Human Hazards

Caution must be exercised against reaching dangerous conclusions from the present results. Thus, as has been emphasized, it is not safe to conclude that the data imply a threshold dose for all mutations in spermatogonia and oocytes. There might not even be any further reduction in mutation rate with further decrease in intensity. Furthermore, it should not be forgotten that even the lower mutation rates obtained with the present intensity levels are still appreciable and at least as high as *Drosophila* rates for acute irradiation. However, from the results as they stand—results that apply to the germ-cell stages (spermatogonia and oocytes) that are important in appraising human hazards—it does seem safe to conclude that, with at least some intensities of radiation, the genetic damage would not be as great as that estimated from the mutation rates obtained with acute irradiation.

Summary

New data have clearly confirmed the earlier finding that specific locus mutation rates obtained with chronic gamma irradiation of spermatogonia are lower than those obtained with acute x-rays. Since this result is in contrast to classical findings for *Drosophila* spermatozoa, and apparently contradicts one of the basic tenets of radiation genetics, it was important to determine what factors were responsible for it.

Experiments undertaken for this purpose reveal the following: (i) the lower mutation frequency is due mainly to difference in dose rate of radiation, rather than quality; (ii) a dose-rate effect is not obtained in experiments with mouse spermatozoa, confirming classical findings for spermatozoa, and indicating that the explanation for intensity dependence in spermatogonia resides in some characteristic of gametogenic stage; and (iii) a dose-rate effect is found not only in spermatogonia but also in oocytes, where cell selection is improbable, indicating that the radiation intensity effect is on the mutation process itself.

A threshold response for all mutations in spermatogonia and oocytes is not a necessary consequence of the findings. Plausible hypotheses consistent with the present results can lead to other predictions.

From a practical point of view, the results indicate that the genetic hazards, at least under some radiation conditions, may not be as great as those estimated from the mutation rates obtained with acute irradiation. However, it should not be forgotten that even the lower mutation rates obtained with the present intensity levels are still appreciable (*16*).

References and Notes

1. W. L. Russell and E. M. Kelly, *Science* 127, 1062 (1958).
2. W. L. Russell and L. B. Russell, in *Proc. 2nd Intern. Conf. Peaceful Uses Atomic Energy, Geneva, 1958*, in press.
3. W. L. Russell, L. B. Russell, E. F. Oakberg, in *Radiation Biology and Medicine*, W. D. Claus, Ed. (Addison-Wesley, Reading, Mass., 1958), pp. 189–205.
4. We are greatly indebted to Dr. M. L. Randolph and Mr. D. L. Parrish for the dosimetry, which will be described elsewhere. It should be noted that recent refinements in dosimetry have resulted in some changes subsequent to publication of our preliminary abstract on this subject [W. L. Russell and E. M. Kelly, *Science* 127, 1062 (1958)]. Thus, doses listed in that abstract as 600 r at 100 r/wk and 100 r at 10 r/wk correspond, respectively, to 516 r at 90 r/wk and 86 r at 10 r/wk in later publications (*2, 3*), including the present one.
5. W. L. Russell, *Cold Spring Harbor Symposia Quant. Biol.* 16, 327 (1951).
6. W. L. Russell, *Genetics* 41, 658 (1956).
7. We are indebted to Dr. A. W. Kimball for statistical advice and computations.
8. A. Birnbaum, *J. Am. Statist. Assoc.* 49, 261 (1954).
9. H. J. Muller, in *Radiation Biology*, A. Hollaender, Ed. (McGraw-Hill, New York, 1954), vol. 1, pp. 475–479.
10. This conclusion is not meant to exclude the possibility of special types of intensity effect such as that reported by A. M. Clark [*Nature* 177, 787 (1956)] for sex-linked lethals in *Drosophila* spermatozoa at high dose rates in the presence of sodium azide.
11. E. F. Oakberg, *Proc. 10th Intern. Genet. Congr.* (1958), vol. 2, p. 207.
12. W. L. Russell, L. B. Russell, J. S. Gower, S. C. Maddux, *Proc. Natl. Acad. Sci. U.S.* 44, 901 (1958).
13. T. C. Carter, *Brit. J. Radiol.* 31, 407 (1958).
14. W. L. Russell and L. B. Russell, *Radiation Research*, in press.
15. T. C. Carter, M. F. Lyon, R. J. S. Phillips, *Nature* 182, 409 (1958).
16. We are grateful to Mrs. M. B. Cupp, Miss J. W. Bangham, and the other members of the Mammalian Genetics and Development Section who assisted with the laboratory work. The Oak Ridge National Laboratory is operated by Union Carbide Nuclear Company for the U.S. Atomic Energy Commission.
17. W. L. Russell, J. W. Bangham, J. S. Gower, *Proc. 10th Intern. Genet. Congr.* (1958), vol. 2, p. 245.
18. W. L. Russell, L. B. Russell, M. B. Cupp, *Proc. Natl. Acad. Sci. U.S.*, in press.

Groningen Radiocarbon Dates III

H. de Vries and H. T. Waterbolk

The present series of radiocarbon dates obtained at the University of Groningen covers the period from March 1956 to August 1957. The first two lists (*1, 2*) will be referred to as I and II. Characteristics of the counters and descriptions of the technical procedures, statement of errors, and so forth, were given in list II.

