References and Notes

1. K. C. Atwood and S. L. Scheinberg, *Science* **127**, 1058 (1958), abstr.; *J. Cellular Comp. Physiol.* **52**, suppl. 1, 97–123 (1958); S. L. Scheinberg and R. P. Reckel, *Genetics* **44**, 533 (1959), abstr.; K. C. Atwood and D. Megill, *Science* **130**, 1411 (1959), abstr.; S. L. Scheinberg and R. P. Reckel, *Genetics* **45**, 621 (1960); ———, *Science* **131**, 1887 (1960).
2. K. C. Atwood and S. L. Scheinberg, *Science* **129**, 963 (1959).
3. L. E. Young and E. Witebsky, *J. Immunol.* **51**, 111 (1945).
4. R. B. Goudie, *Lancet* **272**, 133 (1957); K. C. Atwood, *Proc. Natl. Acad. Sci. U.S.* **44**, 1054 (1958).

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New Source of the j_2 Gene Governing Jointless Pedicel in Tomato

Abstract. A multiple-flowered, jointless pedicel, single plant appeared in the tomato variety 146 in 1958. The gene governing the jointless pedicel character was found to be identical with the j_2 gene found in a tomato strain from the Galapagos Islands. The character is considered to be a mutant and of potential value in the development of mechanically harvestable tomatoes.

An off-type, single plant of the tomato variety 146 (*1*), with multiple flower clusters, was found in a commercial field in 1958. Plants grown in 1959 from seed of this plant produced flower clusters with jointless pedicels. The clusters were bifurcate, differing from those of plants with the j_1 gene (*2*). They were similar in appearance to the jointless pedicel clusters of strain LA 315 received from C. M. Rick. Strain LA 315 was derived from LA 166, a collection of *Lycopersicon pimpinellifolium* from Indefatigable Island of the Galapagos Island group (*3*). The jointless pedicel character of strain LA 315 was reported by Rick to be different from that determined by the gene j_1 and was assigned the symbol j_2 (*3, 4*). As far as we know this has been the only report of the j_2 gene.

A series of crosses was made between the 146 selection and normal jointed, jointless j_1 type, and jointless j_2 type, using LA 315 for the last cross, with the results shown in Table 1.

Crosses 1, 2, and 3 indicated that 146 selection pedicel type was recessive to normal jointed, was conditioned by a single factor, and was like j_2 pedicels in appearance. Crosses 4, 5, and 6 indicated that 146 selection was not identical with jointless j_1, because the F_1 was jointed, both jointless types appeared in the F_2, and the two backcross populations were distinct, each approaching 1 : 1 ratios for jointed and jointless, with the backcross parent pedicel type only represented.

Crosses 7, 8, and 9 established the identity of the j_2 gene for jointless pedicel in 146 selection and LA 315, with all populations having j_2 pedicels.

In contrast with clusters of 1 to 6 flowers in most j_1 tomato strains or varieties, the j_2 clusters, as grown at Riverton, New Jersey, have from 7 to 30 or more flowers per cluster, although actual fruit set is usually 1 to 4 per cluster. The 146 selection differs from LA 315 in lacking the large and leaflike calyces and the ovoid fruit described for the latter (*3, 4*). The character behaves normally in crosses and has been combined with both determinate, *sp* and dwarf, *d* characters and with the double recessive, *d, sp*. Germination of seed is normal.

The jointless pedicel character results in a minimum of stems remaining on picked ripe fruit. This characteristic may be useful in the development of mechanically harvestable tomato varieties (*5*).

The origin of the j_2 character in 146 is unknown. The LA 315 j_2 was not grown in local experimental plantings until 1960, whereas the 146 selection appeared in 1958. This eliminates the possibility that a chance field pollination from LA 315 introduced the gene to the 146 variety.

Table 1. Classification of tomato plants for pedicel type.

