



LISTAHÁSKÓLI ÍSLANDS

Iceland University of the Arts

Gene editing in the garden

A historical analysis on the accessibility of gene editing tools

Elín-Margot Ármannsdóttir

Final thesis for an MA-degree

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Supervisor: Búi Bjarnar Aðalsteinsson

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Abstract

The world of science appears often as a distant discipline, disconnected to the day to day life. However most objects surrounding us were once in a laboratory. Smartphones are a good example. They are computers that can fit in anyone's pocket. Their primary form, the first computers, however use to take as much space as a cupboard and could fit an entire laboratory. What is developed in a laboratory may one day, if successful, find its place in everybody's home or hand.

The digital field has known an important boom in discoveries and it seems that the biotech field is on its way to follow the same path. All eyes are directed toward gene editing and the recent gene editing tool: CRISPR-cas9. This tool allow its user to modify the DNA of any organism and thus create a new one. Discovered in 2012, the technology can, today, be purchased by any biohackers on the internet. Gene editing is no longer restricted to laboratories but find its way into the home.

Gene editing however is not a new technology. Radioactive sources such as cobalt-60, are a way to induce mutation in living organism, it is called: radiation breeding. In fact, this technology already found its way into the English housewives homes of 1960. Muriel Howorth, a dedicated enthusiast scientist, created in 1948 the Atomic Gardening Society. The society offered different activities, one of which was to grow irradiated seeds to help scientists find lucrative mutation.

Muriel Howorth society disappeared in 1963. The loss of its leader and the lack of results might have been the cause of its decline. However today, enthusiasts scientists, makers or biohackers benefit from internet and its flow of information. In this thesis we explore how Muriel Howorth helped a technology such as radiation breeding entering the homes in 1960 and discuss how CRISPR-cas9 might follow a similar path in the years to come.

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Introduction

In 2012 at the university of Berkeley in California, Jennifer Doudna and her team made a discovery that led to the development of CRISPR-cas9, a technology that considerably reduces the time and work needed to edit DNA.¹ Since then editing DNA of any living organisms is as easy as writing basic code for software engineers.

CRISPR-cas9 is the genetic equivalent of Microsoft Word.² The technology is less expensive and complicated than previous methods. Bio Hackers and enthusiast biologist can already purchase CRISPR-cas9 kits online, for no more than 159 dollars.³ Even if CRISPR-cas9 is patented it is easy to imagine how a DIY (Do-It-Yourself) gene editing laboratory could be created in someone's basement. There are already predictions of the end of the digital era and the start of the age of biotechnology. The idea that anyone can create or modify any kind of organism and that those organisms could be harmful, bioterrorism, scares the public.⁴ However it is not an unprecedented situation. Products developed with a questionable technology to alter DNA entered our homes and supermarkets almost sixty years before CRISPR-cas9. This technology is called radiation breeding and is still today considered a part of traditional breeding methods.

After the Second World War and the disastrous effects of atomic bombing, the US government started a promoting movement for the nuclear research: Atoms for Peace. They used radioactive sources to generate mutations in plants and thereby created the atomic gardens. Plants were irradiated in the hopes that they might mutate in an “useful” way. The research was advertised in institutions such as schools and hospitals.⁵ At that time citizen could apply to get a cobalt-60 radioactive source to create their own atomic garden.⁶ Muriel Howorth a woman from Eastbourne took this opportunity to heart and

¹ Jennifer A. Doudna, and Samuel H. Sternberg, *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution* (United States: Houghton Mifflin Harcourt, 2017).

² Megan Molteni, “Everything You Need To Know About Crispr Gene Editing,” *Wired*, April 27, 2018, www.wired.com/story/wired-guide-to-crispr.

³ The Odin, “DIY Bacterial Gene Engineering CRISPR Kit,” the odin, George Church and Josiah Zayner, accessed December 7, 2018 on www.the-odin.com/diy-crispr-kit.

⁴ Molteni, “Everything You Need To Know About Crispr Gene Editing.”

⁵ Dwight D. Eisenhower, “Atoms for Peace” (speech delivered on a UN assembly in New York, December 8, 1953), www.eisenhower.archives.gov/research/online_documents/atoms_for_peace/Binder13.pdf.

⁶ Paige Johnson, “The Atom-Blasted Seeds of C.J. Speas, Atomic Entrepreneur,” *Atomic Gardening: an online history* (blog) accessed December 7, 2018 on

create the atomic gardening society, a movement that gathered enthusiastic gardeners interested in growing irradiated seeds hoping to discover new mutations.⁷

Howorth used a variety of publications, organizations and staged events to promote atomic science and specifically addressed women. According to the historian Paige Johnson, Howorth used communication strategies that are similar to those used today. She was good at gathering people and align them to her cause. This is how she was able to bring atomic science in the hands of English housewives.⁸

This thesis explores the history of the Atomic Gardening Society through the theory of social movement elaborated by Herbert Blumer and later described by Donatella Della Porta and Mario Dianni in 2006 in their book “*Social movements, an introduction*”. The thesis is an analysis of Muriel Howorth activities from 1948 to 1962 and the most important factors in the creation of the Atomic Gardening Society. The analysis will then be used in comparison with current development of CRISPR-cas9 within the community of DIY-Biology. This writing is an attempt to answer the question: How did an unreliable technology like cobalt-60 end up in citizen backyards and could CRISPR-cas9 follow a similar path?

1. Context

On August 6th and 9th in 1945 the destructive power of nuclear technology was showcased to the world with the consecutive bombing of the Japanese cities Hiroshima and Nagasaki. The bombs were responsible for the deaths of at least 129 000 people, many more died later from the effects of burns and radiations.⁹ After the bombing Japan

www.atomicgardening.com/1958/10/20/irradiating-seeds-for-fun-and-profit-c-j-speas-life-magazine-photos.

⁷ Muriel Howorth, *Atomic gardening for the layman*, (St. Leonard-on-sea, Great Britain: King Bros and Potts LTD, 1960), P.63

⁸ Paige Johnson, “Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth.” *The British Journal for the History of Science* 45, no. 04 (December 2012): 551–71. doi.org/10.1017/S0007087412001057.

