

# On the origin of the *Retinospora* forms in *Thuja*, *Biota* and *Chamaecyparis*

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In species of *Chamaecyparis*, *Thuja* and *Biota* the morphologically very distinct developmental stages are a characteristic feature.

As the seedlings grow out from seeds they have needle leaves which resemble the needles of *Juniperus communis*, common in this country. This first stage lasts usually from 10 to 12 weeks, then shoots with scale leaves appear. The intermediate stage, during which the two kinds of leaves are present, may last for several weeks, and even several months. During this stage the primordial leaves gradually disappear and the newly growing shoots have only scale leaves, same as those on fully mature shoots.

It is very interesting that gardeners have succeeded to perpetuate these separate stages, and one often sees in gardens specimens several years old with juvenile leaves. Because these forms deviate from the normal type, they have at first been named „*Retinospora*“, a name used even now, synonymously. Thus in the *Thuja occidentalis* L. species there is a juvenile form with needle leaves the name of which is *Th. occ. Ohlen-dorfii* Beissner, and for which the synonyms are: *Th. occ. ericoides* Beissner & Hochst, *Th. ericoides* hort., *Retinospora ericoides* hort., *Retinospora dubia* Carr. The perpetuated intermediate form is known under the name of *Th. occ. var. Ellwangeriana* Beissn. and synonymously *Retinospora Ellwangeriana* hort. Fig. 1. illustrates these forms.

From *Biota orientalis* Endl. species a seedling form has been separated. and perpetuated. The different synonymous names given to it are: *Biota orientalis decussata* M a s t., *Retinospora flavescens* hort., *Retinospora juniperoides* Carr., *Retinospora rigida* Carr., *Retinospora squarrosa* hort., *Chamaecyparis decussata* hort., *Juniperus glauca* hort., *Frenela glauca* hort. The name given to the intermediate form in this species is *Biota orientalis meldensis* Mast., of which the synonyms are: *Biota meldensis* Laws., *Thuja*

*meldensis* hort., *Thuja hybrida* hort., *Retinospora meldensis* hort. The seedling form of the *Chamaecyparis pisifera* Endl. appeared about 1843, and is named *Ch. p. squarrosa* Beissn. & Hochst., its synonymes are: *Chamaecyparis squarrosa* Sieb. et Zucc., *Ch. leptoclada* Endl., *Ch. veitchii*

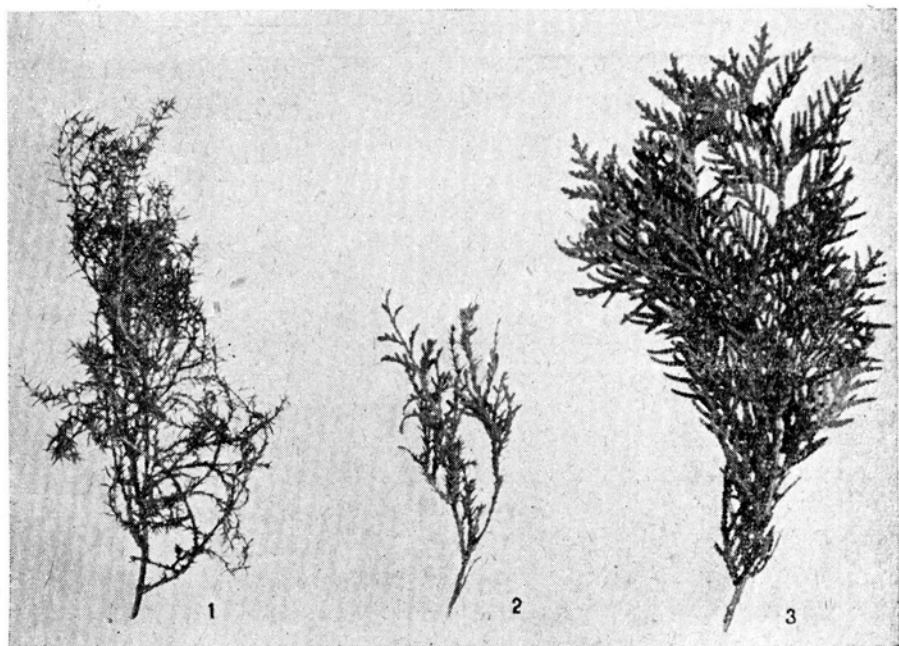


Fig. 1. Left: — *Thuja occidentalis* var. *Ohlendorffii*, center: — *Thuja occidentalis* var. *Ellwangeriana*, right — *Thuja occidentalis*.