Samples numbered between 600 and 900 were measured in the small counter; samples numbered between 500 and 600 and between 1200 and 1500 were measured in the large counter; and samples between 900 and 1200 and above 1500 were measured in the medium-sized counter.

Measurements on the radioactivity of shells and snails from different environments during the last 4 years have been published separately (*3*), since they are not given "dates." One of the conclusions drawn from these measurements is that the amount of carbon-14 in the atmosphere increased by about 5 percent between the end of 1953 and the spring of 1957. This increase is due to the explosions of atomic bombs. A group of Würm interstadial samples has been published separately (*4*), since they require a more detailed discussion. The results can be summarized briefly as follows: About 26,000 years ago a fairly short interstadial (or warmer oscillation) occurred, which produced the Paudorf fossil soil. The first Würm interstadial occurred at about 50,000 years ago, no indication of a warmer period between 50,000 and 26,000 years ago being found up to now.

The remaining dates are given here in four groups (Tables 1–4). The first group consists of a series of geological samples from northwestern Europe; it

Dr. de Vries is professor of biophysics at the Physical Laboratory, University of Groningen, Groningen, Netherlands. Dr. Waterbolk is professor of prehistory at the Biological-Archeological Institute, University of Groningen.

includes some standard sections and datings of pollen zones. Group 2 deals with archeological samples from Europe. Group 3 deals with archeological samples outside of Europe; and group 4 deals with special problems.

Since completion of the present list, a careful study has been made of a series of samples of known age (*5*). It was found that the activity of radiocarbon in the atmosphere was going up and down even before the Industrial Revolution. This affects the dating results in a complicated way which cannot yet be taken into account here. Our recent standard turned out to be about 3 percent too low in activity relative to the average of the samples from between A.D. 1500 and 1800. As a first correction, 240 years should be added to all Groningen radiocarbon dates published up to now, including those in the present list. Besides this general correction, another correction, which may amount to 100 years, has to be applied. This may be in either direction, and it depends in an irregular way on the age of the sample.

Table 1. Geological problems, including the dating of pollen zones (from "standard profiles"). All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
Roggendorf, near Melk (Austria). Peat layer, underlying mud and redeposited löss and supposed to be of interstadial age (*6*). Submitted by F. Brandtner, Vienna.		
Upper sample (3.15 to 3.30 m).	Gro-1301	7760 ± 120
Other part of upper sample.	Gro-1186	8100 ± 100
Lower sample (4.20 to 4.35 m).	Gro-1198	11,400 ± 90
Since recent contamination of the samples is nearly impossible, the peat layer is obviously of late- and postglacial age. The pollen diagram does not completely exclude this possibility.		
Laacher See (Eifel, Germany).		
Piece of wood cut out of a charred beam (diameter 20 cm), found in the volcanic Trass in the Brohltal. The trass belongs to the great middle Allerød eruption of the Laacher See.	Gro-1184	11,025 ± 90
Submitted by B. Frechen, Bonn.		
Charred wood found at a depth of about 5 m in the volcanic Trass in the Gleesertal. The flora of this Trass contains some thermophilous species which previously had not been found in the Allerød in Germany. Therefore, a Boreal age of the corresponding eruption was supposed. Collected by J. Schweitzer and submitted by R. Brinkman, Bonn.	Gro-1199	10,680 ± 85
It is interesting to recall the date of the volcanic eruption in the Schalkenmehrer Maar, already published (*2*) (Gro-961, age 10,550 ± 100 yr). The Brohltal date falls according to expectation well within the Allerød period. The Gleesertal date, however, corresponds to that of the Schalkenmehrener Maar and belongs to the Younger Dryas time. Apparently, in this period the climate in the area was better than could be concluded from the available botanical evidence. There is thus no proof for postglacial volcanic activity in the Eifel.		
Standard pollen diagrams from Spain. The samples were collected and submitted by J. Menendez Amor (Madrid) and F. Florschütz (Velp, Netherlands), who also prepared the pollen diagrams. Details are being published (*7*).		
Laguna de las Sanguijuelas (Lago de Sanabria, Zamora, Spain). Seven samples from a former lake, filled with 8 m of lacustrine and peat deposits. Some of the gyttja samples contained less than 1 g of carbon.		
Peat (depth, −0.50 m); start of strong increase of quercetum mixtum, decline of *Pinus*.	Gro-687	720 ± 90
	Gro-698	730 ± 80
Peat with gyttja (−1.90); *Quercus* and *Pinus* dominant.	Gro-709	4270 ± 120
	Gro-1002	4190 ± 60
Gyttja (−3.70); decrease of quercetum mixtum, increase of *Pinus*.	Gro-704	6670 ± 145
Gyttja (−5.10); start of quercetum mixtum.	Gro-703	8160 ± 190
Gyttja (−7.00); beginning of Allerød.	Gro-688	11,585 ± 200
Gyttja (−7.50); middle of Bölling.	Gro-702	12,830 ± 280
	Gro-708	12,660 ± 220
Gyttja (−7.70); beginning of Bölling.	Gro-705	13,700 ± 300
Laguna Arroyas (Lago de Sanabria, Zamora, Spain). Gyttja (−5.35); mixture of *Pinus, Betula,* and quercetum mixtum throughout the section.	Gro-1078	7360 ± 65
Buelna (Asturias, Spain).		
Peat (−0.50); start of continuous *Fagus* curve, last decrease of *Corylus*.	Gro-1075	2260 ± 45
Peat (−0.72); start of *Corylus* increase.	Gro-1076	1775 ± 65
Montes del Buyo (Galicia, Spain). Peat (−2.70).	Gro-1077	7830 ± 75
Torreblanca (Castellón de la Plana, Levante, Spain).		
Peat (−0.90)	Gro-1073	1670 ± 45
Peat (−2.40)	Gro-1074	4120 ± 60
Peat (−4.20)	Gro-1072	6280 ± 85
	Gro-1097	6150 ± 60
In all cases where the pollen diagrams gave a well defined assignment to a typical climate (for example, Bölling, Allerød), the dates turned out to be synchronous with the corresponding periods in northwestern Europe and North America.		
Guiana shelf (South America). In connection with sedimentological studies, a number of carbonate samples (shells, foraminifera, and so forth) from the Western Guiana shelf were dated. They were submitted by D. J. G. Nota, Wageningen. Further details are being published (*8*).		
Station DN 1079, surface.	Gro-462	12,165 ± 350
Station DW 1153, surface.	Gro-473	11,560 ± 240
Station DI 1055, 0.10 to 0.50 m.	Gro-697	5600 ± 150
Station DI 1055, 0.90 to 1.30 m.	Gro-693	5630 ± 160
Station DI 1055, 1.80 to 1.90 m.	Gro-691	6400 ± 145
Station DI 1047, 0.15 to 0.25 m.	Gro-692	14,220 ± 350
Station DI 1047, 0.65 to 0.75 m.	Gro-981	17,550 ± 110
Station DO 1089, 0.30 to 0.60 m.	Gro-985	3400 ± 50
Station DO 1089, 1.40 to 1.60 m.	Gro-991	5980 ± 60
Station DV 1147, 0.40 to 0.80 m.	Gro-984	3210 ± 75
Station DV 1147, 2.50 to 2.80 m.	Gro-982	5075 ± 60
Samples DN 1079 (depth 103 m) and DW 1153 (depth 135 m) consist of calcareous reef material from the shelf rim. Apparently, the reef formation took place in the Pleistocene, when the sea level was about 73 m lower than at present.		
Samples DI 1055 were investigated to determine the mean age of the *Amphistegina lessonii* association which at		

