Seasonal Variability in Early Hominid Predation

Most archeological sites in Olduvai Gorge beds I and II may be dry season occupations.

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The predatory behavior of early African hominids has been of considerable interest to anthropologists for many years. Knowledge of the role of animal foods in their diet and subsistence behavior is critical to any satisfactory explanation of human origins and evolution. Much of our current understanding of early hominid predatory behavior derives from comparative studies of our closest living relatives among the nonhuman primates, and of contemporary hunters and gatherers. For example, observers of baboons and chimpanzees in the wild have documented the importance and regularity of predation among these primates (*1*). These studies provide valuable insights into the probable role of meat eating, cooperative hunting, and meat sharing among early hominids who lived in a savanna environment.

Research among contemporary hunters and gatherers has also played an important role in shaping our views of early hominid diet and predatory activity (*2*). For example, such studies have emphasized the importance of plant and small animal foods in the diet and behavior of nonarctic hunters and gatherers (*3–5*), even among groups that inhabit areas with relatively large standing crops of ungulates (*6*).

The archeological remains themselves, however, provide the most direct approach to the study of early hominid predatory activity (*7*). Unfortunately, such studies have been hampered by the scarcity of adequate quantitative faunal data from habitation sites. Recently this situation has been remedied by the publication of the inventory of archeological materials from beds I and II at Olduvai Gorge in Tanzania (*8*). The Olduvai report provides detailed counts and taxonomic identification of the faunal remains from numerous localities within the gorge. Here we examine early hominid predatory activity by using the faunal data from Olduvai. These data are compared systematically to the prey taken by contemporary Bushman hunters and gatherers; the basis for such comparison is discussed below. Seasonal variability in the proportions of various prey types hunted by the Bushmen is analyzed, and a possible means for assessing the seasonality of early hominid predatory activity at Olduvai is suggested.

Bushman and Early Hominid Predation: Basis for Comparison

The archeological material from beds I and II at Olduvai Gorge (about 1.85 to 1.0 million years ago) consists almost entirely of stone tools, animal bones, and a number of fragmentary hominids (*8*). Remains of plants that were almost certainly part of the diet of these hominids have not been preserved. Thus our analysis focuses exclusively on the Olduvai fauna. In order to meaningfully compare these data with dietary information from contemporary hunters and gatherers, one must find modern groups whose hunting activities have been documented quantitatively. Furthermore, one must find groups that occupy broadly comparable habitats and that exploit a similar range of animals. These restrictions limit us to the Bushmen of the Kalahari region in southern Africa. Comparison of the Olduvai fauna with that of the Bushmen seems justified and potentially productive for several reasons.

1) Bushmen hunting activities, prey types, and monthly kill frequencies have been well documented (*3–5, 9–14*).

2) Present-day Olduvai Gorge and the Kalahari are situated in arid to semiarid parts of Africa and have similar annual rainfall patterns. Precipitation in both areas is variable and markedly seasonal. Rainfall at Olduvai, during the 8 years for which records are available, ranged from 27.6 to 105.2 centimeters per year and averaged 56.6 centimeters per year (*15*). Rainfall data for the Kalahari are spotty, but suggest an average of 40 to 50 centimeters per year in the more northerly parts diminishing in the central Kalahari to about 20 to 30 centimeters per year (*11, 14*).

At Olduvai most rain falls between September or October and May, with heavy rains beginning in December or January and persisting until March or April (*15*). The seasonality of rainfall in the Kalahari is very similar. Rains fall between October or November and May, with heavy rains beginning in December or January and ending in March or April (*11, 14*).

3) The climate at Olduvai Gorge throughout bed I deposition was semiarid, with conditions slightly more moist in the lower fossiliferous part of the sequence and more arid in the upper part (*15*). During bed II times the climate continued to be semiarid, resembling that of the drier, upper part of bed I (*15*). We therefore assume that the average annual precipitation during most of bed I and bed II deposition was broadly comparable to that in the Gorge area today, and thus was also broadly comparable to the present-day rainfall in the Kalahari region. Moreover, in the absence of evidence to the contrary, we make the assumption that the seasonality of rainfall at Olduvai during bed I and bed II times was similar to what it is now in the area, and therefore was broadly comparable to the seasonality of rainfall in the present-day Kalahari.

