

1 **75 Years ago *Arabidopsis* was first suggested as a Model Plant – But how did *Arabidopsis***
2 **Col-0 become the standard Natural Accession?**

3 **A short history of *Arabidopsis thaliana* (L.) Heynh. Columbia-0**

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8 **The Origin of *Arabidopsis thaliana* Research (1905 – 1943)**

9 Modern work with *Arabidopsis thaliana* goes back to the German botanist Friedrich Laibach
10 who, while working as a Ph.D. student in the laboratory of Eduard Strasburger in Bonn, analyzed
11 the number of chromosomes in different plants that he had collected around Bonn and his
12 hometown Limburg^{1,2}. The first *Arabidopsis* plants to be experimented on were collected by
13 Laibach in 1905, and belonged to the natural accession Limburg (Laibach introduced a system of
14 naming the natural accessions after the places he collected them from)². Laibach found that they
15 carried 5 pairs of chromosomes, one of the smallest numbers known at the time (he published his
16 results in 1907, even though *Arabidopsis* was only included in the written thesis, but not
17 specifically mentioned in the paper)¹⁻³. Unfortunately, the natural habitat of the Limburg
18 population was destroyed shortly after to make way for the new “Autobahn” (highway),
19 connecting the cities of Frankfurt and Köln². At the time, *Arabidopsis* was ‘only known to florists
20 and taxonomists, who had nothing better to do than constantly change its name and systematic
21 positioning’, as Laibach put it in 1965². However, he became interested in the little weed, and
22 between 1930 and 1950 collected seeds from over 150 different natural accessions (or races, as
23 he called them) of *Arabidopsis* from anywhere he or his colleagues travelled to^{2,4}. Laibach kept
24 all of these individual seed lines meticulously organized and maintained in his Department at
25 Frankfurt University, and his collection eventually formed the foundation of the *Arabidopsis*
26 Information Service (AIS) seed bank in the 1960s, which itself served as the basis for the modern
27 Columbus (ABRC), Nottingham (NASC) and Tsukuba (RIKEN) stock centres decades later^{2,5,6}.

28 ***Arabidopsis thaliana* First Proposed as a Plant Model (1943 – 1957)**

29 Laibachs’ interest and preliminary studies of *Arabidopsis* eventually resulted in a now famous
30 publication titled ‘*Arabidopsis Thaliana* (L.) Heynh. als Objekt für genetische und

31 entwicklungsphysiologische Untersuchungen' (*Arabidopsis Thaliana* (L.) Heynh. as an object
32 for genetic, developmental and physiological analyses'), in which Laibach points out the benefits
33 of working with *Arabidopsis* (easy to grow, small genome, short lifecycle, high seed yield, can be
34 crossed and mutated...)³. Based on these observations he proposed to adopt *Arabidopsis* as a
35 model organism for plant science, pointing out how comparable it is in its suitability to the 'prime
36 example' of other models, *Drosophila melanogaster*³. This proposal however, was largely
37 ignored by the scientific community at the time, who needed almost another 40 years to finally
38 see the light and adopt *Arabidopsis* as a plant model system⁷. One academic who shared
39 Laibach's enthusiasm for *Arabidopsis* was György P. Rédei from Hungary, who in 1955 had just
40 finished his Ph.D. thesis, working on tomato and wheat⁸. After reading Laibach's article, Rédei
41 recognized the potential of *Arabidopsis* for genetic studies, and with the help of his supervisor,
42 Prof. Györffy, he asked Laibach for some *Arabidopsis* seeds to start his own work on this new
43 model⁸. The seeds he obtained were the four natural accessions Graz, Limburg, Estland and
44 Landsberg⁹. Rédei took these four lines with him, when he left Europe to start his own laboratory
45 at the University of Missouri in Columbia, Mo⁹. For the next 20 years Rédei remained the only
46 researcher working on *Arabidopsis* in the United States; or, as his former colleague Prof. Doug
47 Randall put it, "George was 20 to 30 years ahead of his time"¹⁰. This situation, however, made it
48 incredibly hard for Rédei to receive funding⁹. In fact, one of his funding applications to the
49 National Science Foundation was now famously rejected on the basis that '*the genetics panel*
50 *does not believe that it is worthwhile to develop Arabidopsis as a new model organism for*
51 *genetic studies because only prokaryotes can contribute significantly to new knowledge*'⁹. But
52 Rédei refused to give up on *Arabidopsis* and from the four seed lines he had received from
53 Laibach, chose Landsberg as his model for future work. This choice was due to that Estland
54 phenotypically did not match its description and Graz was late flowering, while Landsberg
55 matched the description and seemed vigorous and healthy (it is not clear on which grounds
56 Limburg was dropped)⁹.

