Ras 1933b; Sewertzowa 1928, 1931) "MGR detection technique," more universal and less laborious and subjective than that based on onion roots. Thus, in the early 1930s, onion recipients in MGE research were almost completely superseded by yeast in the USSR and by bacterial ones in Europe and the United States. Their extensive use made it possible to elaborate and describe complicated experimental conditions for observing MGR (see methods in (Rahn 1936; Gurwitsch and Gurwitsch 1934; Gurwitsch 1945, 1968), and their present-day reanalysis in Chap. 20 and (Volodyaev and Beloussov 2015; Volodyaev et al. 2021)). All this potentiated broadening of research activities and wide application of MGE for studying biochemical and physiological processes (see Chaps. 22 and 23, and (Gurwitsch and Gurwitsch 1934, 1959)).

In 1928–1938, the topics of MGE and MGR research were greatly diversified:

- Development of spectral analysis and its application to study nerve and muscle activity
- Physical detection of MGR
- Discovery of UV-chemiluminescent reactions
- Attempts to apply MGR to medical diagnostics; analysis of physiological states and biochemical processes in vivo

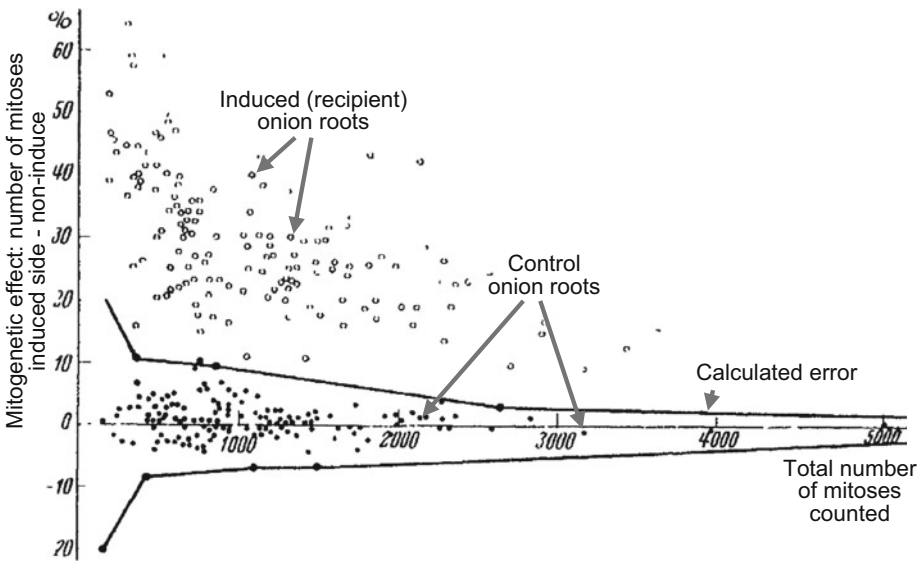

Fig. 2.13 The results of all publications of the Gurwitsch school devoted to MGE on onion roots by 1929. The filled circles are control roots; the hollow circles are recipients in MGE experiments. Each point is the result of one experiment. All control experiments fall within the area of the calculated error; all induced roots fall outside this area. Thus, in all the experiments analyzed, the result is reliable. (Adapted from Rahn (1936). Copyright 1936, with permission from Springer Nature)

- Study of MGR at stress conditions ("degradation MGR") and its difference from physiological MGR
- Discovery of "secondary MGR," emitted by some systems after exposure to MGR from other sources (see more in Chap. 22)

Theoretical efforts to comprehend extensive experimental data led to the concepts of free-radical mechanisms of MGR generation and "nonequilibrium molecular constellations" (i.e., delocalized electron-excited states) in biological systems (details and references see below).

The main focus of research works visibly shifted from biology to physics, chemistry and medicine. Several authoritative medical teams joined the field, for instance, the group headed by R. Seyderhelm, Director of Hospital of the Holy Spirit (Frankfurt am Main, Germany) (Heinemann 1932, 1934, 1935; Seyderhelm 1932; Seyderhelm et al. 1932; Heinemann and Seyderhelm 1933, 1934). Blood as the most commonly used object of medical tests and easily available active inductor of MGE had already got the top priority among biological inductors, MGR of blood in various physiological and pathological states was studied in-depth (Siebert 1930; Gurwitsch and Salkind 1929; Yefimov and Letunov 1934; Golshmid 1934; Gurwitsch and Gurwitsch 1934) and led to the discovery of the first tumour marker (Gurwitsch and Gurwitsch 1937; Siebert and Seffert 1937). Also wide-scale experiments were devoted to application of MGR spectral analysis to nerve and muscle activity research.

In this period, the trend of proceeding from study of MGE per se to its application as an analytical and diagnostic method began to show, and strengthened later on. As A. Gurwitsch stated "We suggest that... the use of the mitogenetic method will prevail and will gradually push into the background ...the question of mitogenesis itself" (Gurwitsch and Gurwitsch 1999).

2.2.3.2 Further Development of the MGR Spectral Analysis

After rough estimations of MGR spectral range, its spectral composition was further studied with spectrographs, in which the photographic plates were replaced with series of biological detectors – which were onion roots in the first experiments (Reiter and Gabor 1928a), and usually yeast cultures later (Frank 1929) (see scheme of experimental setup in Fig. 2.14 and examples of spectra in Figs. 2.15 and 2.16).