hort., *Cupressus squarrosa* Laws., *Retinospora squarrosa* Sieb. et Zucc., *Retinospora glauca* hort., *Retinospora leptoclada* Sieb. The perpetuated intermediate form is named *Chamaecyparis pisifera plumosa* Otto, and synonymously: *Ch. plumosa* hort., *Retinospora plumosa* Veitch. In the *Chamaecyparis thyoides* Brotton species there also are two forms, the seedling form, named *Ch. th. ericoides* Sudworth. with synonyms: *Cupressus ericoides* hort., *Juniperus ericoides* Nois., *Frenela ericoides* hort., *Retinospora ericoides* Zucc., *Widdringtonia ericoides* Knight: and the intermediate form obtained in 1850 in Andeleys in France and named *Ch. th. Andeleynsis* Schneider the synonyms of which are: *Ch. leptoclada* Sudw., *Ch. sphaeroidea* var. *andeleynsis* Carr., and *Retinospora leptoclada* Gordon. Finally, in the *Chamaecyparis obtusa* Endl. species there is a seedling form very distinctly deviating from the normal type the name of which is: *Ch. obt. ericoides* Boehmer with synonyms: *Juniperus Sanderii* hort., *Retinospora obtusa* Sieb. et. Zucc., *Retinospora Sanderi* San-

der. Also in this species there are intermediate forms: *Ch. obt. Keteleeri* Staud., and the very similar in its outward appearance *Ch. obt. Crippsii* Rehder, obtained some 80 years ago by the gardener Cripps in his nursery in Tunbridge Wells.

The important differences in the foliage and even the shape of the perpetuated juvenile forms and the species from which they are derived have caused the long persistent opinion that these forms belong to separate genera (*Retinospora*, *Frenela*, *Widdringtonia*). This opinion is shared, among others, by the eminent French dendrologist Carrière (6). C. Koch is the first to affirm that the *Retinospora ericoides* form is derived from *Thuja occidentalis*. L. The origin of the remaining forms has been established, in most cases by the eminent German dendrologist, L. Beissner. The papers in which this writer explains how both the seedling and the intermediate forms originated were published in the well-known journal „Gartenflora“ in 1879, and 1882. (1. 2. 3).

In his paper „Beobachtungen ueber aechte und falsche *Chamaecyparis* (*Retinospora*)“ Gartenflora 1879, Beissner states that the more exactly these forms are analysed and compared, the more evident it becomes, that they all are juvenile forms (Je genauer wir diese verschiedenen Pflanzen betrachten und vergleichen, desto mehr werden wir in dem Gedanken bestaerkt, dass sie alle ohne Ausnahme nur jugendliche Pflanzen darstellen“).

Undoubtedly Beissner must be credited with the merit of establishing the origin of most seedling and intermediate forms. His studies have checked the utter confusion caused by giving various names to the different forms of one species.

However, the problem how these forms have been perpetuated is not yet elucidated sufficiently. L. Beissner thinks that in all cases both the seedling and the intermediate forms are perpetuated by the simple process of making cuttings from ends of seedling shoots, while they still are in the primordial state. The perpetuation of these forms would be the work of Japanese gardeners. („Ihr durchweg dichter, gedrungener Wuchs, die Unfruchtbarkeit grösserer Exemplare, dann auch die bekannte Vorliebe der Japaner, zwergige Pflanzen zu erziehen, müssen uns den Gedanken erwecken, dass wir es mit jugendlichen, künstlich durch Stecklinge fixirten Formen zu tun haben“). Further on in this paper L. Beissner states that the *Thuja occidentalis* var. *ericoides* form (according to Dallimore and Jackson, Handbook of Coniferae — *Th. occ.* var. *Ohlendorfü*) is raised by planting cuttings from shoots of young *Thuja occidentalis* seedlings. The plants so obtained are not capable to produce scale leaves („hier ist also die Pflanze in der ersten Entwicklungs-

periode durch Stecklinge fixirt, nicht faehig Schuppenformige Zweige zu bilden). Also the intermediate form of *Th occ.* var *Ellwangeriana* is obtained, according to this author, in the same manner, and it is his opinion that everyone can repeat such an experiment, („Zum Ueberfluss kann ein Jeder von Sämlingen der *Thuja occidentalis* die Zweigchen, mit nur linienfoermigen Blättern, dann solche, wo beide Formen vertreten, abschneiden und das Experiment nachmachen. Auch ich that dies und erzog genau dieselben Pflanzen“).