⁹ A. W. Oughterson, G. V. LeRoy, A. A. Liebow, E. C. Hammond, H. L. Barnett, J. D. Rosenbaum, and B. A. Schneider, *Medical Effects Of Atomic Bombs The Report Of The Joint Commission For The Investigation Of The Effects Of The Atomic Bomb In Japan Volume 1*, (Washington, United States, April 19, 1951), doi.org/10.2172/4421057.

surrendered and the Second World War ended, the Allies won and the United States soon became the most influential economic power in the world.¹⁰

Post-war opinion on nuclear

The two bombs were the pioneering weapons of a new kind of technology: nuclear fission. Discovered in 1938 by German Otto Hahn and his assistant Fritz Strassmann. Nuclear weapons were previously tested in the desert at the north of Alamogordo, New Mexico, but had never before been detonated within inhabited areas and its living beings. There were conflicting opinions amongst the scientist about targeting inhabited cities, as some thought that showcasing the powerful effect of the bomb would have been enough to ensure Japan's surrender.¹¹ The destructive effects of radiations were well known at the that time, as a few scientists died from exposure to radiation during their research (notably the scientist Marie Curie in 1934). However the attacks happened and the aftermath created interest in researching their effect. As seen in the text form:

... on the American side, there was recognition of the urgent need for research on the medical and genetic aftereffects of radiation, but the military authorities also had interest in the offensive and defensive implications of atomic radiation. On the Japanese side, there was an unmet expectation of medical care coupled with a suspicion of the American motives.¹²

In September 1945, the U.S. Army, the Navy, and the Manhattan District sent teams to Hiroshima and Nagasaki to study the medical effects of the atomic bombs. They joined a team of Japan scientists and sent their report back to the U.S as the Joint Commission for the Investigation of the Effects of the Atomic Bombs. The *Atomic Bomb Casualty Commission (ABCC)* was created in November 1946 in Japan for a long-term

¹⁰ Tim McMahon, "Inflation and CPI Consumer Price Index 1950-1959," inflationdata, accessed December 11, 2018 on inflationdata.com/articles/inflation-cpi-consumer-price-index-1950-1959.

¹¹ Terrence R. Fehner and F. G. Gosling, "Debate Over How to Use the Bomb, Late Spring 1945," The Manhattan Project, an interactive history (blog), webarchive, September 17, 2007. [web.archive.org/web/20070917023738/http://www.cfo.doe.gov:80/me70/manhattan/debate.html](http://www.cfo.doe.gov:80/me70/manhattan/debate.html).

¹² Frank W. Putnam, "The Atomic Bomb Casualty Commission in Retrospect," (this paper was presented at the symposium "A Song Among the Ruins: 50 Years of the Japanese/Academy Cooperative Studies of Atomic Bomb Survivors," organized by John E. Dowling and Alvin G. Lazen and held at the 134th Annual Meeting of the National Academy of Sciences on April 30, 1997) *USA*, 1997.

study of atomic bomb casualties. They focused on medical and scientific studies of the survivors of the atomic bombing and their children. According to the garden historian Paige Johnson;

“It is difficult to trace to a single source, but may have arisen through reports such as this one from 1947, [probably a report from ABCC as they were the only official scientific commission in Japan] in which plants grown in the “atom-blasted” soil at Nagasaki were recorded as being double in size, and reportedly the “crop yield today from land at blast center is twice that from normal soil.”¹³

At the time the potential effects of radiation on living organisms DNA was known, the research and studies on Japanese ground brought to light mutations caused by the radiations of the bombings. Some plants were twice their usual size. Images from reports show an interest from the scientific teams for those mutations. Media such as LIFE magazine, spread studio images of those mutated plants. Based on the widespread coverage of these mutated anomalies we can assume that this marked the beginning of an era with a growing hope to harness radioactive energy for good within the field of agriculture.



¹³ Paige Johnson, “Born from the Bomb,” *Atomic Gardening: An Online History* (blog), accessed November 15, 2018 on www.atomicgardening.com/1945/08/09/nagasaki-plant-mutations.

Image 1 & 2: “Born from the Bomb.” *Atomic Gardening: A Timeline of Events* (blog), accessed November 9, 2018, on www.atomicgardening.com/1945/08/09/nagasaki-plant-mutations.

Meanwhile tension between communist USSR and capitalist U.S. increased. Political oppositions between the two big winners of the war created tensions resulting in the so-called cold-war. Both of the countries nurtured scientific research especially in nuclear weaponry disregarding their citizens fears and concerns.

Turning war into peace

At the beginning of the 50's, the American president Eisenhower became aware of the nuclear studies and weapons capacity of the Soviet Union. The USSR was never considered as a friend of the US which can be heard in Eisenhower speech “*Atoms for Peace*” delivered in New York the 8th December of 1953. There is always a clear distinction in the speech between the “*friends and allies*”: Great Britain, Canada, France and the Soviet Union. Eisenhower mention the deep “*fear of the atom*” from the American public after the events of the second world war. A fear that he shares in the acknowledgement of the Soviet Union weaponry:

“But the dread secret and the fearful engines of atomic might are not ours alone.[...] The secret is also known by the Soviet Union.”¹⁴

“even a vast superiority in numbers of weapons, and a consequent capability of devastating retaliation, is no preventive, of itself, against the fearful material damage and toll of human lives that would be inflicted by surprise aggression.”¹⁵

In the speech *Atoms for Peace* Eisenhower tried to reassure the American and worldwide public (as he delivered the speech at a United Nations meeting) of the U.S. intentions regarding the use of nuclear armament research. The speech is part of a public relation campaign, “*Operation Candor*”, aimed at gaining trust and understanding of the American citizen in the state investment in nuclear armament research. The war created

¹⁴ Eisenhower, “*Atoms for Peace*.”

¹⁵ Eisenhower, “*Atoms for Peace*.”

space for scientific research which also lead to the creation of many laboratories and jobs. In this time of peace they had to find a new purpose for their investment. Well depicted by Eisenhower's promise to lead the research towards a “*peaceful pursuits of mankind*”.

*“Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world. Thus the contributing powers would be dedicating some of their strength to serve the needs rather than the fears of the world.”*¹⁶

The “Atoms for Peace” program was launched by the US government after the president’s speech. Equipment and information were provided to schools, hospitals and research institutions, and to some extent were made available to the general public. After the war, many among the scientific field believed that nuclear power could be domesticated to serve a number of worldwide issues such as famine and energy shortages.¹⁷ The U.S. government needed to reinvent their investment in nuclear research from having a destructive purpose into a constructive one. This is very clearly highlighted in Eisenhower’s speech where it says, “[i]t is not enough just to take this weapon out of the hands of the soldiers. It must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace.”¹⁸

¹⁶ Eisenhower, “Atoms for Peace.”

¹⁷ Helen Anne Curry, *Evolution Made to Order*, (United States: the University of Chicago Press, 2016).

¹⁸ Eisenhower, “Atoms for Peace.”



Image 3: A flowering garden represents ‘Progress’ in an exhibition at Dorland Hall, London, depicting the two potential roads of atomic energy. The exhibition, part of the ‘Atom Train’, was the first to present atomic energy to the public and was sponsored by the British Atomic Scientists Association. Photograph credit: Reg Birkett/Keystone/Getty Images, ‘A choice of future’, 23 January 1947.

Image 4: “Atoms for Peace.” *Atomic Gardening: A Timeline of Events* (blog), accessed November 9, 2018, on www.atomicgardening.com/1953/12/08/atoms-for-peace.