4) In the Olduvai region there is relatively little seasonal variability in temperature (*15*), whereas, in the Kalahari, the division of the year into warm and cool seasons is more pronounced. Numerous ecological studies, however, suggest that rainfall is far more important than temperature as a factor limiting production in arid or semiarid regions of the tropics and subtropics (*16*). Anthropologists working with contemporary hunters and gatherers in arid and semiarid areas of Africa and Australia have also noted the importance of precipitation as a limiting factor (*3, 17*). Thus, we assume in this discussion that rainfall is far more critical than temperature to the subsistence behavior of hunters and gatherers in the Kalahari and was more critical at Oldu-

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vai. Obviously, this assumption may need modification.

5) The range of animals exploited by early hominids at Olduvai Gorge is broadly comparable to the range hunted by Bushmen. The taxa from beds I and II that have been reported in detail (primarily, the larger reptiles and mammals) include Chelonia, Crocodylidae, Primates, Carnivora, Proboscidea, Equidae, Rhinocerotidae, Suidae, Hippopotamidae, Giraffidae, and Bovidae (*8*). Rodents and birds were also abundant at Olduvai but inventories have not yet been published (*8*). Virtually the same range of taxa are exploited by the Bushmen, although several of the larger mammals (rhinoceros, hippopotamus, elephant, buffalo, zebra) have disappeared, or have become very rare, in the past century (*9, 14, 18, 19*).

Among the larger animals, bovid remains are by far the most numerous prey found at Olduvai, and most are of ". . . medium-sized species, ranging from animals the size of a wildebeeste to that of reed buck or bush buck" (*8*). Bovids of comparable size also predominate among the larger mammals hunted by the Bushmen (*9, 11, 18*).

Comparison of Bushman and Early Hominid Prey

Silberbauer (*9–11*) provides estimates of the number of kills made each month by a band of G/wi Bushmen (about 85 members) during the course of an average year. His counts are modal values based on observations made between 1959 and 1966 (*11*). Comparable, although less extensive data for the G/wi are available in Tanaka (*12*). Silberbauer's data are shown in Table 1, where they are grouped into taxa equivalent to those used by Leakey (*8*) for the Olduvai

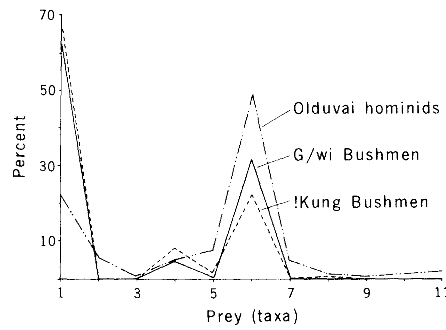

Fig. 1. Frequency distributions of prey taken by Olduvai hominids and by Bushmen (*8, 11, 13*). Prey (taxa): 1, Chelonia: 2, Crocodylidae; 3, Primates; 4, Carnivora; 5, Suidae; 6, Bovidae; 7, Equidae; 8, Giraffidae; 9, Rhinocerotidae; 10, Hippopotamidae; and 11, Proboscidea.

fauna. To arrive at these values, the monthly tallies were added together to provide an annual total for each taxon. Proportions of each were then determined. These proportions are also given in the table and are shown graphically in Fig. 1. The taxa in the figure are arranged approximately in order of increasing body size.

Wilmsen (*13*) provides data on prey taken by a group of !Kung Bushmen between late August 1973 and January 1974. These data are also shown in Table 1 and Fig. 1. The similarity between the data for G/wi and !Kung is striking. It suggests that these two groups of Bushmen, despite different settlement systems (*4, 10*), have remarkably comparable overall predation patterns.

Leakey (*8*) has provided tabulations of the number of bones identifiable to various taxa that were recovered from 22 levels at nine different localities in Olduvai Gorge. Three principal assumptions have been made by us in using these data.

1) The fauna reported from the excavated portion of each occupation level is assumed to be reasonably representative of the total fauna in that occupation level.

2) The thickness of deposit, and thus the probable number of occupations, varies considerably from site to site. For instance, DK level 3 is only 9 centimeters in thickness, whereas HWK East level 2 is nearly 205 centimeters thick (*8*). No attempt is made in our analysis to deal with this variability in thickness of deposit. However, the problem is discussed in greater detail below.

3) The number of individual animals at each site is presently unknown. In the absence of such data, the proportion of each taxon is estimated from the number of identifiable bones.