Description	Sample No.	Age
present is found between 65 and 90 m. Part of this fauna is corroded. In view also of the fact that *Amphistegina* generally occurs in shallower water, it is supposed that a mixture of recent and subrecent specimens is present. The C^{14} dates are in agreement with this assumption.		
Samples DI 1047 are rather old, probably because of redeposition of Pleistocene reefs. The sounding lead yielded indications in this direction.		
Samples DO 1089 and DV 1147 were investigated to determine whether at the present sea level reworking of sandy material takes place. This presumption is proved by the radiocarbon dates, since even at a depth of 2.50 m the age of the shells is not more than about 5000 yr.		
Maas en Waal (province of Gelderland). Four samples from a standard peat section in the Land van Maas en Waal. The pollen diagram was prepared by F. Florschütz. Submitted by L. J. Pons, Bennekom.		
LOG a, Early Subboreal.	Gro-666	4400 ± 120
LOG ba, Early Atlantic.	Gro-662	6850 ± 130
LOG c, Boreal.	Gro-661	8785 ± 160
LOG d, Preboreal.	Gro-665	9825 ± 200
The dates agree with radiocarbon dates from the same pollen zones from other standard sections in northwestern Europe.		
Zuid Holland (Netherlands). Peat lenses occurring below old sea clay (oude blauwe zeeklei) at several places in the province of Zuid Holland. Pollen analysis points to an Atlantic age.		
Berkel, depth 5.50 to 6.00 m, O.D. (ordnance datum).	Gro-1122	5280 ± 90
Nootdorp, depth 5.50 to 6.00 m, O.D.	Gro-1119	5360 ± 70
Boskoop, depth 2.00 m below the surface (5.00 m, O.D.).	Gro-1013	5760 ± 60
Not indicated, depth 0.70 m below the surface.	Gro-1116	4090 ± 55
Apart from the last sample, which might have been contaminated by recent roots, the dates confirm the pollen analytical determinations.		
Vinkeveen (province of Utrecht). Three samples from a standard peat section near Vinkeveen, submitted by J. Bennema, Bennekom.		
End of quercetum mixtum dominance (depth 1.25 to 1.30 m).	Gro-978	4200 ± 80
Beginning quercetum mixtum dominance after *Alnus* dominance; at the same time, first influence of the "oude zeeklei" (old sea clay) in the profile. Age expected about 4000 B.C. (depth 1.80 to 1.90 m).	Gro-988	5150 ± 65
Intersection of *Pinus* and *Alnus* curves. Age expected 5500 B.C. (depth 2.73 to 2.83 m).	Gro-980	5890 ± 60
Three samples from another profile in the same peat section. Submitted by J. Bennema, Bennekom.		
Oligotrophic peat, sub-Atlantic (depth 0.80 to 0.90 m).	Gro-1014	2010 ± 50
Carex-Phragmites peat, sub-Atlantic (depth 1.35 to 1.45 m).	Gro-1015	2075 ± 75
Carex-Phragmites peat, beginning *Fagus* curve, Subboreal (depth 3.20 to 3.30 m).	Gro-1009	2855 ± 60
The second series of dates is according to expectation. The dates from the first series are younger than was anticipated on the basis of pollen analysis by Florschütz. This deviation was suggested to be due to downward transport of humus, but according to our experience this is improbable in this case.		
Houten (province of Utrecht). Well preserved leaves included in a laminated sand at a depth of 3.00 m. The sand fills a Rhine delta gully, and was inhabited in Roman times. The leaves would date the formation of the gully, which was thought to take place between 1000 and 500 B.C. Collected by K. J. Hoeksema, Bennekom. This result implies that between 3200 B.P. and Roman times the gully was filled up again with about 2 m of deposits. This is considered reasonable.	Gro-1010	3200 ± 50
Beerta (province of Groningen). *Phragmites* peat, immediately above and below a heavy decalcified clay, containing *Phragmites* roots, at a depth of 2.20 to 2.90 m below O.D., at Kloostergare near Beerta. This clay could date either from the Boreal-Atlantic transition or from a later period. Collected and submitted by L. A. H. de Smet, Winschoten.		
Top sample.	Gro-1163	2305 ± 65
Bottom sample.	Gro-1164	2910 ± 60
The dates indicate that the clay was deposited in the early sub-Atlantic.		
Rauwerd (province of Friesland). Top of sedge peat containing some clay at a depth of 2.70 to 2.80 m below the surface, underlying sediments from the pre-Roman sub-Atlantic transgression phase, which in the western part of the Netherlands is dated at about 300 B.C. Submitted by J. Cnossen, Heerenveen. The date is according to expectation and confirms the supposed contemporaneity of the pre-Roman transgression phase.	Gro-1167	2200 ± 65
Takoradi (Ghana). Mangrove wood from a fossil forest, exposed below high-water mark, lying on the surface of continental deposits, which were flooded by the second Holocene transgression. This transgression has recently been recognized at a number of places along the African coast. In the continental deposits artefacts occurred from the end of the Middle Stone Age. Submitted by O. Davies, University College, Achimota.	Gro-1194	5570 ± 70
Zwartemeer (province of Drenthe). Two samples from the upper sub-Atlantic part of the large, raised bog in the southeastern part of Drenthe near Zwartemeer. They were taken to complete the Emmen standard diagram from the same raised bog, described in the previous list (*2*), in which the sub-Atlantic period was practically lacking, owing to buckwheat cultures.		
Depth −0.50. Considerable increase of *Carpinus* (from 3 to 8 percent).	Gro-1168	1440 ± 40
Depth −1.15. First small increase of *Carpinus* (from 0.2 to 1.0 percent).	Gro-1170	2025 ± 70
A more considerable part of the sub-Atlantic peat had been removed by the buckwheat cultures than was anticipated. Although the dates are a valuable addition to the Emmen ones, the middle and upper part of the sub-Atlantic period remains to be investigated.		