All this, according to *B e i s s n e r*, is also true in the case of different *Biota (Thuja) orientalis* forms, and primarily in the case of the intermediate form known under the name of *Biota meldensis*. („Der klarste Beweis für obige Abstammung aber ist, dass *Biota meldensis* als Samen zu *Biota orientalis* zurückkehrt, wie ich dies selbst erprobt habe. Ueberdies steckte ich die Zweigchen, die den Uebergang von den nadelförmigen zu den schuppenförmigen bilden von *Biota orientalis* geschnitten und erhielt daraus *Biota meldensis*“).

In the second paper on variations in Conifer seedlings — „Ueber Formveränderungen von Coniferen-Sämlingen“, Gartenflora 1879, — *B e i s s n e r* discusses the possibility of raising the juvenile form *Chamaecyparis squarrosa* (*Ch. pisifera* Sieb. et Zucc.) from *Biota orientalis* cuttings. Though, in this case his estimation of the origin of this form is wrong, he stresses that if *Chamaecyparis squarrosa* is to be raised from *Biota orientalis* cuttings, the small branches with needle leaves found just above the cotyledons must be careffully chosen for making the cuttings. („Um *Chamaecyparis squarrosa* aus Stecklingen von *Biota orientalis* wieder zu erziehen, muss man genau darauf achten, nur die kleinen Zweigchen mit kreuzständigen Blättern, welche wir dicht ueber den Samenlappen finden, zu wählen“). In the same paper, he reports that in this way he succeeded to perpetuate a similar form of *Thuja articulata*. („Ich fixirte solche Zweige von *Callitris quadravalvis (Thuja articulata)* durch Stecklinge. Diese Pflänzchen zeigen jetzt theils linienförmige Blätter, theils weitgliedrig spitzig-schuppenformige Zweige, die bisher nicht in die ausgebildete Pflanze uebergehen und daher für den Beschauer, welcher die Entstehung nicht kennt, eine neue hübsche Form darstellen“).

*L. B e i s s n e r*'s theory that seedling and intermediate forms of *Biota*, *Thuja*, *Chamaecyparis* and other species can be perpetuated by cuttings was questioned soon after his papers were published, and in 1882 a paper entitled: „Stecklingspflanzen von *Cupressus funebris* bilden dennoch vollkommene Bäume“ (8) was published against it in the Gartenflora. The author of this paper writes: („Die Annahme derjenigen, welche unbedingt darauf schwören, dass Stecklingspflanzen von Cupressineen, welche im jugendlichen Zustande von noch nicht mit voll-

kommen ausgebildeten Blättern versehenen Pflanzen geschnitten wurden, zeitlebens so verbleiben, wodurch jene zahlreichen angeblichen Retinosporen entstanden seien, — erleidet doch Ausnahmen. Meine alten Pflanzen von *Cupressus funebris* stammen sämtlich als Stecklinge von Pflanzen, welche noch die Nadelform der Blätter hatten, was bei diesen Coniferen sehr lange dauert. Aber diese Pflanzen bildeten, nachdem sie die gehörige Grösse erlangt hatten, genau dieselben vollkommenen ausgebildeten Blätter (Schuppen), wie die ältesten ausgebildeten Bäume, wenn auch im Innern unterdrückte schwache Zweige vom Anschein eines *Juniperus* mit nadelartigen Blättern vorkommen.“).

In spite of these objections the theory was generally accepted and was supported in many works — Eg. J. P. L o t s y in his „Vorträge ueber botanische Stammesgeschichte“ vol. 3, page 117 (9), describing the seedling forms from the conifer genera and species of the subfamily Cupressaceae writes that the Japanese succeeded to perpetuate them by making cuttings from seedlings. („Nun ist es den Japanern gelungen, solche Jugendformen durch Stecklinge zu vermehren und auf dem Jugendzustande zu erhalten“), Further on L o t s y writes: „Da der Uebergang von der Jugendform zur erwachsenen Form meistens nicht unvermittelt geschieht, gehört zu jeder Garten-Retinospora auch noch eine Uebergangsform, welche ebenfalls durch Stecklinge fixirt werden kann und zwischen ersterer und der erwachsenen Form vermittelt“.