Thus, according to the data of both groups, the MGR spectra belonged to UV. The differences in specific spectral regions with mitogenetic activity between (Reiter and Gabor 1928b) and (Frank 1929) (compare the spectra in Figs. 2.15 and 2.16) are apparently due to different recipients (onion roots in Reiter and Gabor (1928b) and agar yeast cultures in Frank (1929)), and other methodological details (see more in Chaps. 20 and 21). Yet, the general conclusion was similar: the MGE was stimulated by ultraweak UV light emitted from the inductor.

Later, with improvement of spectral resolution, the authors were able to obtain MGR spectra of a wide range of chemical systems and biological inductors and construct a database of their "spectral fingerprints" (Ponomarewa 1931; Kannegiesser 1931; Decker 1936; Billig et al. 1932; Braun 1934) – see Fig. 2.17. Analyzing these data, Gurwitsch, following (Frankenburger, 1933) made another assumption, which was more than 30 years ahead of the emergence of modern concept. They suggested that different bands in the MGR spectra correspond to different excited states generated in the system, mostly by recombining free radicals. It is these excited states that determine the wavelength of photon emission, rather than any special qualities of the ongoing processes (Gurwitsch and Gurwitsch 1934, 1959) (see more in Chap. 21).

The mitogenetic spectral analysis opened up the possibility of noninvasive study of biochemical processes in living organisms, which was widely used for system analysis (Gurwitsch and Gurwitsch 1934, 1959; Gurwitsch 1968) and medical diagnostics (Gurwitsch and Gurwitsch 1938; Gurwitsch et al. 1947). As A. Gurwitsch wrote, "contrary to any biochemical methods, the analysis is made not after, but during the functioning" (Gurwitsch and Gurwitsch 1934).

2.2.3.3 The Negative Side: Drawbacks of Biological Detection of MGR

Yet, not everything was so smooth. As it was already mentioned in introduction, biological detection of MGR had a number of serious disadvantages, that caused a lot of

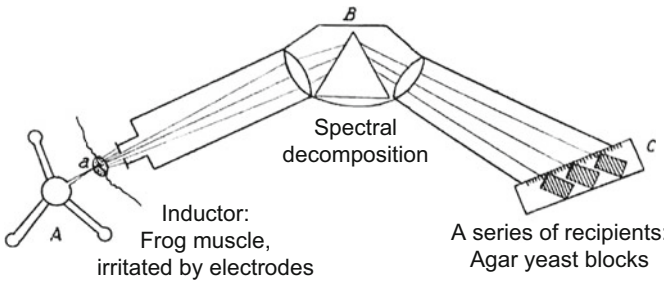

Fig. 2.14 "Mitogenetic spectral analysis." Scheme of experimental setup. (Adapted from Frank (1929) and Gurwitsch and Gurwitsch (1932). Copyright 1932, with permission from Springer Nature)

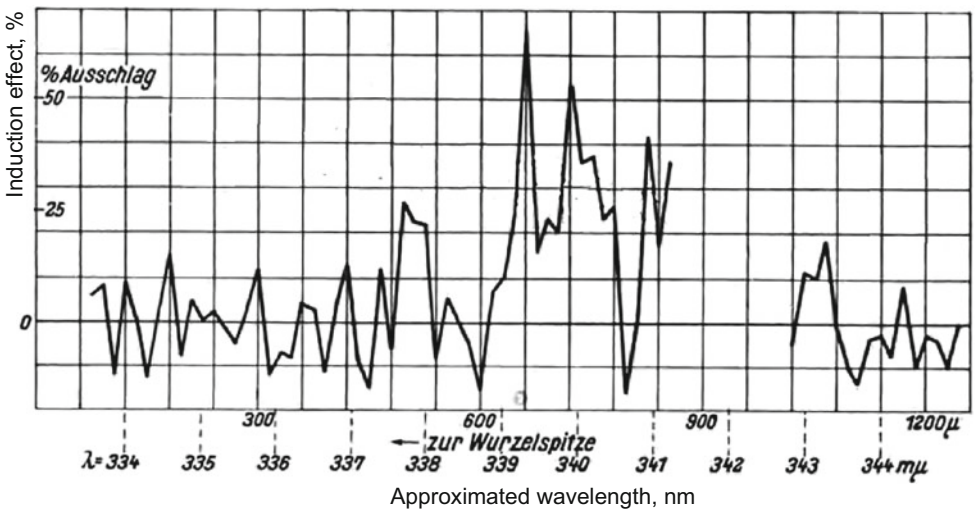

Fig. 2.15 MGR spectrum from rat sarcoma, obtained using onion roots as biological detectors. (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

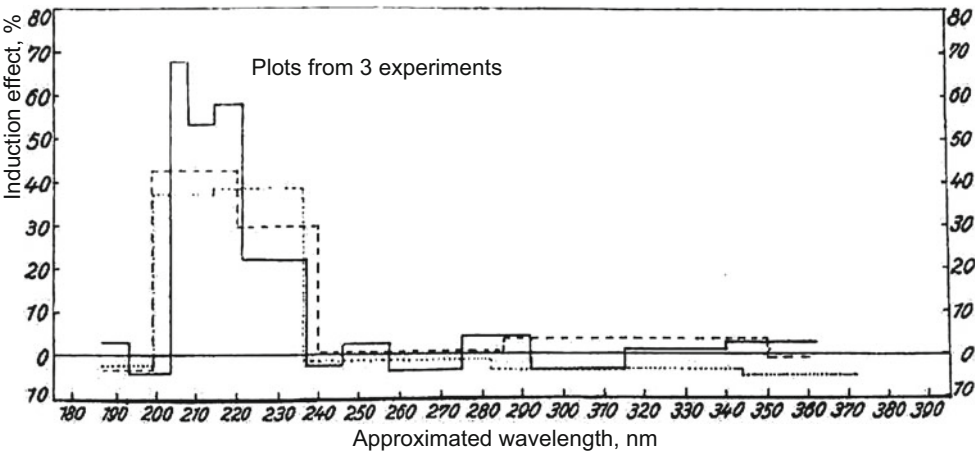

Fig. 2.16 MGR spectrum from frog muscle in tetanus state, obtained using agar yeast cultures as biological detectors. (Adapted from Frank (1929) and Gurwitsch and Gurwitsch (1932). Copyright 1932, with permission from Springer Nature)