Table 2. Archeological samples (Europe). All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
Salzofenhöhle (Totengebirge, Austria). Charcoal collected by K. Ehrenberg, Vienna, in the famous Salzofen cave. The problem in this cave is whether the presence of large numbers of skulls and other bones of *Ursus spelaeus* is due to human activity (*9*). It is supposed on paleontological and paleobotanical evidence that the habitation took place in an interstadial period. The sample was submitted by A. Bohmers, Groningen. The quantity of charcoal was not sufficient for the larger counter. The present date fully confirms the Pleistocene age of the cave contents.	Gro-761	34,000 ± 3000
Lascaux (France). To solve the problem of the age of the famous paintings in the Lascaux cave, a number of samples were collected by A. Glory, Strasbourg, which were directly correlated with archeological remains. So far, only two samples have been measured: charcoal in a hydrocalcite layer on top of a human femur at the entrance of the cave (C), and charcoal with "palettes de couleurs" (B), originating from the "passage."		
Sample C.	Gro-1182	8270 ± 100
Sample B.	Gro-1514	8060 ± 75
The recent findings of leaf impressions of *Corylus* and *Quercus* in layer C agree with the date obtained. The present dates have apparently no relation to the older paintings; they merely show that the cave was still inhabitated in the Mesolithic period. The investigations are being continued.		
Mesolithic samples from the Netherlands. Charcoal from Mesolithic fireplaces (*10*) of the same kind as described in the previous report (*2*) from Haule and Waskemeer. These fireplaces are usually found at places of dense flint concentrations on coversand ridges near bogs or brook valleys. Submitted by A. Bohmers, Biological Archaeological Institute, State University, Groningen.		
Duurswoude I (province of Friesland).	Gro-1173	7460 ± 100
Duurswoude III.	Gro-1175	7470 ± 70
Een I (province of Drenthe).	Gro-1505	7560 ± 110
Een II.	Gro-1508	7485 ± 100
Siegerswoude (province of Friesland).	Gro-1509	7720 ± 70
Oirschotse heide (province of N. Brabant).	Gro-1510	7270 ± 60
Drouwen (province of Drenthe).	Gro-1513	7635 ± 90
de Leyen (province of Friesland). Charred *Corylus* nuts from the culture layer of the Mesolithic site of de Leyen.	Gro-685	6960 ± 140
Apart from the last one, which has a very different flint typology, all the sites, including Haule and Waskemeer, appear to date from the Boreal period.		
Geleen (province of Limburg). Two charcoal samples from the early Danubian site (ältere Linearbandkeramik) of Geleen (*11*).		
Pit H 11.	Gro-995	6130 ± 60
Nr 838.	Gro-996	5935 ± 60
The dates fully agree with those obtained from other Danubian sites. On the basis of pottery typology, Geleen should be somewhat earlier than the greater part of the nearby Sittard site (*2*). The dates from Sittard (5790 ± 190, 6100 ± 140, 6200 ± 150) however, do not differ very much from those of Geleen. Apparently, these settlements lasted for only a few hundred years, and the whole typological evolution took place within that period.		
Hekelingen (province of South Holland). Animal bones from the Neolithic settlement of Hekelingen (*12*), from which, in the previous list (*2*), charcoal had been dated at 4200 ± 120 (Gro-254). Submitted by P. J. R. Modderman, Amersfoort. There is no significant difference between bone and charcoal.	Gro-684	4080 ± 85
Chalain (Jura, France). In the neighborhood of the Lac de Chalain in the French Jura two sites were excavated in 1955 by F. Bourdier, Musée National d'Histoire Naturelle, Paris, who collected a number of samples, which were submitted by Florschütz.		
Site Escalon (Ilot des roseaux). At least four superposed archeological levels within lake marl. The samples consisted of wood from the culture layers.		
Layer 3 (−1.10 m) with pottery of Horgen type.	Gro-949	4100 ± 60
Layer 5 (−1.34 m) with pottery of the same type.	Gro-670	4090 ± 115
Layer 9 (−1.75 m) with uncharacteristic pottery.	Gro-950	4265 ± 80
Layer 12 (−2.25 m) with pottery of clear Cortaillod type.	Gro-672	4180 ± 130
	Gro-970	4350 ± 80
Site Bailloud (Vernois sud). One archeological level, dated by Late Bronze Age pottery (Bronze IV, according to Dechelette). The sample was taken from a wooden plank, belonging to the habitation floor. The dates agree with expectation; pollen diagrams are being prepared by Florschütz.	Gro-671	2860 ± 80
	Gro-683	2985 ± 100
Nieuw Dordrecht (province of Drenthe). Wood from a trackway (*13*), which according to pollen analysis would be of late Neolithic age.	Gro-1087	3840 ± 55
Valthe (province of Drenthe). Wood from the famous trackway "Valtherbrug" (*14*), the age of which has been much discussed. The Neolithic age of the trackway of Nieuw Dordrecht is fully confirmed by the C^{14} analysis. The Valthe trackway is obviously much younger. The samples were submitted by W. van Zeist, Biological Archaeological Institute, Groningen.	Gro-1085	2055 ± 50
den Treek (municipality of Leusden, province of Utrecht).		
Charred beam placed above a Drakenstein urn in tumulus 1 at den Treek, municipality of Leusden (*15*). Submitted by P. J. R. Modderman, Amersfoort.	Gro-968	3090 ± 70
Charcoal which most probably is contemporaneous with a cremation interment in a coffin in tumulus 2 at den Treek.	Gro-971	3300 ± 75
The date of the first sample agrees with that of tumulus E of Knegsel (see below), which also contained a Drakenstein urn (Gro-1034, age 2850 ± 40 yr). The second date proves that the cremation interment dates from the Early Bronze Age. Early cremations were also found at the Halve Mijl-Toterfout necropole (see below), for example, in		