Clearly, these are important assumptions. The nature and similarity of patterning of the Olduvai and Bushman data obtained in our study, however, suggest that they may not be unreasonable.

The bone counts for each taxon, taken directly from Leakey (*8*, table 4), were tallied across all 22 levels. Proportions were then determined from the totals. The results are summarized in Table 1. Locality DK produced 4600 loose crocodile teeth that Leakey (*8*) believes were shed by living animals. These have been excluded from the tabulations. An additional 112 crocodile teeth were similarly excluded from the counts for FLK NN level 4.

The proportions of the various taxa from Olduvai are compared graphically in Fig. 1 with the prey taken by !Kung and G/wi Bushmen. The frequency distributions are very similar, despite the differences in method by which the data were compiled. It will be particularly interesting, when sufficient data become available, to compare the frequency distributions of the various bovids taken by early Olduvai hominids with those taken by Bushmen. Obviously, a great deal of potentially important information is lost by treating bovids as a single group.

Table 1. Prey exploited by Bushmen and Olduvai hominids (*8, 11, 13*).

Taxa	G/wi Bushmen		!Kung Bushmen		Olduvai Gorge	
	Number of animals	Percent	Number of animals	Percent	Number of identifiable bones	Percent
Chelonia	440	63.4	233	67.3	3219	21.6
Crocodylidae	0	0	0	0	836	5.6
Primates	0	0	0	0	115	0.8
Carnivora	32	4.6	28	8.1	739	5.0
Proboscidea	0	0	0	0	310	2.1
Equidae	0	0	0	0	733	4.9
Rhinocerotidae	0	0	0	0	95	0.6
Suidae	1	0.1	6	1.7	1131	7.6
Hippopotamidae	0	0	0	0	209	1.4
Giraffidae	1	0.1	1	0.3	221	1.5
Bovidae	220	31.7	78	22.5	7276	48.9

Seasonal Variability in Bushman and Early Hominid Predation

Examination of Fig. 1 reveals three groups of animals, Chelonia, Carnivora, and Bovidae, that were frequent prey of the present-day Bushmen studied and of the Olduvai hominids (*20*). In the subsequent analysis, attention is focused specifically on these. Ideally, rodents and birds should be included, but data on these animals at Olduvai are not yet available.

Silberbauer's data for the G/wi Bushmen (*11*) are discussed first. The number

Table 2. Prey taken each month by G/wi Bushmen (*11*).

Month	Season*	Total killed per month	Chelonia Number	Chelonia Percent	Carnivora Number	Carnivora Percent	Bovidae Number	Bovidae Percent
September	D	26	0	0	6	23.1	20	76.9
October	D	21	0	0	1	4.8	20	95.2
November	R	81	50	61.7	4	4.9	27	33.3
December	R	104	90	86.5	0	0	14	13.5
January	R	107	90	84.1	0	0	17	15.9
February	R	106	90	84.9	0	0	16	15.1
March	R	101	80	79.2	2	2.0	19	18.8
April	R	69	40	58.0	4	5.8	25	36.2
May	D	21	0	0	1	4.8	20	95.2
June	D	24	0	0	5	20.8	19	79.2
July	D	17	0	0	3	17.6	14	82.4
August	D	15	0	0	6	40.0	9	60.0

*Rainy (R), or dry (D).

and proportion of Chelonia, Carnivora, and Bovidae taken each month by the G/wi are listed in Table 2. Because only three taxa are being considered, the proportions listed in the table can be illustrated conveniently on a triangular graph (Fig. 2). The patterning by season of these data is unambiguous. The cluster on the right side of the graph contains all of the dry season months (May through October). The cluster on the left side contains only rainy season months (November through April).

Patterning within clusters is less clear but is also potentially interesting. Within the dry season cluster, the very early and very late months of the season (May and October) have similar proportions of Chelonia, Carnivora, and Bovidae and are somewhat isolated from the months representing the middle of the dry season. A similar pattern is apparent for the early and late rainy season months (November and April). These two months fall together on the graph and are separated from the others.

The number and proportion of Chelonia, Carnivora, and Bovidae taken each month (September 1973 through January 1974) by !Kung Bushmen are listed in Table 3 and shown graphically in Fig. 2 (*13*). Data for the month of August have been excluded because detailed observation of hunting activity did not begin until late in the month. The !Kung data also separate into two distinct clusters in Fig. 2. One cluster represents the last part of the dry season (September through October 18); the other represents the early part of the rainy season (October 19 through January).