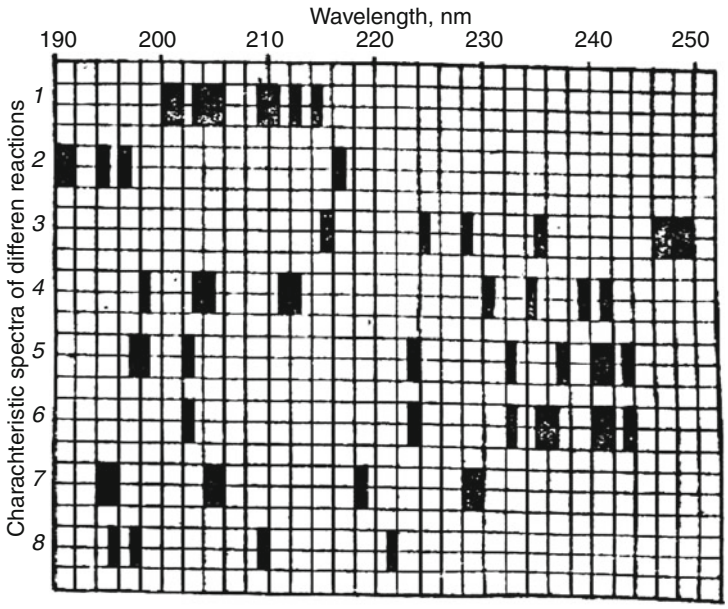

Fig. 2.17 Mitogenetic spectra of several characteristic biochemical inductors: 1 – creatine phosphate breakdown; 2 – glycolysis; 3 – phosphatase exposure on nucleic acids and lecithin; 4 – fluorescence of peptide bond; 5 – enzymatic breakdown of maltose; 6 – enzymatic breakdown of sucrose; 7 – breakdown of urea; 8 – lipolysis. (Reprinted from Gurwitsch and Gurwitsch (1959). Copyright 1959, with permission from Springer Nature)

criticism and led to some distrust to the phenomenon. Much later, this skeptical attitude resulted in significant oblivion of the fundamental works and perception of the whole area as pseudoscience.

Here are the main drawbacks of biological detection of MGR:

2.2.3.3.1 Subjectiveness

As the very effect was "detected" by people, visually comparing the "MGR-stimulated" organism (culture) to the "non-irradiated" control, a lot of criticism was (rightly) focused on possible mistakes and even (unconscious) falsification that could be made by researchers (Hollaender and Claus 1935; Bateman 1935). Yet, a number of MGR works were performed at quite high quality standards, with appropriate controls, blind detection and good statistical analysis (Tuthill and Rahn 1933; Ferguson and Rahn 1933; Wolff and Ras 1931a, 1933a; Chariton et al. 1930; Schwemmle 1929).

2.2.3.3.2 Slurred Experimental Conditions and Too Much Speculation Mixed with Real Data

In the 1920s–1930s, the experimental conditions were usually described rather vaguely, e.g., "20-hour-old yeast culture on wort agar at room temperature" without any information on its physiological state or medium content. As O. Rahn wrote, "Unfortunately, it was not stated that 12 °C is considered a normal room temperature in Moscow and Leningrad, and investigators following such directions literally, and at American room temperatures, would doubtless have obtained an entirely different physiological stage" (Rahn 1934a).

The experimental details and results were frequently alternating with explanations and reflections on the topic, which made impression of a science-fiction literature, simultaneously far from the mainstream of contemporary science and too hypothetical. Bibliographic references in publications of Gurwitsch's school and some other researchers were often incomplete or even absent, though updated data were usually discussed quite carefully in the body of the article (see, e.g., (Gurwitsch and Gurwitsch 1934)).

The materials and methods of some "early works" were partially cleared up in Rahn (1936) and Gurwitsch (1968) and, nowadays, carefully analyzed in Volodyaev and Beloussov (2015) (see Part V).

2.2.3.3.3 Problems with Reproducibility

All the authors of positive works pointed out that the experimental conditions had to be very carefully adjusted and methods of biological detection were extremely vulnerable to any subtle deviations from procedures. Moreover, nearly all the leading researchers – Gurwitsch (Gurwitsch and Gurwitsch 1934, 1959), Rahn (1934a, 1936), Wolf (1932) and others, which headed laboratories with extensive experience of positive experiments, honestly reported periods of unexplained failures in getting any effect. As Rahn wrote, "Professor Gurwitsch has told the author that in his experience <MGE failures> usually remained for several days, or even for a number of weeks, and it was impossible to produce even the simplest mitogenetic effect. Eventually the culture reacted normally again…" Doctor Heinemann, after a very successful diagnosis of cancer by the absence of blood radiation… with yeast as recipient, suddenly experienced a complete lack of reaction, and none of the various attempts to obtain normal reactions proved successful, not even the testing of a large number of different yeast cultures… Professor Werner Siebert's many successful experiments with yeast detector have been mentioned in many chapters of this book. But with him, too, the yeast suddenly ceased to react… Gurwitsch and his group also had long periods of negative results in their laboratory, which came and went at irregular intervals. (Rahn 1936).