Description	Sample No.	Age
tumulus 1 (Gro-1051, age 3240 ± 65 yr).		
Halve Mijl-Toterfout (municipality of Veldhoven, province of Noord Brabant). A series of charcoal samples from the Bronze Age necropole of Halve Mijl-Toterfout from which three determinations were published in the first list of dates (*1*). As no Gro- numbers were added at that time, they are included in the present list. For the location of the samples and so forth, see Glasbergen (*16*). The samples are also of importance for checking the relative chronology of the barrows as suggested by Waterbolk's pollen analysis. Therefore, they are arranged according to the pollen chronology.		
Tumulus 4, sample 87.	Gro-066	3375 ± 200
Tumulus 1^{B1}, sample 74a.	Gro-050	3450 ± 100
Tumulus 1^{B2}, sample 65b.	Gro-1053	3340 ± 130
Tumulus 1, sample 1e.	Gro-1051	3240 ± 65
Tumulus 5, sample 42.	Gro-1003	3060 ± 50
	Gro-989	3070 ± 50
Tumulus 19, sample 16a.	Gro-1025	3055 ± 50
	Gro-1033	2960 ± 50
Tumulus 8, sample 49.	Gro-049	3055 ± 90
Tumulus 8, sample 49.	Gro-990	3010 ± 60
Tumulus 10, sample 51.	Gro-1000	3080 ± 50
Tumulus 9, sample 84.	Gro-1022	3100 ± 50
	Gro-1029	3090 ± 40
Tumulus 15, sample 64.	Gro-1001	3030 ± 60
Tumulus 3^{1}, sample 55.	Gro-1024	3160 ± 50
	Gro-1030	3045 ± 50
To this series can be added a sample from Knegsel, tumulus E, also excavated by Glasbergen.		
Tumulus E, sample 6b.	Gro-1028	2850 ± 40
	Gro-1034	2850 ± 40
On the whole, the relative chronology based on pollen analysis is confirmed. On the basis of the grave typology, tumuli 3 and 9 could be somewhat earlier than suggested by pollen analysis. The radiocarbon dates point in the same direction.		
Tumulus E of Knegsel, containing a Drakenstein urn, appears to be younger than is supposed on the basis of pollen analysis. The date, however, is in agreement with that obtained from tumulus 1 of den Treek (see above). The samples were submitted by W. Glasbergen, Groningen.		
Pylos (Greece). Charred beam of palace from Mycenean times, probably of Nestor. Collected by C. W. Blegen, Cincinnati. Submitted by H. Brunsting, Leiden. The date is according to expectation.	Gro-998	3010 ± 50
Deventer (province of Overijsel). Charcoal from the Early or Middle Bronze Age settlement on the Margijnenenk, municipality of Deventer (*17*). Depth about 1.00 m. The pottery does not allow an exact date for the settlement. Submitted by P. J. R. Modderman, Rijksdienst voor het Oudheidkundig Bodemonderzoek, Amersfoort. The radiocarbon date proves a Middle Bronze Age dating of the settlement.	Gro-955 Gro-967	2820 ± 70 2890 ± 70
Elst (province of Gelderland). Human skull, which, on anthropological grounds, was thought to be of Pleistocene age. In the neighborhood, mammoth bones have been found. The sample was submitted by J. Huizinga, Utrecht.		
Human skull.	Gro-997	2325 ± 75
Mammoth bone.	Gro-712	> 20,000
The skull is obviously of late Holocene age.		
Dorregeest (municipality of Uitgeest, Noord Holland). Fragment of a wooden harrow, found in a pit at Dorregeest, excavated by F. C. Bursch. The stratigraphical context is not clear. At the site both medieval and Iron Age remains were found. Submitted by J. M. G. van der Poel, Wageningen. The date proves that the harrow indeed belongs to the earlier habitation phase. It is the oldest harrow so far known.	Gro-1171	1680 ± 60
"Eschböden" (Emsland, Germany). Three charcoal samples collected in the bottom part of "Eschböden," that is, the soil of fields which in the course of centuries has grown in thickness as a result of manuring with turf from sheep stables. The age of the "Esche" is a much discussed problem. Collected and submitted by G. Niemeier, Braunschweig.		
Hesselte.	Gro-1008	1200 ± 45
Ahlen.	Gro-1037	1670 ± 45
Milte.	Gro-1038	1860 ± 50
	Gro-1052	1840 ± 50
The "Esche" appear to be older than generally is believed, and seem to go back as far as the beginning of our era. The date of Milte is in agreement with that of some sherds found in the same layer.		
Wijster (municipality of Beilen, province of Drenthe). Wood from the front wall of an Anglo-Saxon hut (*18*). A date of A.D. 400 was expected on the basis of the presence of sherds of a late Roman glass bowl in the filling of the hut. Submitted by H. T. Waterbolk, Groningen. The date (*18a*) is somewhat younger than was expected, but there is no real proof that the sherds are contemporaneous with the hut. They surely got in the hut after it had collapsed, but they may have been lying in the soil, which originally formed the side walls of the hut. There are traces of earlier habitation at the site.	Gro-1176	1315 ± 40
"Roodzand." Fairly frequently a typical red sand (roodzand) is found on the Veluwe (province of Gelderland). The origin of this red sand has been a subject of many speculations. One theory, which is supported by the present dating of charcoal found in the sand, correlates it with charcoal production for iron foundries, of which many remains have been found and which have been dated in about the 8th century (*18a*). The sample was submitted by G. Maarleveld.	Gro-1103	1100 ± 65
Ghent (Belgium). Wooden structure below the "Gravensteen," on archeological evidence supposed to be of Viking age. The presence of Vikings in Ghent from 879–881 is a historical fact. A second wooden building below the Gravensteen dates from about A.D. 1035. Submitted by E. G. Boers, Ghent. The date (A.D 1016 ± 50) does not agree with the assumption that the building was erected by the Vikings; it agrees with the age of the second building (*18a*).	Gro-1046	940 ± 50