Lee (*3*) recorded the number of kills made in July 1964 by !Kung in the same general area as that studied subsequently by Wilmsen. These data (Chelonia 0 percent; Carnivora 28.6 percent; Bovidae 71.4 percent) also are plotted in Fig. 2. By combining Lee's information with that provided by Wilmsen, patterning emerges within the !Kung dry season cluster similar to that observed for the G/wi. The late dry season months are isolated somewhat from July, the month which falls more toward the middle of the season. However, this apparent patterning within the !Kung dry season cluster must be viewed with caution until more extensive data, collected in a single year, become available.

The proportions of Chelonia, Carnivora, and Bovidae were determined for each level at Olduvai Gorge by using the counts provided by Leakey (*8*). These data are shown in Table 4. Each level was then plotted on the triangular graph in Fig. 2. They separate into two nonoverlapping clusters, corresponding almost exactly to the rainy season and dry season dichotomy observed in the Bushman data. Four of the levels (18 percent) fall in the Bushman rainy season cluster [DK (all levels); FLK NN level 3; FLK NN level 1; MNK Skull Site]. Three of these are among the earliest occupations in the Gorge and coincide with a period of slightly reduced aridity (*15*). The remaining 18 levels (82 percent) fall within the Bushman dry season cluster.

Examination of Fig. 2 reveals that Che-

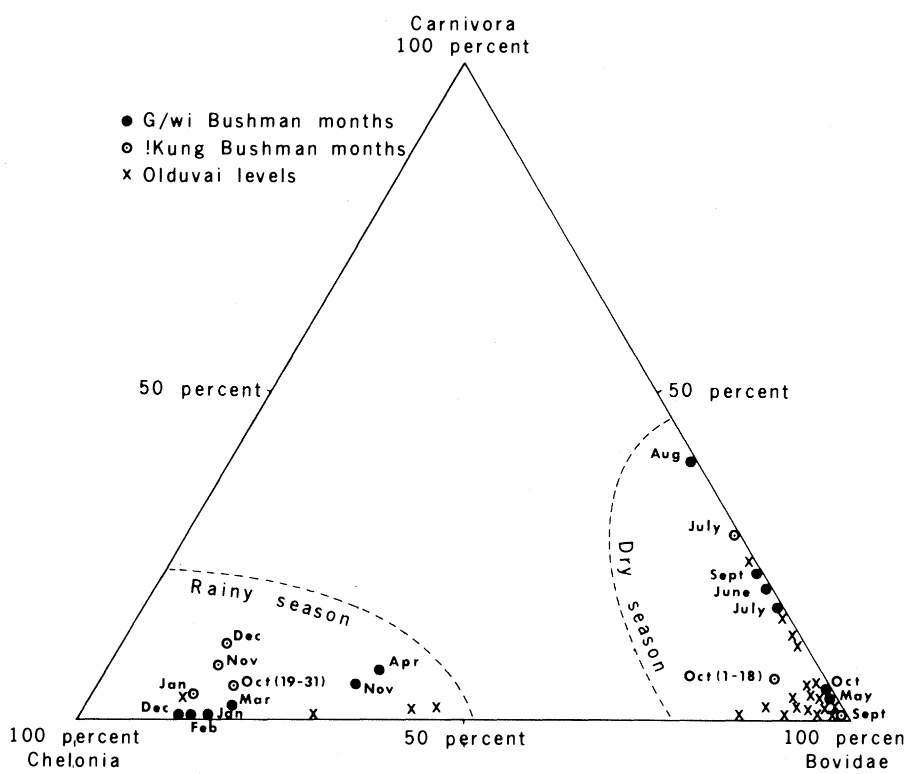

Fig. 2. Proportions of Chelonia, Carnivora, and Bovidae taken each month by G/wi and !Kung Bushmen compared to proportions of these animals found in archeological levels at Olduvai Gorge (*8*, *11*, *13*). Data used to construct figure may be found in Tables 2–4.

lonia are largely responsible for the clear-cut separation of the two principal clusters. This group of animals, therefore, deserves further comment. Several genera of land tortoises (family Testudinidae) and at least one genus of semiaquatic tortoise or terrapin (family Pelomedusidae) have been reported in the Kalahari region (*11, 14*). These tortoises apparently hibernate during the dry season and do not emerge until shortly after the first rains, when they are collected in considerable numbers by the Bushmen (*13, 19, 21, 22*).