A. Gurwitsch suggested that these days of failures related to the changes in radiofrequency background, L. Wolff and G. Ras explained them by specific changes of biological detectors themselves, some other authors named climate variations as probable reason, etc. (Rahn 1936). In any case, it should be clearly stated that some important factor (or factors) influencing MGE had not been determined.

Thus, despite significant successes in the field of mitogenesis, including insights that were decades ahead of their time, the direction critically required objective methods of physical detection and validation of biological data.

2.2.3.4 The First Works on Physical Detection of Ultraweak Photon Emission (MGR)

Beginning from the first experimental evidence that MGE is caused by weak UV radiation (MGR), the researchers' natural desire was to observe MGR with physical methods. In the first attempts made on photographic plates, no positive results were obtained, even with multiday exposures (Taylor and Harvey 1931; Magrou 1930a, b; Reiter and Gabor 1928a). As indicated in Frank and Rodionow (1932), "In experiments of Protti (1930), the source of radiation was blood on glass wool..., the exposure lasted 70 hours … <However>, the blood in vitro loses its ability to <induce MGE> after 10–15 min, and after spending many hours in the atmosphere of oxygen, phenomena completely different from MGR can appear... In the experiments of Brunetti (Brunetti and Maxia 1930), the effect on the photographic plate was observed after preliminary intense illumination of the object. Apparently, <in both works> MGR did not act on the photographic plate, and the blackening was the result of phosphorescence or chemiluminescence (probably in visible spectral range)." The use of photocells gave no results either (Schreiber and Friedrich 1930; Chariton et al. 1930; Kreuchen and Bateman 1934).

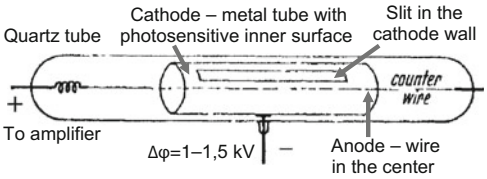

Fig. 2.18 Photosensitive modification of the Geiger–Muller counter proposed by Rajewsky (1931). (Adapted from Rahn (1936). Copyright 1936, with permission from Springer Nature)

The first successful attempt of physical registration of MGR was made by Rajewsky (1930, 1931) with the help of a photosensitive modification of the recently proposed Geiger–Müller counters (Geiger and Müller 1928a, b). The counter cathode was a metal cylinder with a cut-through window, the inner surface of the cathode being covered with a photosensitive layer (Fig. 2.18). The thin-wire anode was placed in the center of the cylinder. The potential difference between the cathode and the anode reached 1.5 kV. The entire structure was placed in a quartz flask filled with an inert gas.

The MGR source was placed outside the flask opposite the window in the cathode, so that the MGR emitted by it passed through the window to the photosensitive layer. A quantum of light entering the photo layer knocked out an electron from it, which accelerated in the counter field and led to an avalanche-like gas ionization detected by an electrometer and an automatic counter (Frank and Rodionow 1932).

Using this setup, the author was able to detect radiation from the onion root, onion gruel and carcinoma and estimate its intensity at ~10–100 quanta/s (Rajewsky 1931).

Similar devices were constructed in other laboratories (Frank and Rodionow 1932; Barth 1936; Grebe et al. 1937; Audubert 1938). By selecting the photosensitive layer, the resistance value, the gas composition, etc., the authors managed to get devices sensitive in the spectral region of MGR (Fig. 2.19). With these, they got reliable results of UPE detection from MGE inductors (Fig. 2.20), comparing it to no UPE from noninductors (Fig. 2.21). The parameters of UPE estimated in Audubert (1938) were: intensity ~100–1000 quanta $\cdot$ s^{-1} $\cdot$ cm^{-2} and wavelength ~230–240 nm (according to the data given in Audubert (1938), it should be somewhere between 200 and 280 nm).

As discussed below (and also in Chaps. 20 and 21), significant doubts in the very existence of MGR were arising due to difficulties in its physical detection. However, the described photosensitive modifications of Geiger–Muller counters let the researchers overcome this problem and obtain stable results on the MGR physical detection. As academician S.I. Vavilov concluded: "Emission of ultraviolet rays in many chemical reactions and biological processes is completely confirmed by usual physical methods.

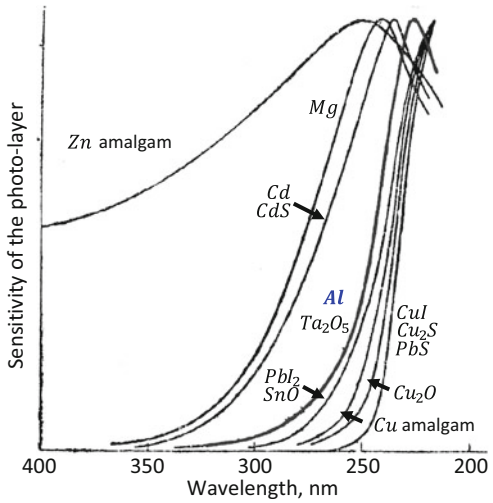

Fig. 2.19 Sensitivity spectra of modified Geiger–Muller counters with various photo-sensitive layers (the photosensitivity spectrum of the setup used in Figs 2.20 and 2.21 is highlighted in blue). (Adapted from Audubert (1938). Copyright 2006, with permission from John Wiley and Sons)