Description	Sample No.	Age
Karolingian Chapel (Nijmegen, province of Gelderland). In view of a controversy as to the age and building history of the tuff part of the so-called Karolingian Chapel, a number of corresponding wood samples were dated. Gro-976 and Gro-1502 were submitted by J. G. Deur, Nijmegen; Gro-977, by H. Brunsting, Leiden.		
Beam from upper part of central pillar structure.	Gro-976	760 ± 40
Beam from lower part of central pillar structure.	Gro-1502	900 ± 40
Other beam, belonging to the same early part of the building.	Gro-977	900 ± 45
According to these dates, there is indeed a difference in age between parts of the central structure. However, the earlier part does not appear to go back to Carolingian times (*18a*). There are also architectural arguments in favor of a date in the first half of the 11th century A.D.		
Rijnsburg (province of South Holland). Two skeletons from a group of graves found during the excavation of the Abbey of Rijnsburg. The first was thought to be that of Floris V, Count of Holland, who was murdered in 1296. The second is from a skeleton lying close to the former. Submitted by W. Glasbergen and B. K. S. Dijkstra, Groningen.		
I.	Gro-677	945 ± 100
	Gro-680	900 ± 70
II.	Gro-1111	970 ± 40
The dates are systematically somewhat too old; a more detailed investigation into the possibilities of errors with dating of bones is planned, including a calibration with more recent bones (*18a*).		
Bargen (Schaffhausen, Switzerland). Charcoal from medieval (14th century) iron melting oven. Submitted by W. Guyan, Schaffhausen. The date agrees with the expectation.	Gro-1005	640 ± 50
	Gro-1020	660 ± 45