The tortoise inventory from Olduvai Gorge has not yet been published. So far, only the remains from FLK NN level 3 have been identified down to genus and species. All of these remains belong to a single species of terrapin, *Pelusios castaneus*, a form that still lives in East Africa (*8, 23*). The limited information that is available on the behavior of *Pelusios* suggests that it generally hibernates during the dry season, perhaps even if water is available year round (*22*). The presence of numerous *Pelusios* remains at FLK NN level 3 supports the contention that the Olduvai levels that appear on the left side of Fig. 2 are, in fact, rainy season occupations. This conclusion, of course, will have to be reconsidered if it is shown that the tortoises did not hibernate or that they were not part of the food remains (*24*).

Thus far, the fact that many of the Olduvai levels may represent multiple occupations has been ignored. The clear-cut patterning of the data, however, suggests that reoccupation of sites may not present a major problem. If a site was reoccupied several times, and each occupation occurred during a different season of the year, one would expect the levels to be scattered much more widely in Fig. 2. The fact that they are not implies that each reoccupation tended to occur during more or less the same season of the year.

The patterning of Olduvai levels within the dry season cluster deserves further comment. It has already been noted that the early and late dry season months of the Bushmen can be distinguished from the months falling more toward the middle of the season. Very similar patterning of the Olduvai levels can be observed within the dry season cluster. Fourteen (78 percent) are grouped together with the early and late dry season months of the Bushmen. And, as might be expected, many of these levels contain modest proportions of tortoises. The remaining four levels (22 percent) are strung out along the right-hand edge of the graph (FLK North levels 1-2 to 5). Their position suggests that they may be sites occupied more toward the middle of the dry season. These levels contain virtually no tortoise remains. Tantalizing as the patterning within the dry season cluster may be, independent means of evaluating its significance are lacking at present. The patterning may well reflect only "noise" in the data as a result of such things as sampling bias or variability deriving from reoccupation of sites at slightly different times within the dry season.

Table 3. Prey taken each month by !Kung Bushmen (*13*).

Month	Season*	Total killed per month	Chelonia Number	Chelonia Percent	Carnivora Number	Carnivora Percent	Bovidae Number	Bovidae Percent
September	D	15	0	0	0	0	15	100.0
October 1–18	D	15	1	6.7	1	6.7	13	86.7
October 19–31	R	57	44	77.2	3	5.3	10	17.5
November	R	147	112	76.2	15	10.2	20	13.6
December	R	51	38	74.5	6	11.8	7	13.7
January	R	46	38	82.6	2	4.3	6	13.0

*Rainy (R), or dry (D).

Table 4. Prey taken by Olduvai hominids (*8*).

Locality (level)	Bones* (No.)	Chelonia Number	Chelonia Percent	Carnivora Number	Carnivora Percent	Bovidae Number	Bovidae Percent
BK	559	24	4.3	9	1.6	526	94.1
TK (all levels)	100	0	0	2	2.0	98	98.0
FC West (Tuff)	49	2	4.1	0	0	47	95.9
FC West (Floor)	21	3	14.3	0	0	18	85.7
MNK (Main)	339	19	5.6	9	2.7	311	91.7
MNK (Skull)	95	66	69.5	0	0	29	30.5
HWK East (3–5)	175	3	1.7	9	5.1	163	93.1
HWK East (2)	319	18	5.6	7	2.2	294	92.2
HWK East (1)	262	2	0.8	2	0.8	258	98.5
FLK North (1–2)	1545	1	0.1	193	12.5	1351	87.4
FLK North (3)	696	0	0	117	16.8	579	83.2
FLK North (4)	595	0	0	148	24.9	447	75.1
FLK North (5)	937	9	1.0	122	13.0	806	86.0
FLK North (6)	198	0	0	5	2.5	193	97.5
FLK (13)	76	1	1.3	2	2.6	73	96.1
FLK (15)	92	0	0	1	1.1	91	98.9
FLK (Zinj.)	539	53	9.8	12	2.2	474	87.9
FLK NN (1)	187	98	52.4	4	2.1	85	45.5
FLK NN (2)	151	0	0	7	4.6	144	95.4
FLK NN (3)	1837	1549	84.3	56	3.0	232	12.6
FLK NN (4)	12	1	8.3	0	0	11	91.7
DK (all levels)	2450	1370	55.9	34	1.4	1046	42.7

*Total number of bones identifiable to Chelonia, Carnivora, and Bovidae.