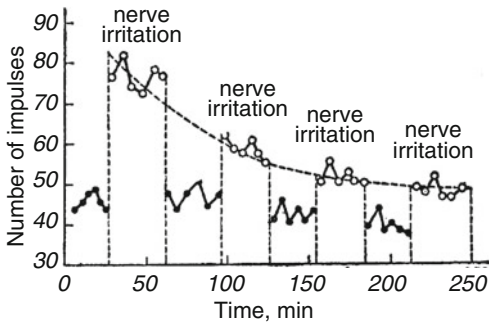

Fig. 2.20 UPE from a periodically irritated frog nerve (Aluminum photocathode, see sensitivity spectrum at Fig. 2.19). The UPE intensity was estimated as ~100 quanta $\cdot$ s^{-1} $\cdot$ cm^{-2}; the UPE wavelength was estimated as 230–240 nm. (Adapted from Audubert (1938). Copyright 2006, with permission from John Wiley and Sons)

...Wavelengths observed by Audubert belong to the same spectral range that was stated in Gurwitsch's laboratory" (Gurwitsch and Gurwitsch 1948).

Thus, the initiation factor proposed by Gurwitsch was convincingly identified by the end of the 1930s.

2.2.3.5 Obtaining MGE from Physical Sources of UV

As data on the physical nature of MGR were accumulated, its imitation by physical sources became no less important and obvious. The first attempts of it were made in Frank and Gurwitsch (1927) and Reiter and Gabor (1928a). The authors used spark discharges of aluminum (Frank and Gurwitsch 1927; Reiter and Gabor 1928a), zinc and cadmium (Chariton et al. 1930), as well as mercury, amalgam, or silver arc lamps

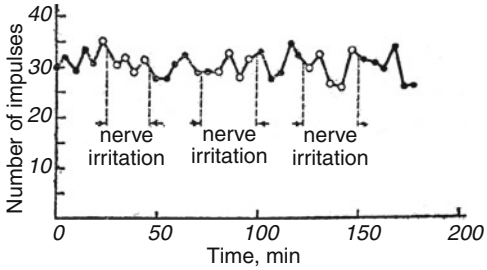

Fig. 2.21 UPE from frog nerve, killed with ethanol, and periodically irritated identically to Fig. 2.20 (Aluminum photocathode, see sensitivity spectrum at Fig. 2.19). (Adapted from Audubert (1938). Copyright 2006, with permission from John Wiley and Sons)

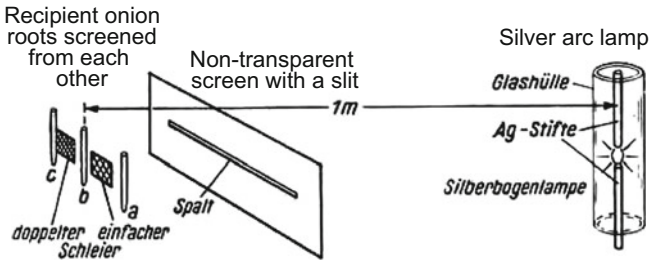

Fig. 2.22 Device for conducting stimulation of MGE by radiation from a physical source (silver arc lamp). (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

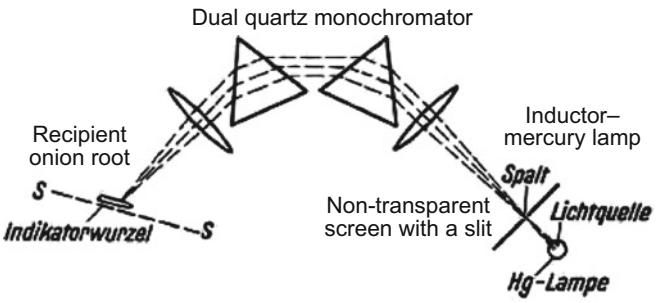

Fig. 2.23 Device for inducing MGE by narrow-band radiation from a physical source (mercury lamp). (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

(Reiter and Gabor 1928b) as sources of ultraviolet radiation (the device schemes are shown in Figs. 2.22 and 2.23).

Despite technical difficulties (the need to attenuate light from the lamp by 10^{10} times or more, the dangers of exposure to extraneous light, the need to control the state of the biological recipient, etc.), the authors managed to obtain MGE from physical sources and construct the dependence of MGE on the wavelength (Fig. 2.24, according to Reiter and Gabor (1928b)) and both the wavelength and the intensity (Fig. 2.25, according to Chariton et al. (1930)) of the stimulating radiation.

The differences in specific spectral regions with mitogenetic activity between the data (Reiter and Gabor 1928b) and (Chariton et al. 1930) (compare the spectra in Figs. 2.24 and 2.25), are apparently due to the attenuation method used (i.e., final intensities of the inducing light) and different recipients (onion roots in Reiter and Gabor (1928b) and yeast in Chariton et al. (1930)).

Another important feature was that MGE from physical UV sources was observed only at intensities several orders of magnitude higher than those estimated for MGR in the

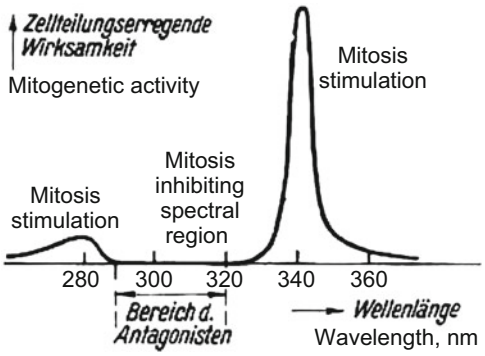

Fig. 2.24 Spectra of mitogenetic activity of ultraweak UV light from physical sources. (Adapted from Reiter and Gabor (1928b). Copyright 1928, with permission from Springer Nature)

experiments with Geiger–Muller counters. The authors interpreted this as evidence that MGR had some special properties that light from physical sources did not have – specific spectrum, some kind of temporal dynamics, etc. (Chariton et al. 1930).