The eminent dendrologist A. R e h d e r writes in B a i l e y 's Encyclopedia of Gardening (1) in a paper entitled „*Retinospora*“ that B e i s s n e r has proved experimentally the possibility of raising the juvenile forms by making cuttings from the shoots of seedlings with primordial leaves. Seedlings growing in unfavourable nutrition condition retain their primordial state much longer and this probably is the reason why by making repeated cuttings from their shoots it is possible to perpetuate the juvenile form so well that they sometimes produce fruit without changing the foliage on the fruiting branches. („With the exception of *Retinospora ericoides*, which C. K o c h recognized as the juvenile form of *Thuja occidentalis*, the origin of this juvenile form remained doubtful, until L. B e i s s n e r, after having carefully studied the subject for years disclosed the relationship of the various forms. He showed by experiment that it is possible to raise the same form by making cuttings from seedlings which have still retained their primordial foliage. In some plants, especially if they have not sufficient nourishment, the primordial foliage is retained longer than usual and these have probably been selected for perpetuating the juvenile state by means of cuttings. By continuing through many generations the propagation of

those branches which show the juvenile state most distinctly, these forms have become well fixed varieties, and even sometimes bear without changing the foliage on the fruiting branches.“).

The same opinion is expressed by H. Molisch in his handbook „Pflanzenphysiologie als Theorie der Gärtnerei“ (13). W. F. Neger in a book entitled „Die Nadelhölzer (10) writes: „Unter Retinospora versteht man Pflanzen, welche dauernd (nadelartige) Primärblätter bilden. Solche werden von den Gärtnern in der Weise erhalten, dass von jungen, mit Primärblättern versehenen Pflanzen Zweige abgeschnitten und als Stecklinge vermehrt werden“. This opinion is also expressed by A. M. Negru in a book entitled — Theoretical Bases of Plant Breeding (11) S. Makowiecki in a book on ornamental trees and shrubs (12) describing the *Chamaecyparis pisifera* varieties, and mainly the var. *squarrosa* variety, writes that “it is a juvenile form perpetuated by means of cuttings from the first lower branches of seedlings“ (page 377). Finally, in a paper entitled “Geschlechtsreife, Blühwilligkeit und Senilität bei hölzigen Gewächsen“ published in vol. XXII of “Der Züchter” (14) F. Passecker notes that the Japanese know how to perpetuate the juvenile state of some trees by preventing their passing into the later developmental stages, and that according to Beissner the juvenile forms may be perpetuated by cuttings made from the first branches of seedlings. (“Die Japanese verstehen es solche Gehölze dauernd in der Jugendform zu erhalten und den Uebergang zu wesentlich anders aussehenden geschlechtsreifen Altersformen zu verhindern”. “Nach L. Beissner verharren Stecklingspflanzen dauernd in der Jugendform, wenn man sie von den ersten Seitensprossen eines jungen Sämlings gewinnt”. (l. c. page 27, 28).

Is it true however, that *Retinospora* forms appeared because of the skill of Japanese gardeners to interrupt the normal developmental cycle of some species? Is Beissner right when he emphatically states that *Retinospora* forms may easily be perpetuated by simply making cuttings from seedling shoots? Is it really so easy to disturb the so long established ontogenetic process? Would it not be more accurate to suppose that the appearance of *Retinospora* forms which still occur is caused by mutations, which are noted even by Beissner, Rheder and Lotsy? In the paper already mentioned Rheder writes that Beissner observed the appearance of shoots in the mature state on the branches of old individuals well fixed in the juvenile form. (“...he also published cases in which larger plants of these doubtful forms *Retinospora* have been observed accidentally to develop branches with the foliage of the typical forms.”). On the other hand Lotsy writes that in mature individuals typical in their species seedlings or intermediate shoots appear as an



atavistic phenomenon ("Anderseits kann die erwachsene Form atavistisch einen Zweig der Jugendform oder der Uebergangsform zeigen" — l. c. page 117, vol. 3, Botanische Stammesgeschichte).

Everyday gardening practice shows that mutations can easily be perpetuated by planting cuttings or by grafting. In this way many colour leaf, drooping, dwarf and pyramidal forms of trees and shrubs have been perpetuated.

In order to establish whether juvenile forms would really be perpetuated by means of cuttings from seedling shoots with needle leaves, I carried out a series of experiments in the years 1949—1953. The species experimented with were *Thuja occidentalis* and *Biota orientalis*, the seeds of which were obtained in 1949 from the Warsaw University Botanical Garden and in 1951 and 1952 from Kórnik. In 1949 the seeds of both these species were sown out on the 8th of May. They germinated about the 10th of June. At the beginning of July the seedlings were 2—3 cms high and cuttings could be made. 261 cuttings were made from *Thuja occidentalis* and 173 from *Biota orientalis*. For cuttings only the main shoots were used, as the side shoots had not grown out at the time. The cuttings were cut off just below the cotyledons. Cuttings were planted in boxes filled with coarse river sand. A control group of seedlings was left to develop normally. Observations showed that not one of the cuttings retained the juvenile state, and all passed gradually throu the developmental stages characteristic of both species and finally attained the state typical for mature individuals. The morphological changes in plants grown from cuttings were somewhat retarded in comparison to the developmental changes in the seedlings. This retardment was due to the interruption in development of the cuttings until they produced a root system.