There had been some investigations into radiative effects and induced mutations of plant material prior to 1945, however the bombings, its casualties and later the Atoms for peace program opened the way to radioactive agriculture called the Atomic garden.

2. The technology

Reports from the ABCC generated an interest in plant mutation caused by intentional exposure to a radioactive source. With the Atoms for Peace movement, the U.S government was willing to support and finance new research on the uses of radiation for industry (x-raying for flaws in steel, for example), medicine (this is where “nuclear medicine” begins), and agriculture (the Atomic gardens).¹⁹

¹⁹ Paige Johnson, “Government Gamma Gardens,” *Atomic Gardening: A Timeline of Events* (blog), accessed November 23, 2018 on www.atomicgardening.com/1958/10/01/rebuilding-plants.

Editing DNA with cobalt-60 radioactive source

Radiations are able to alter the genome of any organism. They shot through the chromosomes making them produce something different from the parent.²⁰ They are usually responsible for various radiation diseases, tumours and cancers but can in a very few instances alter the DNA material and provoke a lucrative mutation. Radiation experiments on plants date back to 1920 prior to the sadly famous bombing. According to Muriel Howorth in her book “*Atomic gardening for the Layman*”, “*Swedish scientists were the keenest to try out this new process and by 1935 they were working, not only with X-rays, but with atomic radiations from cobalt-60 and other radioactive substances.*”²¹

At the beginning of the 50’s the new atomic age enabled the application of new ionising radiations as mutative tools. Scientists created atomic gardens, with the radioactive source at the centre and the plants arranged in concentric circles around it as we can see on image 4 bellow. The radioactive source was contain in a lead lined chamber underground, which was raised above when needed. There were a series of fences and alarms to keep people from entering the field when the source was above ground.²²

Plants and seeds had their genomes “rebuilt” by being exposed to a cobalt-60 source. This method did not deliver predictable outcomes in the plants, some might grow with abnormalities or tumours and some did not grow at all. This process offered a faster way to affect the genome compared to traditional breeding but the outcomes where extremely random, as the radiation blindly triggered DNA mutation in plant genome. Scientists hoped that an increased rate of random mutations would help in the search for a genome that would have better qualities than the original plant (increased yield, disease resistant etc.).²³

²⁰ Howorth, *Atomic gardening for the layman*, P.20.

²¹ Howorth, *Atomic gardening for the layman*, P.20.

²² Paige Johnson, “Government Gamma Gardens.”

²³ Paige Johnson, “Government Gamma Gardens.”



Image 5: One of the first gamma-garden was built at Brookhaven National Laboratories in Rhode Island, in 1949. By 1958 atomic agriculture had been taken up in government laboratories around the world: Virginia, Florida, Wales, Sweden, Norway, Russia and Costa Rica.

Out of the laboratories

Through this DNA modification method many plants have been created. Muriel Howorth talks about the staple crop of Sweden, a kind of barley developed in atomic gardens by Swedish scientists. A mutant that produced *“more grain and resisted summer wind storms because it had mutated with short, strong stalks. Today this barley is world-renowned, but since the seed is needed for home culture it is not permitted to export this species yet.”*²⁴ (she wrote the book in 1960). According to Paige Johnson those mutants born from radioactive exposure are still present today.

*“By 1962, there were 9 “induced mutant” cultivars. In 1969, there were 77, and 1,200 by 1990. As of 2008, more than 2,700 varieties resulting from mutagenic experiments have been released. Some were induced by x-rays, and some from chemical mutagens, but most from gamma-rays identical to those produced in the gamma gardens of the midcentury.”*²⁵

The public could access seeds derived from Atomic gardens recognised as better crops as they were put on the market. However Atoms for Peace program also promoted atomic entrepreneurship for a short while. The goal of the program was to encourage

²⁴ Howorth, *Atomic gardening for the layman*, P.11.

²⁵ Paige Johnson, “Government Gamma Gardens.”

communal participation within the field of nuclear research as well as giving countries that had not previously possessed nuclear technology the opportunity to access its potential. This allowed for easier access to this technology where institutions like schools, laboratories, hospitals and civilians were granted radioactive materials in the hopes that they could further develop usage for it. For a limited time period it was possible to acquire a licence, provided by the government, for possessing and using a radioactive Cobalt-60 source. One of those applicants was an oral surgeon and enthusiast inventor Clarence J. Speas. He received a Cobalt-60 radioactive source that the Atomic Energy Commission granted him in 1957.²⁶

3. A key partnership

There were two major actors that permitted the Atomic gardens to enter the public's backyard. Without the encounter of those two persons, the research for useful mutants through exposure to radioactive source would have hardly left the laboratories. Those two were the previously mentioned Clarence J. Speas and Muriel Howorth. In 1957, Clarence J. Speas received a letter from Muriel Howorth, a politically active English citizen that had a particular talent to gather people around her cause.²⁷

Through her life Muriel always demonstrated activism and a particular interest in public debate. She was an active feminist and was particularly good at gathering people into her cause. In 1948, Muriel read *The Interpretation of Radium* by Frederick Soddy an English radiochemist. Soddy was convinced of the necessity of public engagement with science in a way that prefigured the advocacy of atomic scientists after the Second World War. Muriel was animated by this reading, "*by the time I had reached page 183 I was a firm believer in the power of the atom for good.*" On that page she had read, "*the nation which can transmute matter could transform a desert continent, thaw the frozen poles, and make the whole world one smiling Garden of Eden.*"²⁸ This new interest became her new cause. She was firmly convinced that nuclear energy was the answer to the problems

²⁶ Howorth, *Atomic gardening for the layman*, P.19.

²⁷ Howorth, *Atomic gardening for the layman*, P.22.

²⁸ Howorth, *Atomic gardening for the layman*, preface.

of the world, especially the solution to world hunger and as Soddy she wanted the public to know about this wonderful technology.²⁹

In the United States, Atoms for Peace program was going its way. More and more laboratories were opening, Atomic gardens irradiated more and more plants.³⁰ However the process was time consuming, there were not enough laboratories, not enough scientists to grow and observe interesting mutations in the irradiated plants.

“It was then that Dr Speas exclaimed: “Why not let the private growers help? Why not let the people have a go? Every gardener would surely be interested in mutation research and a million nonscientists would enormously help the development of beneficial new plant strains.”³¹

Clarence J. Speas created a new kind of business, he irradiated seeds and sold them to any gardeners interested to participate or curious about growing “*Atom-blasted seeds*” as seen on the picture below. He built an “*atom-blasted seeds factory*” after being granted the acquisition of ten curies of cobalt-60 in December 1957 by the Oak Ridge Laboratory.



**Image 6: Atom-blasted seed rack in store which will produce mutations – May 1958
Photographer: Grey Villet Photo: Life hosted by Google.**

²⁹ Johnson, “Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth,” P.553.