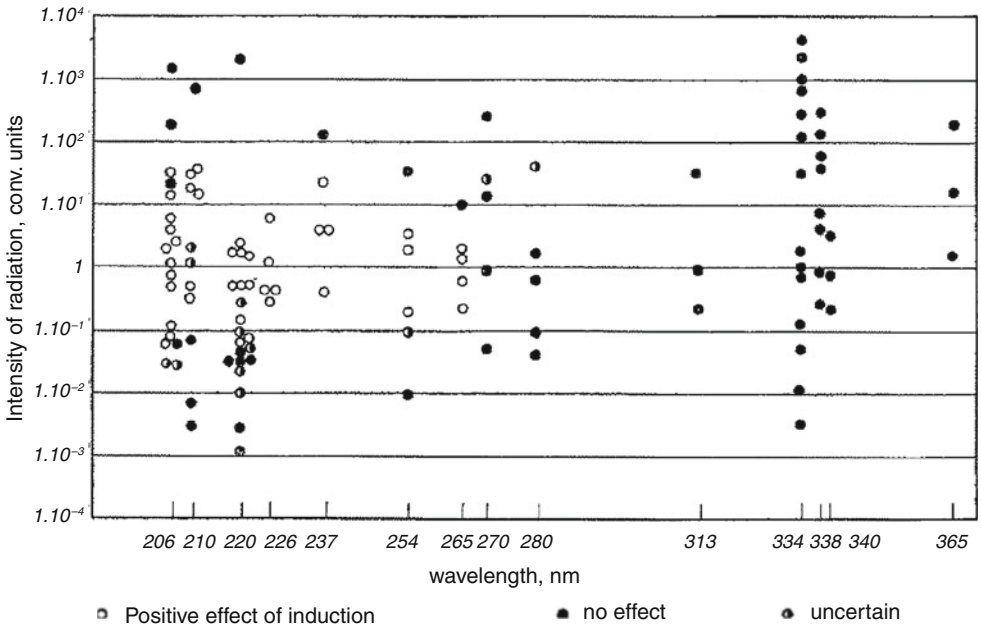

Fig. 2.25 Spectra of mitogenetic activity of ultraweak UV light from physical sources (1 conv.unit equals to 10^{-14} ampere of photocurrent). (Reprinted from Chariton et al. (1930). Copyright 1930, with permission from Springer Nature)

Anyway, both groups obtained reproducible MGE from physical UV sources, which gave the final proof of mitogenetic activity of ultraweak UV.

2.2.3.6 Applied Research Related to MGE: Cancer Quencher

In addition to studying the basic MGE and its physical properties, the authors made some practical observations. Thus, they found that in most cases the blood of a healthy person or animal was a stable inductor of MGE. Yet, the blood of cancer patients ceased to emit MGR. The same effect was observed in mice with inoculated or induced tumors long before the onset of apparent clinical or histological presentation of cancer (Gurwitsch and Gurwitsch 1938). The disappearance of MGR from the blood of cancer patients was caused by formation of a specific substance (or substances) quenching MGR, supposedly due to the disruption of free-radicals generation. It was called the "cancer quencher," which was the first blood tumour marker ever proposed (Gurwitsch and Gurwitsch 1937; Siebert and Seffert 1937; Gurwitsch et al. 1947).

2.2.3.6.1 "Degradation MGR"

In addition to standard MGE inductors, almost any biological system appeared possessing a short-term inducing ability under external destructive or stressful effects: mechanical pressure, cooling, passing electric current, etc. (Gurwitsch and Gurwitsch 1948, 1959). This phenomenon, called by the authors "degradation MGR," could be observed during a limited time, then showed some refractory period and if the impact was reversible, could be reobtained after a long time of "system recovery" (see more in Chap. 22).

Gurwitsch interpreted "degradation MGR" as evidence of the nonequilibrium state of biological systems, destroyed by the externally applied stressful influences, with the appearance of free radicals – sources of MGR (Gurwitsch and Gurwitsch 1948, 1959).

2.2.3.7 The Results of the "Golden Age"

Thus, by the end of the 1930s, the MGE research led to the following results:

- The effect had been confirmed in various laboratories on a number of biological objects.
- MGR spectra were obtained using biological recipients ("detectors").
- Ultraweak luminescence from MGE inductors was recorded in the spectral range of 180–340 nm with intensity of ~10–10^3 quanta · s^{-1} · cm^{-2}, which roughly corresponded to indirect estimates of MGR.
- MGE was obtained from ultraweak radiation of physical sources in the spectral range of MGR estimates.
- The MGR phenomenon began to be used as a research method in biochemistry and physiology and showed its potential for medical diagnostics.

Based on the experimental data on MGR, the following suggestions were made:

- MGR was suggested resulting from recombination of free radicals.
- Biological systems were assumed to be in nonequilibrium (electron-excited) states, and capable of emitting MGR quanta when these states were disturbed.

2.2.4 1938–1948 – "The Sunset of MGR"

2.2.4.1 Criticism

Notwithstanding the large number of publications, confirming MGE, its accurate verification demanded a lot of subtle conditions to be fulfilled. As A.G. Gurwitsch wrote, "With the remarkable exception of the studies of a few authors who really contributed to the new discipline (among them we may mention Magrou and Magrou, Ziebert, Blacher, Wolf, and Zirpolo), all the other numerous tests – with either positive or negative conclusions – led the authors to express doubt" (Gurwitsch and Gurwitsch 1943) (cited from a later English reprint: (Gurwitsch and Gurwitsch 1999)).