57 **The Columbia and Landsberg *erecta* lines Emerge (1957 – 1965)**

58 In 1957 Rédei used his Landsberg seeds in a mutagenesis experiment, where he irradiated the
59 seeds with X-rays and then screened for mutants with interesting phenotypes (meanwhile, in
60 Australia, John Langridge was doing the same for Estland seeds he had received from
61 Laibach)^{9,11-13}. Gene mutagenesis by X-ray irradiation had been described in the 1920s for

62 *Antirrhinum* and *Drosophila*, and one of Laibach's students, Erna Reinholz, went on to establish
63 this technique for *Arabidopsis* seeds^{4,14-16}. One of the first mutants Rédei recovered was the
64 *erecta* mutant, which, with its stunted growth, appeared to be quite sturdy, and he thought it
65 might come in handy for further experimentation^{9,17}. He published the Landsberg *erecta* mutant
66 in a paper dealing with heterosis, despite not being sure if the importance of his observation
67 warranted a full publication¹⁷. His paper therefore opens with the paragraph '*The author feels*
68 *somewhat hesitant to add to the large volume of the literature on the subject but its practical*
69 *importance and theoretical interest prompt the decision in favor of this brief account*'¹⁷.
70 However, in his mutagenesis screen Rédei also realized that the original Landsberg population
71 was actually not a homogenous line, but appeared to be a mix of different lines^{9,11}. Therefore, he
72 chose a single plant from the batch that he had not irradiated, to establish a new, clean line for all
73 further studies^{9,11}. Following Laibach's example of naming the different natural accessions after
74 the location where he found them, he named his new line Columbia^{9,11}. So interestingly,
75 Columbia is an American plant by name, but a central European plant by genetic heritage –
76 something that can be demonstrated experimentally, when analysing its genetic polymorphisms¹⁸.
77 In 1959, another plant biologist, Willem Feenstra from the University of Groningen in the
78 Netherlands, visited Rédei in Columbia and took the Landsberg *erecta* line with him for his own
79 research, establishing this line as a standard in Europe, while Rédei concentrated his work on his
80 own Columbia line^{9,11,19}.

81 ***Arabidopsis thaliana* gets its Breakthrough (1965 – 1996)**

82 In the following two decades, interest in *Arabidopsis* research slowly increased. By the mid-
83 1960s, the AIS (<https://www.arabidopsis.org/ais/newaisvols.jsp>) was established as a yearly
84 newsletter to connect the small *Arabidopsis* research community, and in 1965 the first
85 International Arabidopsis Symposium in Göttingen, Germany, already attracted a full 25
86 participants^{20,21}. The AIS would eventually evolve into the now invaluable The Arabidopsis
87 Information Resource (TAIR) database²². As a result of this increased interest, György Rédei
88 decided to take up Laibach's suggestion from 1943, and published the second article calling for
89 the acceptance of *Arabidopsis* as a plant model in 1975, simply titled '*Arabidopsis* as a genetic
90 tool' (where he pointed out the same benefits Laibach had already pointed out 30 years earlier)²³.
91 Following this publication and a couple of highly influential papers from people like Maarten
92 Koornneef (who worked with Will Feenstra), or Chris R. Somerville and Elliott M. Meyerowitz

93 (converts from the model organisms *Escherichia coli* and *Drosophila melanogaster*,
94 respectively), *Arabidopsis* finally got its break in the early 1980s^{7,24-26}. With *Arabidopsis* now
95 finally established, the third article discussing its role as a model (published in 1985 and pointing
96 out the same benefits that Rédei and Laibach had pointed out 10 and 40 years earlier) was now
97 published in the prestigious *Science* journal⁷.

98 **Col-0 takes over as the Standard Accession (1996 – today)**

99 During the next decade, *Arabidopsis* research was mostly done using the Landsberg *erecta*
100 accession, even though Columbia also regularly appeared, especially in US laboratories or from
101 groups that had obtained seeds directly from Rédei. However, this was about to change when, in
102 1996, Columbia was chosen as the natural accession for the sequencing and annotation of the
103 complete *Arabidopsis* genome²⁷. Despite Landsberg *erecta* being more commonly used at the
104 time, this choice was the obvious one in this case, because the Landsberg *erecta* line had
105 previously been subjected to X-ray irradiation, and therefore carried several unnatural mutations,
106 while Columbia had been maintained as a clean homozygous line^{11,27}. Shortly after the genome
107 was eventually published in the year 2000, Columbia was also chosen as the natural accession for
108 a genome-wide mutagenesis project at the SALK institute in San Diego, resulting in the SALK
109 collection of T-DNA insertion lines – still the biggest resource of ready-to-order *Arabidopsis*
110 mutants²⁸. Following these two massive projects, it was clear that Columbia was firmly
111 established as the number one natural accession for *Arabidopsis* research, while the use of
112 Landsberg *erecta* has been declining ever since. And this all just because the Landsberg batch
113 that György Rédei received from Friedrich Laibach in 1955 was not a homogenous line.