³⁰ Paige Johnson, “Government Gamma Gardens.”

³¹ Howorth, *Atomic gardening for the layman*, P.19.

Clarence J. Speas took care of the publicity of his products, however it was not too difficult to spark the interest of gardeners with a 3 meters tall tomato plant that produced more than 200 hundred tomatoes. In 1957 Muriel Howorth got in contact with him. She had a more advanced idea of opening up atomic agriculture research to the public than Frederic Soddy or Clarence J. Speas. Once she got atom-blasted seeds she saw the opportunity for civilian to take active part in the research,

“I think it is well know that my concern has always been for the layman: that he should understand the fundamentals of atomic energy and how it can be used for the benefit of man in medicine, industry, and agriculture. I now felt that by some stroke of luck which it is difficult to ascribe to chance, I had been given the opportunity -so much longed for- to bring science right into the homes of the people.”³²

In England there was no equivalent to the American Atoms for Peace program. The United Kingdom Atomic Energy Authority (UKAEA) was created in 1954³³, is a UK government research organisation still active today but never opened to enthusiast biologist as the Atoms for peace program was. The enthusiast scientists interest for atomic science carried by Muriel Howorth was a civilian movement that never received any recorded funding from the English government.³⁴

Muriel Howorth created a partnership with Clarence J. Speas. He would irradiate seeds in his radioactive factory and would provide Atom-blasted seeds to Muriel Howorth for her society: the Atomic Gardening Society.

4. Atomic gardening for the housewife of 1960

Muriel Howorth was a politically committed citizen. According to Paige Johnson *“She displayed a unique ability to gather people around her and to make them believe not only in her cause, but Howorth herself.”³⁵* She created several organisations to

³² Howorth, *Atomic gardening for the layman*, P.22.

³³ United Kingdom Atomic Energy Authority, “United Kingdom Atomic Energy Authority,” webarchive, accessed December 10, 2018 on [web.archive.org/web/20130311072331/http://www.uk-atomic-energy.org.uk](http://www.uk-atomic-energy.org.uk).

³⁴ Johnson, “Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth,” P.562.

³⁵ Johnson, “Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth,” P.553.

promote and act for what she believed in. In 1930, she gathered around seven hundred women for her Women's International Film Association in order to bring the influence of the "*thinking British public*" to the film industry.³⁶ Women engagement in masculine field such as the film industry or science (between 1930-1970) and layman's empowerment are recurrent themes in every organisation that Muriel Howorth created. They are the core of her political engagement.

Her interest in atomic science would be translated into a search for atomic knowledge and granting accessibility to a larger audience. More precisely she promoted atomic science in a world that knew the destructive effect of it as shown during the second world war. She stated herself that she "*organized an Atomic Gardening Society to co-ordinate and safeguard the interests of atomic mutation experimenters who would work as one body to help scientists to produce more food more quickly for more people, and progress horticultural mutation.*"³⁷

The atomic organisations that Muriel Howorth created including the Atomic Gardening Society can be considered as early versions of the social movement Do-It-Yourself biology (DIYbiology) officially created in 2008(SOURCE). According to the definition given by Donatella De la Porta and Mario Diani in their book "Social Movements, an introduction", social movements are "*involved in conflictual relations with clearly identified opponents; are linked by dense informal networks; share a distinct collective identity.*"³⁸ DIYbiology stand for enthusiast biologists. They argue that an academic degree in science is not needed to contribute to the scientific research and promote the participation of enthusiast biologist in research and development by spreading knowledge mainly on internet³⁹. They position themselves against the academic structure, organise their network online and share the Do-It-Yourself identity. The Atomic Gardening Society was an organised group of civilian to take action in promoting and participating in atomic science. It share the same goal as the social movement DIYbiology that was not defined yet. The Atomic Gardening Society

³⁶ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.553.

³⁷ Howorth, *Atomic gardening for the layman*, P.22.

³⁸ Donatella Della Porta and Mario Diani, *Social Movements: An Introduction*, (Malden, United States: Blackwell Publishing, 2006), P.20.

³⁹ DIY biology organisation, "home," DIYbio, wordpress, accessed December 5, 2018 on diybio.org.

was Social Movement Organisation or SMO part of an early and undefined DIYbiology social movement, specifically aimed at spreading atomic science among the non-scientists public.

The American sociologist Herbert Blumer identified four stages in the lifecycle of social movements: social ferment, popular excitement, formalization and institutionalization. Today those four stages are studied and known by sociologists as: Emergence, Coalescence, Bureaucratization and Decline.⁴⁰ These stages are visible in Muriel Howorth's activities and include the creation of the Atomic Gardening Society. They allow us to understand how atomic science entered British civilian's backyard.

Emergence

The first stage is characterised "*by unorganised, unfocused agitation during which great attention is paid to the propaganda of "agitators."*⁴¹ Potential movement participants are moved by a condition but they have not taken collective action yet.⁴² The English radiochemist Frederick Soddy wrote the book "*The Interpretation of Radium*" in 1909 as an attempt to open atomic science to a larger audience. Paige Johnson wrote of Frederick Soddy that he "*was convinced of the necessity of public engagement with science,*"⁴³ an opinion shared among the DIYbiology movement. Popularising atomic science is a political movement in the United States supported by the program Atoms for Peace, however in Britain and Europe there is no equivalent. Frederick Soddy's envy of including the public in atomic science can not be considered as a political movement as it was not supported by the British government. Frederick Soddy's movement spread and was shared by fellow scientists like Albert Einstein⁴⁴ and later by members of the public like Muriel Howorth when she read the book in 1948.

The Atomic Energy Association was the first of a series of organised groups Muriel Howorth created around the topic of atomic research. With her atomic organisations Muriel Howorth needed to prove to a suspicious public the potentials of

⁴⁰ Jonathan Christiansen, "Four Stages of Social Movements," EBSCO Research Starters, (2009), page 1, www.ebscohost.com/uploads/imported/thisTopic-dbTopic-1248.pdf.

⁴¹ Della Porta and Diani, *Social Movements: An Introduction*, P.150.

⁴² Christiansen, "Four Stages of Social Movements," P.2.

⁴³ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.553.