Table 3. Archeological samples (Asia, Africa, America).

Description	Sample No.	Age
Niah Caves (West Sarawak, British Borneo). Charcoal samples reflecting tools supposed on archeological grounds to be Middle Stone Age type (unworked stone and pebbles, bone points, animal remains and shell in bulk, quartz pebble fire strikes and charcoal). The first sample (Gro-1159) represents the upper limit of "flake" and "blade" concentration. The second sample (Gro-1158) represents the bottom of the same layer (depth about 1 m). The third sample came from a depth of 2.5 m but from a different location. Archeologically it is somewhat older than the second sample. The deposits continue several meters below the third sample, but are not yet fully analyzed. The results are older than hitherto expected, but they agree with the ideas of the submitter of the sample (*19*). This is the first Paleolithic settlement discovered in this part of the world. The samples were collected by M. W. F. Tweedie, director of the Raffles Museum, Singapore, and T. Harrisson, curator of the Sarawak Museum, during excavations by the Sarawak Museum.	Gro-1159 Gro-1158 Gro-1338	19,570 ± 190 32,630 ± 700 41,500 ± 1000
Jericho (Palestine). Charcoal of Tamarisk from the late pre-pottery Neolithic phase (Layer Y, Square F1). Supplied by F. E. Zeuner, London.	Gro-942 Gro-963	8900 ± 70 8785 ± 100
Zeuner, using a pretreatment with acid only, had obtained (F-38) 7800 ± 160 yr but after an alkali treatment, 8670 ± 200 yr (F-41) was found. When using the same pretreatment, both laboratories thus produce the same figures.		
Egypt. Wood from the First Dynasty tomb of Waji (or Zet) in the necropole at Saqqara, excavated by Emery. It should be about a generation older than the grave of Den (see previous list, 2), which has produced a date of 4450 ± 100 yr (Gro-689). Supplied by H. Barker, the British Museum, London.	Gro-1100 Gro-1109	4120 ± 60 4220 ± 55
Wood from the deck of the funerary ship of Sesostris III. Expected age 3750 yr.	Gro-1157 Gro-1178	3310 ± 55 3370 ± 50
Section of a tree trunk from the pyramid of King Menthuhotep II or III at Dier at Bakri (Thebes). The date of death of this king, irrespective of whether he was Menthuhotep II or III, is reckoned to be about 2010 B.C. This date is based on astronomical evidence. The probable error should not be more than 20 yr.	Gro-1155 Gro-1177	3420 ± 55 3420 ± 55
All the samples came out much younger than was expected. The same was the case for samples from the previous list. The discrepancy is only partially due to isotopic fractionation in the sample. The difference in the C^{13}/C^{12} ratio between the calibration sample and the present two samples was 0.5 percent only. So 80 yr have to be added to the the ages given. The sample from Sesostris III was also dated by Libby, who got (C-81) 3621 ± 180 yr. Our sample was a part of the same piece of wood.		
Fimnah (Israel). Charcoal from a grave in the Wadi Fimnah acropolis in the Negeb Desert. The date is of importance for the history of mining in the area. Both copper and iron were produced at the site (*20*). The sample was submitted by V. P. Sokoloff, Haifa.	Gro-938	2655 ± 65
Wadi Murabaʿat (Jordan). Woolen textile from one of the caves associated with the famous Dead Sea Scrolls. The expected age is approximately 1800 yr (Bar Kochbak's revolt) on archeological evidence. Supplied by F. E. Zeuner, London. With acid treatment only, Zeuner found (F-37) 1350 ± 60 yr. In this case also, the difference is probably due to the pretreatment applied.	Gro-940 Gro-943 Gro-965	1665 ± 42 1575 ± 50 1550 ± 75
Gran Canario. Six samples relating to the fair, blue-eyed people (Guanches), who lived on the Canary Islands before the arrival of the Spaniards. They show anthropological characters of the Cro-Magnon type. Apart from the last sample, the material consists of mummy skins and woody material covering		