114 **Addendum> What about the ‘(L.)’ and the ‘Heynh.’ behind *Arabidopsis thaliana*, and the ‘- 115 **0’ behind Col?****

116 The ‘(L.)’ and ‘Heynh.’, which are often found after *Arabidopsis thaliana*, are so-called
117 ‘authorities’ - the official author abbreviation of the person who gave the plant its name²⁹.
118 Though *Arabidopsis thaliana* was first described by Johannes Thal, who gave it the name
119 *Pilosella siliquosa minor*, it was Carl Linnaeus who named it *Arabis thaliana* (*thaliana* in honour
120 of Johannes Thal)^{30,31}. Therefore, the ‘(L.)’ behind genus and species is the author abbreviation
121 for Carl Linnaeus^{30,31}. Botanist Gustav Heynhold then merged similar plants into one new genus,
122 *Arabidopsis*, signifying *Arabis-like*, and added his own author abbreviation, ‘Heynh.’, behind the

123 one from Linnaeus (Heynholds book ‘*Flora von Sachsen*’ is generally cited here, though I could
124 only find *Arabidopsis* in his book ‘*Nomenclator botanicus hortensis*’)^{30,32,33}. The ‘0’ behind the
125 Col name, on the other hand, signifies the source of an individual seed line³⁴. Over the years,
126 different laboratories that received Col seeds from György Rédei have propagated and
127 maintained their own inbred lines of the original batch. When all these lines were later donated to
128 the seed centres, a numbering system was developed to be able to distinguish these individual
129 lines³⁴. In this system, George Rédeis’ Columbia line in the ABRC stock centre would be named
130 Col-1/CS3176, or Col-1 in short³⁴. The name is made up of [wild type]-[originator]/[maintainer
131 stock-#], with the wild type being ‘Col’, the originator George Rédei, who was designated the
132 number 1, and the maintainer, the ABRC stock centre, carrying it under the stock number 3176³⁴.
133 The line donated by Shauna Somerville to the ABRC, a direct descendent of Rédeis’ Col-1, is
134 Col-2/CS907, or in short, Col-2³⁴. Confusingly, the Col-0 line (Col-0/CS1092) is actually a
135 descendent of Rédeis’ Col-1 line³⁴. It received the lower originator number 0 because it was
136 already maintained and propagated in the original AIS-seed bank by Albert Kranz, and is
137 therefore an ‘older’ stock⁵.

138 **More ‘History of *Arabidopsis*’ Resources:**

- 139 - Friedrich Laibach - 60 Jahre *Arabidopsis*-Forschung, 1905-1965²
 - 140 - György P. Rédei - *Arabidopsis thaliana* (L.) Heynh. A review of the genetics and biology³⁰
 - 141 - Elliot M. Meyerowitz – *Arabidopsis thaliana*³⁵
 - 142 - Chris R. Somerville – *Arabidopsis* blooms³⁶
 - 143 - György P. Rédei - A heuristic glance at the past of *Arabidopsis* genetics⁹
 - 144 - Elizabeth Pennisi - *Arabidopsis* Comes of Age³⁷
 - 145 - Elliot M. Meyerowitz – Prehistory and history of *Arabidopsis* research³⁸
 - 146 - Chris R. Somerville, Maarten Koornneef - A fortunate choice²⁰
 - 147 - Sabina Leonelli - *Arabidopsis*, the botanical *Drosophila*³⁹
 - 148 - Sabina Leonelli - Growing Weed, Producing Knowledge An Epistemic History of *Arabidopsis*
149 *thaliana*⁴⁰
 - 150 - Maarten Koornneef, David Meinke - The development of *Arabidopsis* as a model plant⁴¹
 - 151 - Ute Krämer - Planting molecular functions in an ecological context with *Arabidopsis*
152 *thaliana*⁴²
 - 153 - Nicholas J. Provart et al. - 50 years of *Arabidopsis* research⁴³
- 154

155 **Acknowledgments**

156 Thanks to Imre E. Somssich, Benjamin Schwessinger, Magnus Nordborg, Detlef Weigel, Rüdiger
157 Simon, Kelsey L. Picard and Staffan Persson for helpful comments and support, and the Deutsche
158 Forschungsgemeinschaft (DFG) for funding (project 344523413).

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168 [MTk0My5wZGY=&cidReset=true&cidReq=300415WS14](http://131.130.57.230/clarotest190/claroline/backends/download.php?url=L0xhaWJhY2gtMTk0My5wZGY=&cidReset=true&cidReq=300415WS14)
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