⁴⁴ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.555.

this technology. She had been convinced by Frederick Soddy's book, thereupon she tried to reach a greater audience by popularising and translating this scientific knowledge in more familiar formats for the neophyte. Muriel Howorth and her association actions served as "agitators" to bring attention to her cause. She used mainstream media to speak to a non-scientific audience.⁴⁵ She staged numerous plays with the theme of atomic science. In 1950, on the occasion of the second anniversary of the Atomic Energy Association of Great Britain, she staged *Isotopia: An Exposition on Atomic Structure, Written in the Form of a Mime* (author, Mrs Muriel Howorth) at the Aldwych Waldorf Hotel:

*"This is the kind of information which the Atomic Energy Association disseminates at its meetings here in the Waldorf, and at the meetings of any organisation which appeals for atomic information. The Ladies' Atomic Energy Club devised this Mime to make a visual presentation of the Peace-time uses of the atom . . ."*⁴⁶

At this stage Muriel Howorth was drawing attention on atomic science and her activities but it was unclear why and how the public could engage in atomic science themselves. Her societies were in perpetual evolution, according to Paige Johnson:

*"She adjusted names and adapted goals at will, leaving no record or reasons beyond the sudden appearance of a new letterhead, title or slogan. The Ladies' Atomic Energy Club was originally an auxiliary of the Atomic Energy Association, which was the precursor to the Institute of Atomic Information for the Layman, which itself morphed into the new Institute for Atomic Information."*⁴⁷

Later the Atomic Gardening Society was created. According to Donatella Della Porta and Mario Diani SMOs take up various forms to secure their survival, "*organizations [can be conceived] mainly as unstable coalitions of interest groups that determine goals through a negotiation process: the structure of the coalition, its activities, and its*

⁴⁵ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.556.

⁴⁶ Anon., "Foreign news: the explosion and all," Time, October 30, (1950), P.40, available online at www.time.com/time/magazine/article/0,9171,805562,00.html.

⁴⁷ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.557.

outcomes are strongly affected by environmental factors.”⁴⁸ This fits very well to the rapid development of names and goals of Muriel’s atomic projects.

Coalescence

In the second stage the objectives of action are clearer, potential members of the movement become aware of each other and leaders start to appear.⁴⁹ In 1952 Muriel Howorth wrote to Frederick Soddy to inform him of the creation of her first atomic society, the first SMO of this social movement.

Muriel Howorth was once a Laymen herself. She was not a scientist. She finished a diploma from the Royal Academy of Music and ventured into the world of film. She was herself an enthusiast biologist and, as Frederick Soddy, had the same desire to get the public involved in what she was fascinated by: atomic science. “*What is discovered by the scientist today must be made known, and must be implemented by the layman, for the layman, by you and by me, because it is for you and for me.*”⁵⁰ However she used different methods than Frederick Soddy to open atomic science to the public. Muriel Howorth used mainstream media to explain important and serious science.

She had a genuine talent for self-publication that presaged modern communication. She published books and papers about her activities that relates to today's blogging. As well as paying attention to the branding of her campaigns. She generated slogans, logos and letterhead that gave the impression of a large organisation, issuing press releases; self-publishing supporting documents; and attaching the organisation to a reputable public figure.⁵¹ She developed a successful process to create an SMO: form a society with an official sounding name, find a patron, stage an event and finally work the press.

In the 50’s Muriel Howorth started to build a large network. She first got in touch with major scientists in the atomic research. First Frederick Soddy, whom lead her interest toward atomic science, but also Albert Einstein who became patron of her first

⁴⁸ Della Porta and Diani, *Social Movements: An Introduction*, P.138.

⁴⁹ Della Porta and Diani, *Social Movements: An Introduction*, P.150.

⁵⁰ A Layman, “The Nobel prizewinner’s conference in Lindau, Bavaria”, *Atomic Digest*,(1953), P.18-25.

⁵¹ Johnson, “Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth,” P.555.

atomic organisation. She created relations with people of importance in the atomic science field by showing them interest and recognition for their work.

“Her fawning attitude toward scientists (Howorth’s works are replete with references to their nobility and genius) did not inhibit her approach to them; she simply wrote to Einstein, as she had to Soddy, as she later would to Niels Bohr, telling them of her ventures and asking for their support.”⁵²

In that way she was regularly invited to prestigious scientific meetings like the Nobel laureates in Bavaria, 1953-1954, to which she was personally invited by the conference organizer, Dr F.K. Hein. Her network gave credit to her organisations and good publicity among the scientific community. It also gave her access to scientific material like the irradiated peanuts from dr. Gregory, North California State College. After sending him one of her letters, he would reply back with 2 kilos of peanuts from atomic mutated plants.

Muriel Howorth had the strategic idea to gather a selected number of people around a diner table to whom she would cook the irradiated peanuts dr. Gregory sent her. The dinner party’s guests were all from different field but could all bring valuable help or approbation to Muriel Howorth’s activities. The American Embassy, the United Atomic Energy Authority, the Projects Department of the Ministry of Supply or the British Medical Research Council were represented and gathered by Muriel Howorth during this party.

From the leftover of those 2 kilos of irradiated peanuts, Muriel Howorth decided to plant one. The unusual growth and size of the peanut plant and later its cleverly exposure to the public at the Wannock Show Gardens and Nurseries created the media excitement. The public interest that follow this experiment lead her to create the Atomic Gardening Society.

“Mr. Mutch [head gardener of the Wannock Show Gardens and Nurseries] told me later he was more than interested in this first 'atomic peanut' but was somewhat bewildered when sightseers, looking in the cactus house window where the plant was installed, began

⁵² Johnson, “Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth,” P.555.

questioning him about the methods of atomic radiation and asking him if the nuts would be radioactive.”⁵³

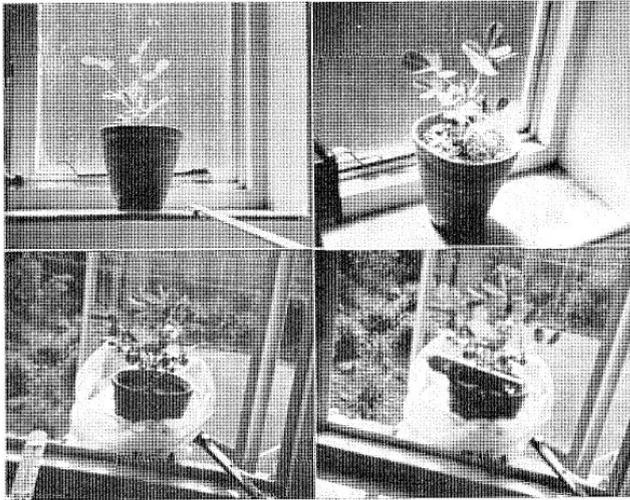


Plate 4

Image 7: Muriel Howorth’s own pictures of the growth of her irradiated peanut, took from her book, *Atomic Gardening for the Layman*.

She used cooking and later gardening, mainstream and women’s fields in the 50’s to gather people and promote Atomic science. This must have been successful as Muriel Howorth narrowed the action of her society to gardening as a mean to popularize Atomic research among civilian.

Bureaucratization

This third stage is defined by a disciplined participation from the stakeholders of the movement, distinct strategies developed and employed to reach the movements goals and the formalisation of a structured organisation.⁵⁴

It’s through the actions of gardening and cooking that the public knows Muriel Howorth. With those actions she was able to spread the atomic science and research. She

⁵³ Howorth, *Atomic gardening for the layman*, P.15.