Cross	Parent plants	Generation	No. of plants of phenotype: Jointed	Jointless j_1 type	Jointless j_2 type
1	146 sel. × Jointed	F_1	11	0	0
1	146 sel. × Jointed	F_2	72	0	16
2	146 sel. F_1 × Jointed	BC1	41	0	0
3	146 sel. F_1 × 146 sel.	BC1	12	0	10
4	146 sel. × Jointless j_1	F_1	6	0	0
4	146 sel. × Jointless j_1	F_2	18	3	1
5	146 sel. F_1 × Jointless j_1	BC1	13	7	0
6	146 sel. F_1 × 146 sel.	BC1	12	0	10
7	146 sel. × LA 315 j_2	F_1	0	0	4
7	146 sel. × LA 315 j_2	F_2	0	0	46
8	146 sel. F_1 × 146 sel.	BC1	0	0	21
9	146 sel. F_1 × LA 315 j_2	BC1	0	0	22

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References

1. G. B. Reynard, *Proc. Plant Sci. Seminar.* **93** (1960), Campbell Soup Co., Camden, N.J.
2. L. Butler, *J. Heredity* **27**, 25 (1936).
3. C. M. Rick, *Am. J. Botany* **43**, 687 (1956).
4. ———, *Tomato Genetics Cooperative Rept. No. 6*, 23 (1956).
5. S. K. Ries and B. A. Stout, *Proc. Am. Soc. Hort. Sci.* **75**, 632 (1960).

7 August 1961

Sources and Isotopic Composition of Atmospheric Sulfur

Abstract. In nonindustrial areas the prime source of SO_4^{--} in rain and snow is atmospherically oxidized H_2S that is produced predominately along coastal belts by anaerobic bacteria. The δS^{34} analyses of atmospheric SO_4^{--} vary from +3.2 to +15.6 per mil in contrast to +20.7 per mil for sea water SO_4^{--}. Contrary to previous studies based on Cl^-/SO_4^{--} ratios, sea spray SO_4^{--} is a minor source.

Studies on the relationship between variations in isotopic composition of sulfur and the genesis of sulfide minerals (*1*) have led us to encounters with the complexities of the biogeochemical cycle of sulfur. One significant portion of this cycle is the role of sulfur in the atmosphere.

Sulfur occurs in the atmosphere predominately, if not exclusively, as SO_4^{--} in aerosols and in SO_2 and H_2S gas. The second form, and in all probability the third, is oxidized to SO_3, which in the presence of moisture subsequently forms hygroscopic SO_4^{--} nuclei. The SO_4^{--} in aerosols is returned to the earth in precipitation of rain and snow—in variable concentrations between essentially 1 to 10 mg of SO_4^{--} per liter of precipitation.

Three sources for SO_4^{--} in the atmosphere have been suggested. The first and most obvious source, especially to urbanites, is industrial SO_2, which, as shown by Junge (*2*), is certainly quantitatively insufficient to account for the total amount of SO_4^{--} in the atmosphere. The second source is H_2S produced by anaerobic bacteria existing in marshes, soil, and lakes and, most important of all, along coastal plains and shelves (*3*). The third source is nonhygroscopic particles of sulfate derived from sea spray (*4*); it has been suggested that SO_4^{--} in particles derived from sea spray forms a stable aerosol that is spread throughout the earth's atmosphere while soluble chlorides that enter the atmosphere by the same process are returned rapidly to the sea.

Nevertheless, not only has the relative importance of these three sources been extremely difficult to ascertain, but skepticism has been expressed about the efficacy of the sea-spray process. In 1953 Hutchinson (*5*, p. 421) noted that information on the isotopic composition of sulfur in rain water "should throw light on this subject." The basis for his statement was that sea-water sulfate has a remarkably constant isotopic composition for sulfur. The S^{32}/S^{34} isotopic ratio is 21.76 ± 0.01 or the δS^{34} enrichment is +20.7 per mil compared to the meteoritic standard of 22.21 for isotopic studies of sulfur (*6*). If sea spray is an important source of SO_4^{--} in aerosols, the δS^{34} composition of SO_4^{--} collected from precipitation should be essentially +20 per mil since very little, if any, isotopic fractionation is expected during the transfer of the SO_4^{--} from the sea spray to the atmosphere.