Description	Sample No.	Age
mummies, which were buried in caves. Submitted by C. R. Gavilanes, Las Palmas.		
Guayadeque, wood.	Gro-1190	980 ± 60
Guayadeque, mummy skin.	Gro-1189	1170 ± 60
Acusa, wood.	Gro-1127	1280 ± 45
Acusa, mummy skin.	Gro-1188	1140 ± 60
Guevas del Rey, wood.	Gro-1191	1420 ± 60
Galdar, wood from a sepulchral monument.	Gro-1192	635 ± 60
The dates, though rather late, are perfectly acceptable. There is no significant difference between the mummy skin and the wood at the first two sites.		

Description	Sample No.	Age
Mayapan (Yucatan, Mexico). Charcoal from burned beam on floor of structure R-87, Mayapan, Mexico. Expected age 500 yr. The specimen should date the approximate termination of the Mayan civilization. The sample was submitted by H. E. D. Pollock, Carnegie Institution of Washington, Cambridge, Mass. There is an upper limit on historical evidence of approximately A.D. 1540 for the ruin of Mayapan. A correction of 100 or 200 yr for the Suess effect would bring the C^{14} date in accord with the archeological evidence.	Gro-1166	400 ± 55

Table 4. Special problems.

Description	Sample No.	Age
Klazienaveen (province of Drenthe). Layer of peat on sand, containing three infiltration bands of humus. The stratigraphy was as follows: Peat up to a depth of 40 cm. At 60 cm the first humus band. At 130 cm a white band in the sand, typical for the Allerød in this region. At a depth of 180 cm the second humus band. At 210 cm the third band. The three layers contained about 5, 1.2, and 1.2 percent of humus, respectively. It was collected by washing the sand with water until it was clear. The water was then centrifuged. For the second band, it was checked that the material obtained was completely soluble in alkali. The samples were collected and submitted by B. van Heuveln.		
Bottom of peat.	Gro-1019	3230 ± 75
First layer.	Gro-1016	2090 ± 50
Second layer.	Gro-710	1535 ± 85
Third layer.	Gro-711	2550 ± 100

Description	Sample No.	Age
It is obvious that humus passed through the peat and perhaps even through humus layers deposited earlier, though it is also possible that the lower layers were produced first. The results are of interest for studies of humus transports in the soil, as well as for discussions of possible errors in C^{14} datings, introduced by infiltration of more recent material. The date of the peat agreed with the pollen analysis (Subboreal).		
Storbreen glacier (Norway). By a special apparatus, CO_2 was collected from about 6 tons of ice by Coachman *et al.* The sample contained about 0.3 g of carbon. The date is in excellent agreement with the estimates made by the Norsk Polarinstitut. A more detailed discussion can be found in (*21*). The main aim of the present measurement was to prove the feasibility of the procedure; further investigations are planned.	Gro-758	710 ± 120

References and Notes

1. H. de Vries and G. W. Barendsen, *Nature* 174, 1138 (1954).
2. H. de Vries, G. W. Barendsen, H. T. Waterbolk, *Science* 127, 129 (1958).
3. H. de Vries, *Science* 128, 250 (1958).
4. ———, *Eiszeitalter und Gegenwart* 9, 10 (1958).
5. ———, *Koninkl. Ned. Akad. Wetenschap. Proc.* B61, 94 (1958).
6. F. Brandtner, *Arch. Aust.* 2, 5 (1949).
7. J. Menendes Amor and F. Florschütz, *Communications of the 5th Inqua-congress*, 1957, vol. 1 in press.
8. D. J. G. Nota, in preparation.
9. K. Ehrenberg, *Quartär* 6, 19 (1954). See also *Osterr. Akad. Wiss. Math. naturw. Kl., Sitzber., Abt. I*, 166, 57 (1957).
10. A. Bohmers, *Palaeohistoria V*, in press.
11. H. T. Waterbolk, *Palaeohistoria VI*, in press.
12. P. J. R. Modderman, *Ber. Rijksd. Oudh. Bodemond.* 4 (1953).
13. W. van Zeist, *Nieuwe Drentse Volksalm* (1957).
14. A. E. van Giffen, *ibid.* (1938).
15. P. J. R. Modderman, *Ber. Rijksd. Oudh. Bodemond.* 6, 59 (1955).
16. W. Glasbergen, *Palaeohistoria II, III*, (1954).
17. P. J. R. Modderman, *Ber. Rijksd. Oudh. Bodemond.* 6, 22 (1955).
18. H. T. Waterbolk, *Nieuwe Drentse Volksalm* (1957).

18a. These comments were written before the correction for Suess effect was known. (See the introductory remarks in this article.) When 240 years are added to these dates, their agreement with expected (historical) age is much better, except for the bone samples.

19. T. Harrisson, *Man*, in press.
20. V. P. Sokoloff, *Science* 123, 587 (1956).
21. L. K. Coachman, E. Hemmingsen, P. F. Scholander, T. Enns, H. de Vries, *Science* 127, 1288 (1958).