⁵⁴ Della Porta and Diani, *Social Movements: An Introduction*, P.150.

learned about Speas activities and came up with the Atomic Gardening Society. Benefiting from the "media boom", she was now offering to the members of her societies in order to grow atom-blasted seeds from the United states⁵⁵.

*"I think it is well know that my concern has always been for the layman: that he should understand the fundamentals of atomic energy and how it can be used for the benefit of man in medicine, industry, and agriculture. I now felt that by some stroke of luck which it is difficult to ascribe to chance, I had been given the opportunity- so much longed for- to bring science right into the homes of the people."*⁵⁶

The newborn society combined what Muriel Howorth tried so hard to do with the previous one. It would bring the "good" atomic science closer to non-scientist individuals. It would empower women by introducing the world of science in their kitchen and garden (science was mainly populated by men in 1960). And it would help science move forward by providing a thousands of assistants growing random atom-blasted seeds to find interesting mutations.⁵⁷

*"Atomic Mutation Experimenters would work as one body to help scientists to produce more food more quickly for more people, and progress horticultural mutation. I had already 300 peanut enthusiasts. I knew that there were, in this country, too few plant geneticists and too few laboratories. I deduced that a few thousand assistants, working under supervision, would greatly assist the scientists to speed up this humanitarian and scientific work."*⁵⁸

On the other hand to help efficiently science organisation and structure was essential. Muriel Howorth gathered a scientific advisory board to supervise the science research aspects of the society's activities. *"Twelve offered me their help. There were six B.Sc.s (Hortic.); four gardening experts or breeders, heads of experimental or national gardens; and two plant geneticists not attached to government or university."*⁵⁹ She then

⁵⁵ Howorth, *Atomic gardening for the layman*, P.26.

⁵⁶ Howorth, *Atomic gardening for the layman*, P.22.

⁵⁷ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.569.

⁵⁸ Howorth, *Atomic gardening for the layman*, P.22.

⁵⁹ Howorth, *Atomic gardening for the layman*, P.23.

created an executive board to conduct the activities of the society. For informal meetings, conferences, exhibitions, and banquets, to the day-to-day office work, Major Howorth (her husband) was in charge as general secretary. Around thirty people experts in their own field were gathered and organised by Muriel Howorth herself to help and organise the activities of the society. People were willing to help and Muriel Howorth took the role of the society's president.

There is no records if those persons were compensated for their work nor if the society brought some sort of incomes to Muriel herself⁶⁰. The membership fees alone were not enough to cover the expense of the prestigious events Muriel Howorth organised. She lived in a modest house in Eastbourne with a retired officer husband. According to Paige Johnson she had no significant income and was often short in fund⁶¹. However Muriel Howorth was skilful to get people involved in her activities, it is highly possible that Members were volunteers and that she was given for free places and materials, using her well developed network.

*"I need hardly say that with this exceptional beginning, due to the interest and most generous help received from persons of note in the plant world, I am, myself, proud to act as its first president."*⁶²

There was two ways to participate to the Atomic Gardening Society, people who helped in the organisation were Members and people who just participated in the activities were Fellows. Every new Fellow was given a brochure, irradiated seeds and progress data cards. Muriel Howorth was very strict with the data card, they must be filled twice a day. Fellow were invited to *"Film-strip projections every first Saturday, club meetings third Wednesdays, quarterly symposia, the Ladies' Club every third Wednesday for tea and talks, and an anniversary dinner annually on 21 October at Claridge's Hotel, in addition to the publication of a quarterly digest."*⁶³

⁶⁰ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.562.

⁶¹ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.562.

⁶² Howorth, *Atomic gardening for the layman*, P. 24.

⁶³ Johnson, "Safeguarding the Atom: The Nuclear Enthusiasm of Muriel Howorth," P.562.

According to Muriel Howorth the beginning of the society were exciting times for every participants of the movement. The society was international, progress data cards came from as far as Australia.⁶⁴

Muriel Howorth and the Members of the society were fully dedicated to the Fellows, according to Donatella Della Porta and Mario Diani “*For people committed to a certain cause, organizations are an important source of continuity, not only in terms of identity, but also in terms of action.*”⁶⁵ The activities and participation of Fellows were strictly organised so everyone knew what they had to do to be part of this movement. However it asks a lot of patience to grow and get interesting results from irradiated seeds. The health state of Muriel Howorth progressively worsen and the society timidly disappeared.

Decline

Herbert Blumer describe the final stage as “institutionalization”, where according to him the movement becomes an organic part of society and turns into a professional structure. However Donatella Della Porta and Mario Diani argue that few SMOs get actually institutionalized. According to them the life expectancy of SMO is short. Their aims are limited, they are linked to a movement and dissolve as soon as the aim of the movement is reached. Also not all movement are successful.

The Atomic Gardening Society was an attempt to get an uninformed public to grow the movement using activities like gardening and cooking to introduce the subject of positive use of nuclear technology. Testimonies from former Fellows express what might have caused the decline of the society. It needed patience and luck to successfully grow an irradiated seed. Christopher Abbey was the youngest Fellow of the Atomic Gardening Society back in 1950, in his testimony he describes his unfruitful attempts “*I hasten to add that it would be generous to say that only 10% or so ever germinated and perhaps just 1% actually grew into successful plants.*”⁶⁶ This lack of success might have

⁶⁴ Howorth, *Atomic gardening for the layman*, P.24.

⁶⁵ Della Porta and Diani, *Social Movements: An Introduction*, P.138.

⁶⁶ Paige Johnson, “Oral Histories of the Atomic Gardens,” *Atomic Gardening: A Timeline of Events* (blog), January 5, 2017, www.atomicgardening.com/2017/01/05/oral-histories-of-the-atomic-gardens.

discourage Fellows of the society. Christopher Abbey also describes Muriel Howorth as demanding, asking for precisions and details when filling the data card, “*Muriel was fanatical about filling in the record cards, twice a day if possible with measurements and photos.*”⁶⁷ Asking a lot from people that are part of a society in their spare time might lead to drop out. Members and Fellows just can not give the investment asked from them. In the end Christopher Abbey confess that despite Muriel Howorth’s effort to popularise atomic science, most of the Fellows did not understand it.⁶⁸ Based on the testimonials it is clear that the decline of the Atomic Gardening Society is explained by a lack of successful experiments as well as demanding workload that might have discouraged people from participating.

In the beginning of the 60’s atomic sciences did not deliver on its promises, it did not provided free energy for all, ended world hunger or secured peace on earth. The public’s interest is turning over space with the launching of the first artificial satellite, sputnik 1, by the Soviet Union in 1957. The United States answered by creating the National Aeronautics and Space Administration (NASA) in 1958, hopes turned to the moon and the possibility to colonise space. Atomic science is part of the past and too linked to wars, the 60’s are known for their multiple peaceful movements that does not fit with the image of atomic science.