Östlund (*7*) recently published the first isotopic analyses of sulfur from SO_4^{--} collected from snow and rain. He also included three isotopic analyses of sea water SO_4^{--}. The sea water analyses he reported are obviously in error as the S^{32}/S^{34} ratios are too high. If the abnormal values are only a question of sulfur isotope standards, which is most likely, these analyses can be salvaged by applying a correction factor of −0.12, as suggested by Östlund (*8*), to all of the S^{32}/S^{34} analyses. This has been done for Östlund's samples listed in Table 1. These corrected values still verify his conclusion that "the sulfate sulfur in precipitation is not likely to originate principally from sea-water spray."

We also concur in this conclusion, on the basis of our analyses of Japanese samples, provided by Ken Sugawara, as listed in Table 1. In addition, however, we have also noted that the SO_4^{--} samples collected by Sugawara from industrial locations are more highly enriched in S^{32} than the samples collected from nonindustrial sites near the western coast of Japan. Although these latter samples do more closely approach the sulfur isotopic composition of SO_4^{--} from the China Sea (Table 1), they are, even so, still enriched by about 5 per mil in S^{32}.

This enrichment is quite typical (*9*) of the isotopic fractionation to be expected by reduction of SO_4^{--} by anaerobic bacteria of the *Desulfovibrio* genus and the resulting evolution of H_2S. Although these coastal samples may still contain SO_4^{--} derived from sea spray, the isotopic analyses indicate that H_2S of biogenic origin, produced in tidal flats and coastal belts, is the prime source of atmospheric SO_4^{--}. Continental and fresh-water environments for the sulfate reducers are unimportant sources of H_2S, as is indicated by the S^{32}-enriched lake water analyses shown in Table 1.

Our isotopic analyses of Sugawara's samples collected from industrial sites exhibit δS^{34} compositions similar to all of Östlund's SO_4^{--} precipitation samples. It is suggested, of course, that these samples contain SO_4^{--} derived predominantly from atmospheric oxidation of SO_2 of industrial origin. If the δS^{34} composition of industrial fuels were uniform, it would be possible to determine quantitatively the specific amounts and sources of atmospheric SO_4^{--}. Analyses, however, of just five samples of Japanese coal (Table 1) indicate the relatively broad spread in their isotopic composition of sulfur. The nu-

Table 1. Isotopic composition of sulfur in industrial coal and sea, lake, and atmospheric sulfate.

Sample location	Sample	Sample content (mg SO_4^{--} per liter)	Sample content* (percent by weight)	Isotopic data: δS^{34} (per mil)	Isotopic data: S^{32}/S^{34}
Ostlund samples†					
Stockholm, Sweden	Snow	1.5		+5.4	22.09
Stockholm, Sweden	Snow	4.0		+6.8	22.06
Köping, Sweden‡	Rain	3.2		+8.2	22.03
Stockholm, Sweden	Rain	7.9		+3.2	22.14
Stockholm, Sweden	Rain	18.8		+5.0	22.10
Stockholm, Sweden	Rain	7.2		+4.5	22.11
Stockholm, Sweden	Rain	5.1		+3.6	22.13
Stockholm, Sweden	Rain	6.1		+6.8	22.06
Stockholm, Sweden	Rain	9.5		+6.8	22.06
Huddinge, Sweden	Rain	5.3		+6.8	22.06
Huddinge, Sweden	Rain	2.8		+6.3	22.07
Flahult, Sweden	Rain	7.6		+7.3	22.05
Port Aransas, Tex.§	Rain			+6.3	22.07
Nahcotta, Wash.§	Rain			+5.4	22.09
Arctic Sea	Seawater	2740.		+20.2	21.77
North Sea	Seawater	2170.		+19.7	21.78
Gulf of Bothnia, Baltic Sea	Seawater	450.		+20.7	21.76
Lake Mälaren	Lake water	47.		+2.7	22.15
Sugawara samples					
Tokyo(A), Japan ‖	Rain	8.9		+7.3	22.05
Tokyo(B), Japan ‖	Rain	8.6		+7.3	22.05
Tokyo(C), Japan ‖	Rain			+5.0	22.10
Nagoya(B), Japan ‖	Rain	2.3		+5.9	22.08
Nagoya(C), Japan ‖	Rain			+3.2	22.14
Wakayama, Japan¶	Rain	3.5		+7.3	22.05
Nara, Japan¶	Rain	1.3		+6.3	22.07
Kurume(A), Japan**	Rain	3.0		+15.6	21.88
Kurume(B), Japan**	Rain	2.1		+12.8	21.93
Kurume(C), Japan**	Rain			+15.6	21.88
Tottori(A), Japan**	Snow	2.7		+13.2	21.92
Tottori(B), Japan**	Rain	2.3		+15.1	21.88
Matsumoto, Japan	Rain			+12.3	21.94
Wakayama, Japan	Seawater			+20.7	21.76
East China Sea	Seawater			+20.7	21.76
Nakai samples					
Long Island Sound, Conn. (surface)	Seawater	2170.		+20.2	21.77
Long Island Sound, Conn. (7-m depth)	Seawater	2170.		+20.2	21.77
Linsley Pond, Conn. (surface)	Lake water	10.2		+7.7	22.04
Linsley Pond, Conn. (13.5-m depth)	Lake water	9.6		+7.3	22.05
Queechy Lake, Conn. (12-m depth)	Lake water	13.8		+7.3	22.05
Kyushu, Japan	Coal		1.54	+23.5	21.70
Kyushu, Japan			1.44	+23.9	21.69
Kyushu, Japan	Coal		3.05	+11.9	21.95
Kyushu, Japan			3.14	+11.9	21.95
Kyushu, Japan	Coal		1.49	+22.1	21.73
			1.48	+22.6	21.72
Hokkaido, Japan	Coal		0.33	+18.3	21.81
Hokkaido, Japan	Coal		0.35	+15.1	21.88