In 1952 and 53 these experiments were repeated on a larger scale in the Institute for Plant Breeding — Research Station in Smolice. This time also the *Thuja occidentalis* and *Biota orientalis* species were used. The seeds were sown out on February 15th 1952. In the case of *Biota* germination is quick and the seedlings were transplanted already on February 22nd. The *Thuja* seedlings were transplanted on March 7th. For experiments 490 *Biota* seedlings were used, but from 120 cuttings were not made and they were left as a control group. From 370 seedlings 358 cuttings from the main shoots and 748 cuttings from branch shoots were obtained. The cuttings were planted in boxes filled with sand and were grown in a glasshouse (Fig. 2). To determine whether the photoperiod had any influence on the perpetuation of seedling and intermediate forms 182 cuttings from the main shoots and 410 cuttings from branch shoots were kept each day in darkness from 6 p. m. till next morning 8 a. b., i. e. they were exposed to daylight only for ten hours daily.

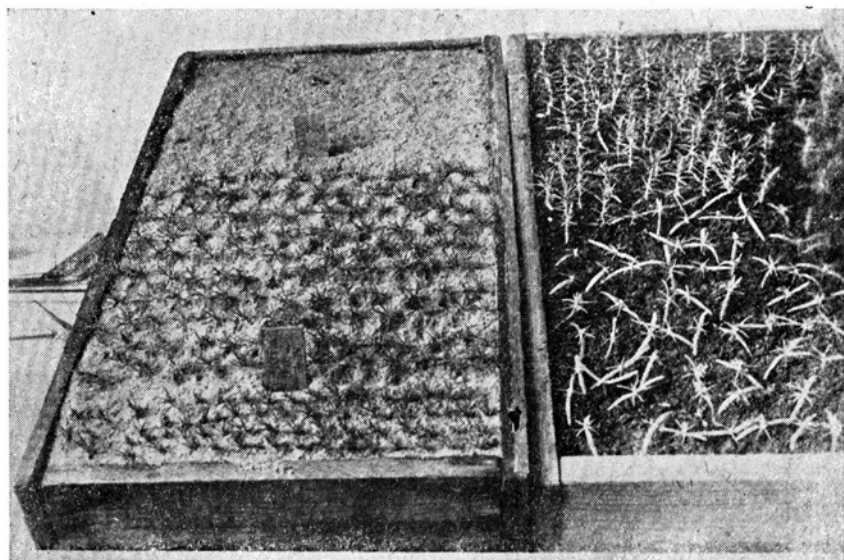


Fig. 2. *Biota orientalis*. Left — Box with planted cuttings obtained from apex shoots of seedlings. Right — Box with seedlings, from those in front cuttings have been taken.

The *Thuja occidentalis* seedlings were treated the same way. From 810 seedlings 210 were left as a control group, and from 600 cuttings were made. The cuttings from the main shoots were divided into two groups: the first group of 283 cuttings took root and grew in daylight of normal duration, and the other one of 308 cuttings had a photoperiod of 10 hours only. Similarly the cuttings from branch shoots were divided into two groups, one of 210 for which the photoperiod was normal, and the other of 225 for which the photoperiod was reduced to 10 hours only.

It must be noted, that not all cuttings took root and some perished before the experiment was terminated. For this reason observation on the changes in the character of leaves were made on a smaller number of individuals than those given above.

Because the making of cuttings, if repeated once only, could be unsuccessful in producing the desired result the procedure was repeated in the middle April 1953. From the already rooted cuttings made from branch shoots of *Biota* seedlings which still retained the juvenile state, the apexes were cut off and planted again. In this way what may be called a second generation of plants was obtained by vegetative propagation. In all cases the development of plants in respect of morphological changes which took place was typical. All the plants, the seedlings as



well as the rooted cuttings, passed through the intermediate form to the mature form in which shoots with scale leaves are characteristic. The morphological developmental stages were shortest in the case of seedlings from the control groups, as they were not injured by the making of cuttings. In *Biota*, in the case of some individuals, intermediate shoots began to form already on May 13th, i. e. 12 weeks after the seedlings