Paige Johnson found records of the Atomic Gardening Society til 1963⁶⁹. Some Atomic Gardeners were still sending reports but the last archival of the society found are from 1963. The movement did not fit the 60’s era, asked too much of its Fellows and did not provide enough satisfaction in its main activity: gardening.

5. Synthetic gardening for our homes

Plants mutated by radiation are still present today. The results of those scientific experimentation can be found in any supermarket. Rio star grapefruit, Gold Nijisseiki Japanese pear, Durum wheat and Reimei rice are the most common plants we can find

⁶⁷ Paige Johnson, “Oral Histories of the Atomic Gardens.”

⁶⁸ Paige Johnson, “Oral Histories of the Atomic Gardens.”

⁶⁹ Paige Johnson, “Oral Histories of the Atomic Gardens.”

that had been genetically engineered using radiations.⁷⁰ Mutations induced by radiation is one of the tools we use to modify the DNA of living organisms. It is not the safest one but somehow found its way into civilian backyard. The bio-tech field is engineering DNA manufacturing tools. In 2012 Jennifer Doudna and her team discovered the ability of CRISPR-cas9 to “edit” the DNA of any organism.⁷¹ CRISPR-cas9 is described as “the microsoft world of gene editing”, it is more precise, safer, cheaper and faster than any other gene editing technology engineered before.⁷² Our understanding of biology is increasing everyday and the movement of popularising science is stronger than ever.⁷³ The term biohackers is used for the amateur genetic engineers, they gather under the movement Do-It-Yourself Biology or DIY-Biology and are widely active online sharing informations for home-made laboratories.

Do-It-Yourself biology

Biological technology or Bio-tech recently made major breakthroughs, CRISPR-cas9 is one of them. According to the sociologist Everett Rogers "*As a body, the biotechnology industry is not unlike where the computer industry was in 1975*"⁷⁴, this year the build-it-yourself microcomputer Altair 8800 was released and Bill Gates and Paul Allen created a company called Micro Soft. Biology is not a field restricted to biologist as stated by DIYbiology. Attempts to bring the biological research and gene engineering tools into people’s home have been many as for example the Atomic Gardening Society. DIYbiology was officially founded by Jason Bobe and Mackenzie Cowell in 2008.⁷⁵ It is a biotechnological social movement that aim to popularise biological science and prove

⁷⁰ William J. Broad, “Useful Mutants, Bred With Radiation,” *The New York Times*, August 28, (2007), www.nytimes.com/2007/08/28/science/28crop.

⁷¹ Doudna and Sternberg, “A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution.”

⁷² Molteni, “Everything You Need To Know About Crispr Gene Editing.”

⁷³ Sylvan Katz, “Forum: Roses Are Black, Violets Are Green – The Emergence of Amateur Genetic Engineers,” *New Scientist*, (1990), accessed December 5, 2018 on www.newscientist.com/article/mg12516984-100-forum-roses-are-black-violets-are-green-the-emergence-of-amateur-genetic-engineers.

⁷⁴ Michael Schrage, “PLAYING GOD IN YOUR BASEMENT,” *Washington Post*, January 31, (1988),

www.washingtonpost.com/archive/opinions/1988/01/31/playing-god-in-your-basement/618f174d-fc11-47b3-a8db-fae1b8340c67/.

⁷⁵ DIY biology organisation, “DIYbio.”

that one does not need any academic degree in biology to significantly contribute to the biological community. The actions of Muriel Howorth and her Fellows could be considered as the ancestors of this modern movement, their aims are really similar but the context when they happen is maybe the key factor of its success.

The means to share information are radically different from those available back in 1960. The rise of internet and platforms of communication like social media, blogs and forums allows people to share any kind of information from anywhere with an internet access. DIYbiology is present online with their official website: diybio.org. They welcome any enthusiast biologist to enter the community, point out to nearest projects or physical community. According to the researcher Sylvan Katz in his article “*Roses are black, violets are green: The emergence of amateur genetic engineers*”:

“A biohacker needs relatively little by way of equipment and supplies. With some ingenuity and access to a basement workshop, a would-be biohacker could construct a sterile work bench, shaker, vacuum pump, centrifuge and distillation apparatus from inexpensive materials and junkyard supplies. The modern kitchen with a microwave oven, dishwasher, refrigerator and blender is an excellent source of additional equipment. Biohackers could acquire commercial grade sugars, salts, acids, bases, alcohols, minerals, vitamins and even some antibiotics and hormones from the supermarket, garden centre and pharmacy, and from veterinary, photography and industrial chemicals supply outlets.”⁷⁶

We could consider DIYbiology/biohackers movement as entering the coalescence phase. They get more and more attention from the public and potential leaders such as Josiah Zayner or the Waag society in Amsterdam starts to appear. The development of CRISPR-cas9 and its possible applications bring even more attention and concern to biohackers and DIYbiology movement. It triggers the imagination of the members of the movement but also the public. DIYbiology is a wide organisation and is lacking official structures. Practicing biology in a hobbyist way was present in Muriel Howorth’s society and is now growing by joining the already well established “makers” movement.

⁷⁶ Katz, “Forum: Roses Are Black, Violets Are Green – The Emergence of Amateur Genetic Engineers.”

Bio Fablab

The boom of the digital field led to technologies closer to the individual scale. The bio-tech field seems to be on the same pathway than the digital field was 40 years ago as stated by Everett Rogers. Prior to 1975 computers were big and expensive. They were confined in laboratories and only used by computer engineers. The microcomputer Altair 8800 changed the state of computers, less expensive and smaller it was also possible to enthusiast computer engineers to build it themselves. The digital field was marked by this wave of enthusiasts computer engineers and those self-funded companies. The famous technology company Apple created in 1976 in Steve Job's garage sold handmade computer assemble by Steve Job's associate Steve Wozniak.

The bio-tech field was marked by CRISPR-cas 9 the cheapest and explicitest gene engineering tool, it is a big step toward individual gene editing tool. Moreover DIYbiology benefit from the makers movement that rose with the creation of the Fablab concept in 2001 from the collaboration between the Grassroots Invention Group and the Center for Bits and Atoms at the Media Lab in the Massachusetts Institute of Technology.⁷⁷

Fablabs provide digital machines and tools to all for the individual, according to the brothers Gershenfeld in their book "*Designing Reality: How to Survive and Thrive in the Third Digital Revolution.*" Fablabs have for priority to be accessible to all. They gather enthusiast inventors and teach one another inside the community how to use the digital and computer assisted machines. This "maker spirit" was also found in Muriel Howorth's society, gathering a public interested in atomic science, teach on an other inside the society and produce new plants. The management and structure of Fablabs are similar, the brother Gershenfeld highlight the need to build a solid ecosystem around a Fablab to ensure its success. This consist in involving a large number of different stakeholders, a strategy we found also in Muriel Howorth network building.