* Determined by Parr Bomb method. † Östlund's isotopic data have been corrected by subtracting 0.12 from ratio values. ‡ Köping is located near Lake Mälaran. § Coastal locations, U.S. ‖ Industrial sites. ¶ Near industrial sites. ** Nonindustrial sites.

merous atmospheric SO_4^{--} samples collected near industrial sites, all of which have S^{32}/S^{34} ratios in excess of 22.03, indicate that the two Japanese coal samples enriched in S^{34} are atypical. Certainly many more δ S^{34} analyses of sulfur in industrial fuels are needed.

It is interesting to note that Junge (*2*) and Eriksson (*10*), using identical data for the concentration of excess SO_4^{--} in precipitation over the United States, have suggested a decrease and an increase, respectively, of excess SO_4^{--} near the coast line. It seems apparent, therefore, that δ S^{34} studies would assist these investigators. In nonindustrial areas, however, the limited present data indicate that H_2S of biogenic origin is the major source of atmospheric SO_4^{--} (*11*).

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References and Notes

1. M. L. Jensen, *Econ. Geol.* **54**, 374 (1959).
2. C. E. Junge, *J. Geophys. Research* **65**, 227 (1960).
3. E. J. Conway, *Proc. Roy. Irish Acad.* **B48**, 114 (1942).
4. K. Sugawara, S. Oana, T. Koyama, *Bull. Chem. Soc. Japan* **22**, 47 (1949).
5. G. E. Hutchinson, *The Earth as a Planet*, G. P. Kuiper, Ed. (Univ. of Chicago Press, Chicago, 1954), pp. 371–433.
6. $\delta\ S^{34}\ \text{(per mil)} = \left(\frac{S^{32}/S^{34}\ \text{(standard)}}{S^{32}/S^{34}\ \text{(sample)}} - 1\right) \times 1000$
7. G. Östlund, *Tellus* **11**, 478 (1959).
8. ———, personal communication (4 July 1960).
9. N. Nakai, and M. L. Jensen, *J. Earth Sci., Nagoya Univ.* **8**, 181 (1960).
10. E. Eriksson, *Tellus* **12**, 63 (1960).
11. This study was financed by the National Science Foundation, grant No. NSF G-10326, and the U.S. Atomic Energy Commission, contract No. AT (30-1) 2261. We are also very grateful to K. Sugawara, Nagoya University, for providing the SO_4^{--} rain samples.