At the same time, the "nonclassicality" of the MGE phenomena naturally aroused skepticism in the scientific community, especially given the vague wording and low level of some works. There were a number of negative publications attempting to verify MGE (Taylor and Harvey 1931; Richards and Taylor 1932; Nakaidzumi and Schreiber 1931; Kreuchen and Bateman 1934; Gray and Ouellet 1933; Lorentz 1929; Westenberg 1935; Hollaender and Claus 1937; Moissejewa 1960), some of which had a significant impact on public opinion. Methodical mistakes of the "negative works" were partly analyzed in Rahn (1934a, 1936), and Zalkind (1940), yet were mostly ignored by Gurwitsch: "We believe that there are no words, harsh enough to condemn those authors who, having set themselves the goal of verifying the existence of the phenomenon, not only ignored our methodological instructions for experimental setup, but acted contrary to them, i.e., used methods that we had explicitly warned against" (Gurwitsch and Gurwitsch 1943) (not translated in Gurwitsch and Gurwitsch (1999)). Detailed analysis and critics of early works will be given in Chaps. 20, 21, 22, and 23. Though most of their negative results could be well explained by incorrect experimental conditions (physiological state of the cells, structure of physical detectors, etc. – see more in Chaps. 20 and 21) (Rahn 1934a, b; Gurwitsch and Gurwitsch 1948, 1999; Barth 1934; Zalkind 1940), they were followed by sharply negative consequential reviews of the topic (Bateman 1935; Anonim 1937; Moissejewa 1960).

2.2.4.2 Geopolitics

Fast decline of works on MGE in Germany began soon after Hitler's accession to power because of the emigration of the leading researchers (D. Gabor, T. Reiter, M. Heinemann and others). Some of researchers left this area in favour of other ones, including military topics (A.F. Ioffe, G.M. Frank, A. Hollaender, O. Rahn, R. Audubert). Audubert left the field, explaining that because of technical limitations his further research would do little other than laboriously accumulate very similar evidence of the phenomenon. The prewar aggravation of international relations cast the shadow of "Soviet science" over the MGE.

Naturally, with the beginning of WWII, research on MGE completely stopped in Western Europe and the United States, and none of these laboratories returned to this topic after WWII and during the Cold War. In contrast to the previous period, in 1938–1948, Soviet researchers were mostly published in Russian (Gurwitsch and Gurwitsch 1945, 1948), and a lot of their works remained unknown to the "western scientists" for decades (e.g., (Gurwitsch and Gurwitsch 1943) was translated only in 1999 (Gurwitsch and Gurwitsch 1999), while many others are still untranslated). In spite of this scientific isolation, hard times of war, evacuation of A.G. Gurwitsch and his colleagues from Leningrad, and inevitable reduction of research activities, these years were still fruitful for mitogenesis in the USSR. The main subjects of this period were: MGE spectral analysis with the focus on nerve activity and carcinogenesis (Gurwitsch et al. 1947; Gurwitsch and Gurwitsch 1945), development of cancer diagnostics and accumulation of clinical data on its successful application (Pesochensky 1942; Avchina 1950; Gurwitsch et al. 1947), and theoretical attempts to explain extensive experimental data previously collected (Gurwitsch 1947a, b). Gurwitsch was awarded with the highest scientific award of the USSR for works on MGE and cancer study (Stalin Prize, 1941).

In this period, physicians actively joined the field, more than 12 dissertations on "cancer quencher" were written including such a prominent one as Doctor of Medical Science dissertation by B.S. Pesochensky defended in Military Medical Academy in the besieged Leningrad (Pesochensky 1942). Experimental cancer studies and data obtained in the leading clinics of the USSR demonstrated that the cancer diagnostic with detection of "cancer quencher" by MGE-methods had specificity and sensitivity of >95% (see Chap. 23). Due to the language barrier, the "cancer quencher" research, probably the most attractive from the point of view of practical applications, remained almost unknown to the western readers.

In the USSR, the postwar raise of research marked with significant growth of publication activity soon gave place to dramatic decline due to political reasons. For a long time, Gurwitsch had been immune to the regular charges of being "bourgeois vitalist" (Lepeshinskaya 1926; Tokin 1933) due to his recognition as a world-known scientist. With ceasing of his worldwide fame and the rise of power of O.B. Lepeshinskaya and other followers of T.D. Lysenko, these charges became really threatening. Mitogenetic researches were persecuted altogether with genetics after the decisions of the "August session of VASKhNIL" (All-Union Academy of Agricultural Sciences) in 1948. In this time, many scientists suffered from political persecution

in the USSR; Gurwitsch had to retire from the post of Director of Institute of Experimental Biology.

2.2.5 After 1948 – After the Sunset

Although the mitogeneticists were never repressed as hard as geneticists in the USSR, the August VASKhNIL session appeared to have a more severe impact on its further progress. While the success of genetics in the Western countries made soviet officials revise their perception of this science, the mitogenetic research was both denounced as "Soviet obscurantism" in the West, and stigmatized as a "bourgeois science" in the USSR. Works on MGE were still continued in several labs in the USSR where some new publications were appearing (Gurwitsch 1968; Avchina 1950; Troitskii et al. 1961; Konev 1965; Gurwitsch et al. 1965). Yet, the scope of work was incomparable to the large-scale research conducted before WWII and even in wartime. The main topics worked on were application of the invented photomultiplying tubes as extremely sensitive detectors of UPE (Gurwitsch et al. 1965; Troitskii et al. 1961), and cancer diagnostics in clinics (Avchina 1950).