"The alignment of these stakeholders is not a one-time event, but a continuing accomplishment, advancing progress toward the threshold challenges of universal fab

⁷⁷ Neil Gershenfeld, Alan Gershenfeld, and Joel Cutcher-Gershenfeld, *Designing Reality: How to Survive and Thrive in the Third Digital Revolution*, (New York, United States: Basic Books, 2017).

*access and literacy (our primary focus here), and other threshold challenges such as risk mitigation.”*⁷⁸

Fablabs and the Atomic Gardening Society are both SMOs of a similar social movement: open science and technology to the larger public. Likewise, DIYbiology is a specific part of this bigger movement but can enjoy the numerous structures created by the makers movement such as Fablabs. Some of those structures already developed a biology part of their activities. The Waag Society is a Fablab and a Fabacademy, defining itself as “*a middle-ground organisation composed of research groups that work with both grassroots initiatives and institutional partners across Europe*”⁷⁹. They created the “Wetlab”, described as “*a leading place for bio-art, biodesign and do-it-together biology in the heart of Amsterdam.*”⁸⁰ The Wetlab publicly assume its connection to the biohackers community and DIYbiology movement, they host meetings with biohackers of Amsterdam and teach any enthusiast biologist how to create their own laboratory and basic biology operations.

New gene editing tools such as CRISPR-cas9, as they are cheaper and easier to use, greatly interest communities and structures like the Waag society. They have the knowledge and capital to invest in those early prototypes of gene editing bio-machines. If the bio-tech field follows a similar rate of technological breakthrough as the digital field did we can expect to each own a small CRISPR-cas9 bio-machine by 2060.

Toward crispr-cas

Internet overflow with informations, step-by-step tutorials are shared on the video platform Youtube, black market use cryptocurrencies for their illegal exchanges and groups are created on Facebook to gather biohackers of the world. Exchanges are faster

⁷⁸ Gershenfeld, Gershenfeld, and Cutcher-Gershenfeld, *Designing Reality: How to Survive and Thrive in the Third Digital Revolution*, P.225.

⁷⁹ Waag Technology and Society, “about us,” Waag, Waag Technology and Society, accessed December 6, 2018 on waag.org/en/about-us.

⁸⁰ Waag Technology and Society, “open wetlab,” Waag, Waag Technology and Society, accessed December 6, 2018 on waag.org/en/labs/open-wetlab.

than ever and hard to control. Debate on the patent of CRISPR-cas9 continues⁸¹ but the gene editing tool has been shared openly in numerous scientific papers. The believe in “science for all” movement is massively shared among the scientific community and Do-It-Yourself CRISPR-cas9 are already available on internet. The ODIN is an American company that sells tools and materials to edit DNA of bacterias, plants, animals and humans. The creator of the company Dr.Josiah Zayner is a global leader of the Biohackers movement and believes the following: “*the future is going to be dominated by genetic engineering and consumer genetic design will be a big part of that.*”⁸² They sell various starter kit using CRISPR-cas9 from 159\$ and ship worldwide. Kits are sent with instructions and informations about the technology, the website itself gives numerous precise and useful information for any beginners. CRISPR-cas9 can already be in our home.

⁸¹ Joe Stanganelli, “The State Of CRISPR/Cas9: Patents And Possibilities,” bio-it world, October 25, (2017), accessed December 6, 2018 on www.bio-itworld.com/2017/10/25/the-state-of-crispr/cas9-patents-and-possibilities.aspx.

⁸² The Odin, “About Us,” the odin, George Church and Josiah Zayner, accessed December 6, 2018 on www.the-odin.com/about-us.

Conclusion

Thanks to dedicated enthusiast of atomic science, Clarence J. Speas and Muriel Howorth, the gene editing technology: radiation breeding entered the civilian backyard in England and spread as far as Australia. Their collaboration and the massive network building and promoting work of Muriel Howorth, made atomic research available to enthusiast biologists. She developed several strategies to get help and approbation from governments and institutions officials but also to popularize atomic science among civilian by employing mainstream activities such as cooking and gardening. She created the Atomic Gardening Society to organise the movement she lead. The society disappeared because of the loss of its main leader, a lack of results and a shift of interest of the worldwide public.

Today biotechnology with the engineering of CRISPR-cas 9 gene editing tool follows a similar path as the digital field in 1975. Gene editing technologies become so cheap and easy to use that DIY kits are already sold online. Unlike the Atomic Gardening Society the DIYbiology movement and organisations such as the Waag Society benefit from the digital revolution, the internet. Exchange are easier and faster through the internet, DIYbiology does not depend on one leader and one physical organisation. Because of internet DIYbiology gathers knowledge, people and structures throughout the world, they can organised themselves in a decentralised way which insures a longer survival of the the movement.

Josiah Zayner could be compared as Clarence J. Speas. He is a biohacker himself and founded a company that sells tools and products to operate gene editing in your home. The Waag society is compatible to the Atomic Gardening Society. It is a structure that belongs to the DIYbiology movement. It is not known if the two are aware of each other but they do belong to the same movement and are both present online on platforms such as diybio.org.

Breakthrough gene editing technology such as CRISPR-cas 9 are already available to the non-scientist public and benefit, in some countries, of physical support from open organisations such as the Wetlab in Amsterdam.

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List of Images

Image 1 & 2: “Born from the Bomb.” *Atomic Gardening: A Timeline of Events* (blog), accessed November 9, 2018, on www.atomicgardening.com/1945/08/09/nagasaki-plant-mutations.

Image 3: A flowering garden represents ‘Progress’ in an exhibition at Dorland Hall, London, depicting the two potential roads of atomic energy. The exhibition, part of the ‘Atom Train’, was the first to present atomic energy to the public and was sponsored by the British Atomic Scientists Association. Photograph credit: Reg Birkett/Keystone/Getty Images, ‘A choice of future’, 23 January 1947.

Image 4: “Atoms for Peace.” *Atomic Gardening: A Timeline of Events* (blog), accessed November 9, 2018, on www.atomicgardening.com/1953/12/08/atoms-for-peace.

Image 5: One of the first gamma-garden was built at Brookhaven National Laboratories in Rhode Island, in 1949. By 1958 atomic agriculture had been taken up in government laboratories around the world: Virginia, Florida, Wales, Sweden, Norway, Russia and Costa Rica.

Image 6: Atom-blasted seed rack in store which will produce mutations – May 1958
Photographer: Grey Villet Photo: Life hosted by Google.

Image 7: Muriel Howorth’s own pictures of the growth of her irradiated peanut, took from her book, *Atomic Gardening for the Layman*.