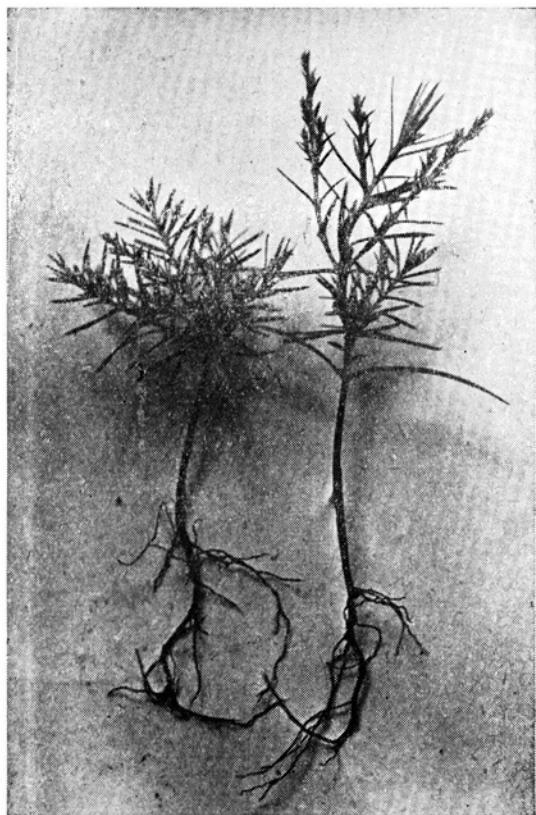


Fig. 3. Intermediate shoots begin to be formed on *Biota orientalis* seedlings.

appeared. In seedlings from which cuttings were made the intermediate shoots were observed for the first time on May 31th, i. e. 2 weeks later. In November 1952 all the plants from both these seedling groups had normal shoots, though on the lower branches of some of them the needle foliage still persisted. Such shoots persisted for quite a long time and disappeared gradually. The beginning of the formation of intermediate shoots is to be seen in Fig. 3.

The planted cuttings from the apex shoots, cut off between the 4th and 24th of April 1952 began to produce shoots with intermediate foliage on June 8th of the same year. In 1953 the number of these plants which still had needle foliage was very small.

On 84 plants which grew in a normal photoperiod the following facts were observed:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with shoots with scale leaves	79	80	81	81	81
Number of plants with shoots with needle leaves	5	3	2	2	1

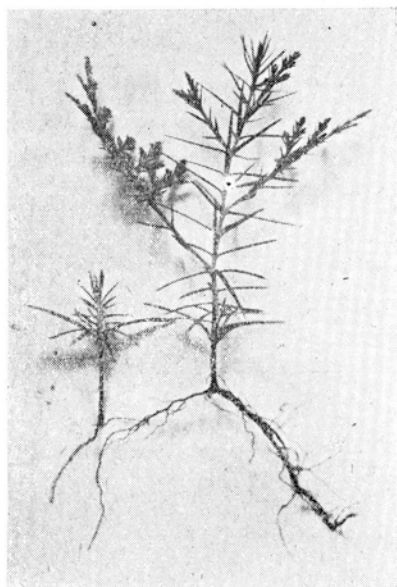


Fig. 4. Two cuttings from apex shoots of *Biota* seedlings planted at the same time. Left — the weaker shoot still retains the juvenile form, and right — the robuster one begins to form shoots with scale leaves.

The plants which retained the juvenile state for a long time did not develop normally, they grew slowly, and most of them perished.

In Fig. 4 two cuttings planted at the same time and obtained from *Biota* seedlings can be seen. The more robust one has already formed shoots with scale leaves, while the weaker one still remains in the juvenile stage.

Planted and rooted cuttings from apex shoots of *Biota orientalis* seedlings forming shoots with scale leaves are to be seen in Fig. 5.

Cuttings made from apex shoots and subjected to a 10 hour photoperiod did not form shoots with scale leaves till the beginning of July 1952.