Soon, visible UPE from biological systems was discovered, and its mechanisms and general prevalence investigated (Colli and Facchini 1954; Tarusov et al. 1961; Vladimirov 1967; Boveris et al. 1981). This part of the story is given in the following Chap. 3. The main point we would like to mention here is that the newly discovered visible UPE was actually never contrasted to MGR at the evidence level, and never disproved its existence.

Though later a number of authors accidentally stumbled upon this topic anew, they mostly exhausted their interest by finding the most easily accessible critical prewar articles (Hollaender and Claus 1937; Anonim 1937; Bateman 1935; Hollaender 1936) assuring them of the falsity of the original works (which they had never read). As written in Metcalf and Quickenden (1967), "These studies were originated by Gurwitsch and are still carried on in the Soviet Union, but almost ceased in Britain and the United States in the 1930s after much careful but negative work (Lorenz 1934; Gray and Ouellet 1933; Hollaender and Claus 1937). Nobody there was able to stimulate cell division with weak ultraviolet light or to detect radiation from rapidly dividing cells with photoelectric or biological detectors" (references saved). Yet, further deepening into the topic and their own positive experimental results made these authors acknowledge the validity of early works and show much more respectful attitude to them (e.g., (Quickenden and Hee 1981)).

However, after 1948, almost all attempts to verify MGE were sporadic and demonstrated lack of knowledge of early works. It should be noted that the early literature on MGE became rather rare, and it was extremely difficult to track research chains and find methodical descriptions. The more so, that Gurwitsch and his pupils when citing other works, usually named only the authors without presenting full bibliographic references.

Interestingly, many scientific results obtained in the "Golden age" of MGE were rediscovered with novel scientific methods, but mostly without reference to early MGE researchers (see below).

2.3 Epilogue: The Paradoxes of Mitogenesis

The story of the mitogenetic effect is full of contradictions. On the one hand, it may seem one of the fallacies of the old days. Yet, a lot of data from the "old days" appeared anticipating much later discoveries (UPE from biological systems, its free-radical nature, peptide tumour markers, two-photon processes, etc.). On the other hand, it may seem solid science, forgotten by accident and/or due to historical troubles. Yet, there were a number of badly done works (both positive and negative) that compromised the whole topic. The very chain of reasoning, that led to the concept of MGE, being the result of constant deep reflection on the processes of cell division and morphogenesis, is actually full of strange and quite doubtful conclusions. As A.G. Gurwitsch wrote, "What may be instructive in our case is that blunders frequently intervened in the chain of our deductions, sometimes in its most crucial links. This happened repeatedly after the discovery of the phenomenon and in the course of its further investigation... It is difficult to understand now, how such a chain of arbitrary and physically rather naive reasoning could have led us to a valid result – discovery of the radiation" (Gurwitsch and Gurwitsch 1999).

Experimental development of the topic was also quite contradictory. As the field of research was quite new, the methodical details were usually not well understood by the authors themselves. Due to the vague procedure descriptions overcrowded with irrelevant information, many of those who wanted to verify the original MGR works missed important recommendations, and lost the effect from the very beginning. Though a number of very serious authors were unsuccessful in obtaining the phenomenon (Taylor and Harvey 1931; Richards and Taylor 1932; Nakaidzumi and Schreiber 1931; Kreuchen and Bateman 1934; Gray and Ouellet 1933; Lorentz 1929; Westenberg 1935; Hollaender and Claus 1937; Moissejewa 1960), most (if not all) of their negative results were quite explainable in the course of the "mitogenetic reasoning" (Rahn 1934a, b; Gurwitsch and Gurwitsch 1948, 1999; Barth 1934; Zalkind 1940), and the "negative works" often directly violated the methods previously developed in "positive works." Interestingly, one of the seemingly most persuasive parts of the critique, the "proof" that the phenomenon of biological UPE is physically impossible (Bateman

1935; Hollaender and Claus 1937; Taylor and Harvey 1931) turned out wrong, as the physically detected UPE from living systems became a well-established fact already in the 1960s (Vladimirov 1967). Many theoretical arguments against experimental results on MGE also failed to stand the test of time, for instance, Bateman's caustic critique of Gurwitsch's experimental results on secondary radiation (see Chap. 22) that violated Stokes law as "fluorescence hitherto unknown... we are seriously asked to believe in its existence" (Bateman 1935) (existence of anti-Stokes processes was predicted and proved much later).

On the one hand, the critique of MGE and MGR mainly became obsolete, and we can clearly state that the key experiments have never been disconfirmed in a conclusive way. On the other hand, most of MGE and MGR experiments cannot be considered absolutely correct without modern verification because of significant advances in biological methods, more stringent requirements for evidence, and statistical processing of data. We consider that the results of early authors must not be taken for granted but surely worth of serious attention and thorough verification with the focus on factors affecting MGE and improving reproducibility.

Trying to make the real situation as clear as possible, in the following parts, we address the topics of UPE in general (the now classic works on free-radical processes accompanied by UPE, which originated from attempts to test MGR on PMTs – Chap. 3 and Part III), its occurrence in nature (Part IV), physical mechanisms (down to quantum dynamical models, which have become achievable only recently, thanks to the development of computer technology – Part III), and applications (Parts IV and VII). Later, we will return to the unsolved mystery of mitogenesis, discussing methodical details of early works, their results and applications, controversies, and problems (Parts V and VI). Finally, we will outline the sudden parallels between the early works and the presently well-established data and come to perspectives and new approaches in this area of science (Part VII). The future will show if there was the baby thrown out with the bath water of mitogenetic works.

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