Summary and Conclusions

A number of interesting and rather unexpected results have emerged from our study. All of these results are extremely tentative and will need to be reevaluated carefully as new data become available from Olduvai Gorge and elsewhere.

1) The range of prey types and the proportion of various sizes of prey taken by Bushmen and by early Olduvai hominids are very similar.

2) When the proportions of Chelonia, Carnivora, and Bovidae are plotted on a triangular graph, the monthly kills made by the Bushmen divide into two distinct clusters. One cluster contains only dry season months, the other only rainy season months.

3) With the same three taxa, the Olduvai levels separate into two clusters on the triangular graph that are almost identical to those of the Bushmen. Only four levels appear to be rainy season occupations. Three of these are among the earliest occupations in the Gorge. The majority of the Olduvai levels appear to be dry season occupations.

4) Patterning of both Bushman and Olduvai data within the dry season cluster may suggest that the majority of Olduvai levels represent early or late dry season occupations. Only four levels appear to have been occupied during the main part of the season. This conclusion is highly speculative and should be regarded with caution until additional data become available.

In conclusion, the archeological record from Olduvai Gorge may reflect only part of the total settlement system of these early hominids. Throughout most of bed I and bed II times, the area of the Gorge that has been sampled thus far appears to have been occupied almost exclusively during the dry season. During the rainy season the Olduvai hominids either moved to nearby areas that have not been sampled or, more probably, as part of their seasonal round, they abandoned the area of the Gorge entirely.

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24. If the vast majority of Olduvai levels do, in fact, represent dry season occupations, then the comparison of prey frequency distributions in Fig. 1 can be improved considerably by using only Bushman dry season data.

25. J.D.S. and D.D.D., working independently and using slightly different approaches, arrived simultaneously at almost identical conclusions concerning the seasonality of the Olduvai sites. We therefore decided to collaborate in this study [see D. D. Davis, *Spatial Organization and Subsistence Technology of Lower and Middle Pleistocene Hominid Sites at Olduvai Gorge, Tanzania* (University Microfilms, Ann Arbor, 1976)]. We thank D. G. Bates, R. E. Blanton, G. L. Isaac, G. A. Johnson, S. H. Lees, H. V. Merrick, and D. Pilbeam for their helpful comments and suggestions at various stages in the study. We are particularly grateful for the use of unpublished data provided by E. Wilmsen and for access to manuscripts granted by R. L. Hay and J. Yellen. D.D.D. also acknowledges support provided by the Society of the Sigma Xi and by the Yale African Studies Council.

NEWS AND COMMENT

White House Science Office: House and Senate Agree on Bill

Congress has cleared the way for the return of a science adviser to the White House. House and Senate conferees resolved differences over details of a science policy bill (*Science*, 16 April) before the Easter recess, and both houses are expected to pass the compromise version soon after Congress reconvenes on 26 April. The legislation is reportedly acceptable to President Ford.

Restoration of a science advisory office to the Executive Office of the President is an objective that has been ardently pursued by leaders of the scientific community since President Nixon relegated the advisory apparatus to the National Science Foundation in early 1973. Since then, NSF director H. Guyford Stever has doubled in brass as President's science adviser.

The new bill (S. 22 and H.R. 10230) provides a legal basis for the prospective Office of Science and Technology Policy (OSTP) significantly different from the one that served the old Office of Science and Technology (OST). The new bill accords the office much broader and more specific policy responsibilities. More important, it gives the office statutory existence whereas OST was created under a reorganization plan proposed by President Kennedy.

Proponents of the new office concede that its effectiveness will depend primarily on the quality of the relationship between the President and his science adviser, who will be director of OSTP; nevertheless they argue that the science adviser's position will be inherently stronger because he will have a clearly defined role in the decision-making process in the Executive.

The key congressional figures in fashioning the new legislation were, on the House side, Science and Technology Committee chairman Olin E. Teague (D–Tex.) and the ranking minority member of the committee Charles A. Mosher (R–Ohio) and, on the Senate side, Senator Edward M. Kennedy (D–Mass.). Kennedy is chairman of a Labor and Public Welfare Committee subcommittee which