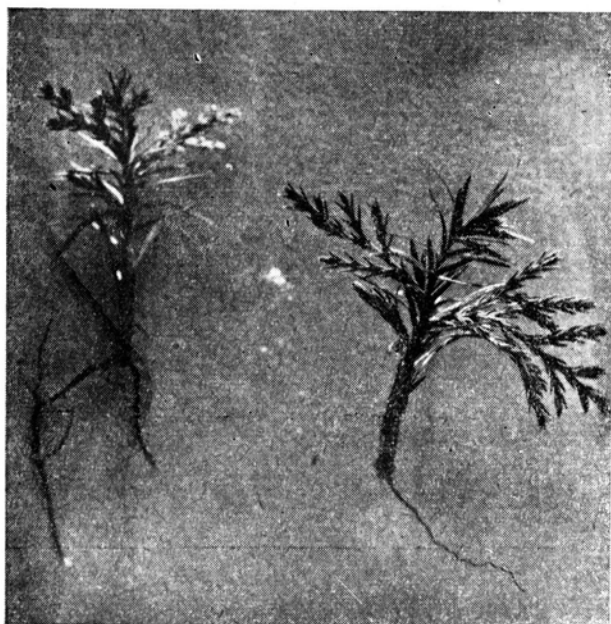


Fig. 5. Rooted cuttings from apex shoots of *Biota orientalis* seedlings forming shoots with scale leaves.

The state of these plants in 1953 is illustrated by the following data:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with shoots with scale leaves	143	143	143	143	143
Number of plants with shoots with needle leaves	7	7	6	1	—

Cuttings from branch shoots were made from June 20th to August 8th 1952 when the branch shoots appeared on the seedlings. Shoots with scale leaves began to appear on the planted cuttings by the middle of October 1952 and on the plants subjected to the limited 10 hour photo-period not till the end of this month.

The state of these plants in 1953 is illustrated by the Table below:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with shoots with scale leaves	146	150	179	179	179
Number of plants with shoots with needle leaves	55	42	6	2	—

In 1953 the number of plants subjected to the restricted photoperiod which survived was 181 and their state in that year is given in the Table below:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with shoots with scale leaves	104	111	138	138	139
Number of plants with shoots with needle leaves	73	57	3	2	—

In the middle of April 1953 cuttings were made from those plants obtained by cuttings from branch shoots of the seedlings which still retained the juvenile state. From the plants growing in normal light conditions 61 cuttings were obtained, and from those which were subjected to the 10 hour photoperiod 107 cuttings were made. Also in the case of plants grown from the repeated cutting no inclination to retain for long the juvenile foliage was noticed.

The table below illustrates the development of cuttings which were rooted and grew in normal light conditions:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with shoots with scale leaves	—	13	17	17	18
Number of plants with juvenile leaves	61	40	8	5	2

The development of plants which rooted and grew in the 10 hour photoperiod was as follows:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with shoots with scale leaves	—	7	24	24	24
Number of plants with juvenile leaves	107	88	32	4	2

The development of *Thuja occidentalis* seedlings and cuttings was slower. The seedlings began to form shoots with scale leaves at the end of June, and the seedlings from which cuttings were made did not form shoots till the first days of July. In spite of this all the 210 seedlings from the control group and approx. 600 seedlings from which cuttings were taken were in the mature state already in November. Fig. 6 represents two *Thuja occidentalis* seedlings one normal and one from which a cutting has been taken.

Cuttings from apex shoots cut from April 30th to May 12th 1952 retained the juvenile state rather long. The development of 90 plants growing in normal light conditions is illustrated by the Table below:

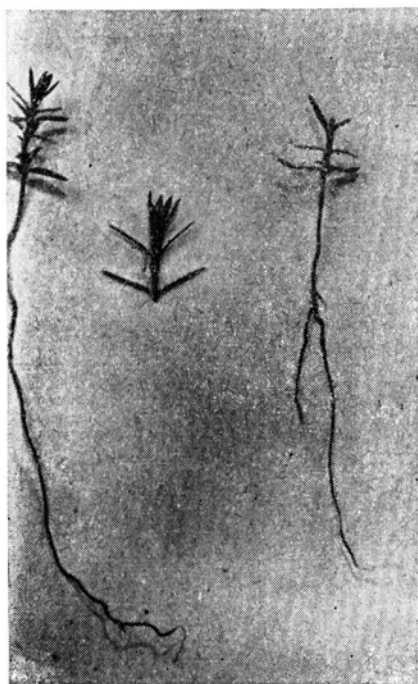


Fig. 6. Two *Thuja occidentalis* seedlings, left — seedling from which a cutting was made, right — normal seedling

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with scale foliage	20	30	47	47	47
Number of plants with needle foliage	70	42	2	2	—

When the photoperiod was 10 hours the plants developed as follows:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
Number of plants with scale foliage	12	10	32	35	33
Number of plants with needle foliage	94	61	25	12	7

The development of cuttings from branch shoots of *Thuja occidentalis* is illustrated by the two Tables given below. In the case of 57 plants rooting and developing in normal light conditions:

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
No. of plants with scale foliage	9	31	46	46	46
No. of plants with needle foliage	48	20	—	—	—

In the case of 106 plants rooting and growing in the 10 hours photoperiod.