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Photoperiodic Response of Female Fringe-Toed Lizards

Abstract. *Uma notata* females were held over the winter under 24 hours of light per day. These animals laid from two to four clutches of eggs, with 4 to 7 weeks between clutches. Clutches contained two to four eggs. Additional light is believed to be more important than heat in causing this response.

Recently Farner (*1*) reviewed the present status of photoperiodicity in the animal kingdom, and Bartholomew (*2*) reviewed photoperiodism in reptiles. Both stated that knowledge of the photoperiodic response in reptiles is extremely limited. Most of what is known concerns males, although Bartholomew (*3, 4*) studied *Xantusia vigilis* females in this regard. However, he found that ovaries in this species reacted to a much smaller degree than testes (*4*). To my knowledge, no one has reported any female reptile ovulating in response to light stimulation. Consequently, the following observations seem worthy of note.

Fringe-toed lizards (*Uma notata*) are abundant in the Algodones Dunes, Imperial County, California. Females lay eggs in the field from April through August, and lay from one to four eggs in a clutch (*5*). The number of clutches per individual each year is unknown, however. These animals normally hibernate beneath the sand from November to February (*5*).

On 20 July 1960, two subadult females, which had been captured 2 days earlier in the Algodones Dunes, were placed in a small terrarium (12½ by 12½ by 24 inches). A 60-watt incandescent light bulb illuminated and heated the terrarium from above, 24 hours per day. Approximately 2 inches of sand covered the bottom of the cage. Sand surface temperatures in the terrarium ranged from 26.2°C to 29.4°C, depending on the sand's location in relation to the light bulb. Surface temperatures did not vary during the period under consideration.

These animals burrowed in the sand a good deal. Thus, they were not exposed to the light for 24 hours each day. It is impossible to say how many hours of light each animal received, since this was determined by the animal's behavior.

On 10 November lizard No. 1 laid its first clutch of eggs, followed about 2 weeks later by animal No. 2 (see Table 1). Both animals possessed bright reddish-orange sides at the time of laying. This color pattern was identical with that seen in the field on adults of both sexes from May to September (*5*). The laboratory animals, at the time of laying, were about the minimum size (snout-vent length) for laying females in the field (*5*).

Table 1. Egg-laying by *Uma notata* in response to light stimulation, 1960–61.

Data	Animal No. 1	Animal No. 2	Animal No. 3
Snout-vent length at 1st clutch (mm)	70	71	76
Date exposed to 24 hr of light per day	20 July	20 July	23 Nov.
1st clutch			
Date	10 Nov.	22 Nov.	24 Jan.
No. eggs	2	2	2
2nd clutch			
Date	9 Dec.	21 Dec.	26 Feb.
No. eggs	3	4	2
3rd clutch			
Date	27 Jan.	12 Feb.	
No. eggs	3	3	
4th clutch			
Date	8 Mar.		
No. eggs	3		
Autopsy date	12 June	10 Apr.	21 Mar.
Condition at autopsy			
Left ovary	6 eggs, 1 large (7.4 mm)	3 eggs, largest 1.0 mm	6 eggs, 1 large (13.7 mm)
Right ovary	6 eggs, 1 large (7.2 mm)	0 eggs	6 eggs, 1 large (12.3 mm)

On 23 November lizard No. 3, which was approximately the same size, was placed in the terrarium. This female had been hibernating in an outdoor cage as part of another experiment. It did not respond to the light or warmth in any manner until 12 December. Then it began to move about and eat. By 14 December it was beginning to acquire the reddish-orange patches on the sides of the abdomen and by 3 January 1961 its sides were bright reddish-orange. It laid its first clutch of eggs 2 months after it was placed in the terrarium. Table 1 summarizes the egg-laying data for the three animals and gives an indication of ovary conditions at autopsy.

The first and second clutches were approximately 4 weeks apart in all animals. Both lizards that produced a third clutch did so about 7 weeks after they produced the second. The single fourth clutch was laid almost 6 weeks later than the third. Thus, the interval between specific successively numbered clutches was about the same for all animals, but the time between an individual's clutches was rather variable. The eggs laid by these lizards averaged 20.2 by 11.7 mm in size (range, 17.5 by 10.0 mm to 24.0 by 13.1 mm). This compares very closely to the average size of eggs found in the oviducts