Date	Apr. 20,53	June 20,53	Aug. 20,53	Oct. 20,53	Dec. 20,53
No. of plants with scale foliage	46	60	97	97	97
No. of plants with needle foliage	61	46	5	1	—

The data given here show that cuttings made from apex and branch shoots from seedlings with juvenile foliage do not create a possibility to perpetuate the juvenile form. Even repeated cuttings from shoots of



already rooted cuttings do not give such results, as it is seen in the case of *Biota orientalis*. The clearly negative results of experiments indicate, in my opinion, that *Retinospora* forms have arisen as „sports“ (K. Darwin used this expression in describing the spontaneous arising of differently shaped or coloured organs in typical specimens.). The fact that *Thuja occidentalis* and *Biota orientalis* have developed many different forms besides those mentioned here supports this opinion. E. g. in the

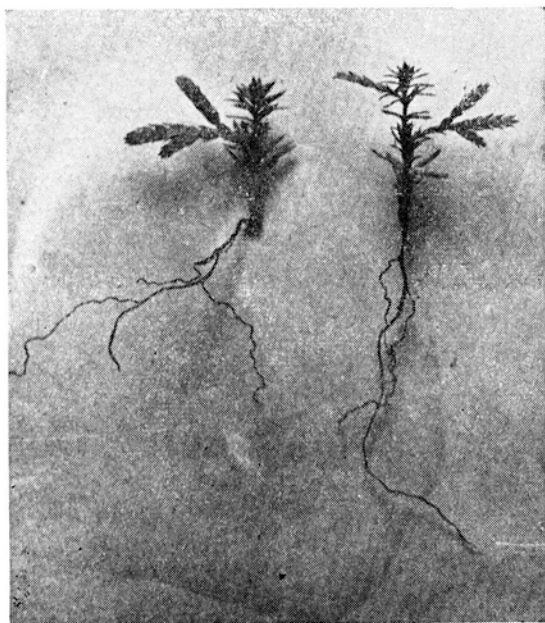


Fig. 7. Cuttings from apex shoots of *Thuja occidentalis* begin to form shoots with scale leaves.

*Thuja occidentalis* species there are forms with white and yellow tinted shoot ends, as in the case of var. *alba* Gordon and var. *aurea spicata* Beissner respectively, or with yellow tinted leaves as in var. *aurea* Nelson. In this species there are also many forms which deviate from normal by their shape which may be pyramidal as in the case of var. *Douglasii pyramidalis* Spaeth, of fastigate as in var. *fastigiata* Jaeger.

In the *Biota orientalis* species also numerous different forms have originated. Besides the juvenile form var. *decussata* Master already mentioned, there also is the form var. *ericoides* Bean which differs from the first one by its bushy habitus. The *Biota orientalis elegantissima* Vos.

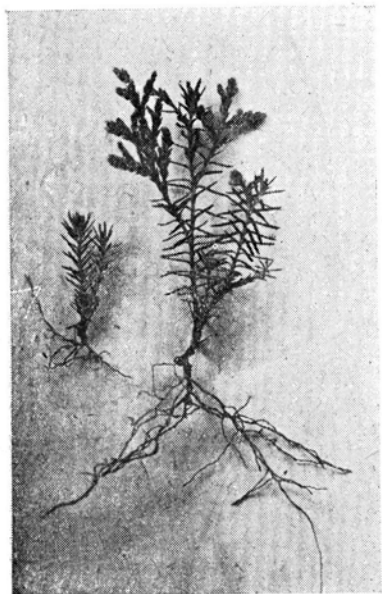


Fig. 8. Two cuttings apex shoots of *Thuja occidentalis*. Left — The weaker shoot still in the juvenile state, Right — the robust one already forms shoots with scale leaves.

form with yellow tinted leaves was obtained — according to W. Dallimore and A. Jackson (7) — in Rollinson's nursery between 1850 and 1860. It was obtained by the selection of seedlings and this clearly indicates that in this case it is a question of spontaneous variation.

If all that has been said is considered it seems very likely that all *Retinospora* forms are „sports“, i. e. that they all have originated spontaneously either as seedlings which retain perpetually their juvenile form, or as shoots with juvenile foliage which appear from time to time on mature specimens. „Sports“ of this kind can be perpetuated and propagated by making cuttings. Cuttings from seedling shoots with juvenile foliage do not give any such results.

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