icle of modern man while indicating a range of movement at the shoulder joint similar to that indicated by the Sterkfontein scapula (*10*). Thus, though the question may still be open, the present evidence favors placement of the bed I "*Homo habilis*" material in genus *Australopithecus* and possibly in species *A. africanus* as well.

The bed II "*Homo habilis*" material differs from the bed I material in size and, to some extent, in morphological detail. In a number of these differing features the bed II material resembles *Homo erectus* (*11*), and its referral to the hypodigm of "*Homo habilis*" has been questioned on morphological grounds (*12*). In addition, the bed I and bed II materials come from different faunal zones and appear to be separated by a time gap which may be as great as 0.7 to 1.0 million years. The questions raised earlier by others cited here have never received satisfactory answers and continue to be valid objections to the concept of "*Homo habilis*."

ELWYN L. SIMONS
DAVID PILBEAM, PETER C. ETTEL
Peabody Museum of Natural History, Yale University, New Haven, Connecticut

References and Notes

1. L. S. B. Leakey, R. Protsch, R. Berger, *Science* **162**, 559 (1968).
2. C. L. Brace, *ibid.* **163**, 1360 (1969).
3. L. S. B. Leakey, R. Protsch, R. Berger, *ibid.*, p. 1360.
4. G. Heberer, *Z. Morphol. Anthropol.* (Stuttgart) **53**, 171 (1963).
5. N. R. Stoll *et al.*, Eds., *International Code of Zoological Nomenclature* (International Trust for Zoological Nomenclature, London, 1964), p. 15.
6. L. S. B. Leakey, *Nature* **209**, 1279 (1966).
7. J. T. Robinson, *ibid.*, p. 957; ———, in *Evolutionary Biology*, Th. Dobzhansky *et al.*, Eds. (Appleton-Century-Crofts, New York, 1967), vol. 1, p. 69.
8. M. H. Day and B. A. Wood, *Man* **3**, 440 (1968).
9. C. E. Oxnard, *Amer. J. Phys. Anthropol.* **29**, 429 (1968).
10. ———, *ibid.* **28**, 213 (1968).
11. P. V. Tobias and G. H. R. von Koenigswald, *Nature* **204**, 515 (1964).
12. D. R. Pilbeam and E. L. Simons, *Amer. Sci.* **53**, 237 (1965); J. T. Robinson, *Nature* **205**, 121 (1965); T. Bielicki, *Current Anthropol.* **7**, 576 (1966).

19 May 1969

Open-Heart Surgery and IQ

The case made by Honzik *et al.* for inferior IQ's in girls undergoing open-heart surgery (*1*) rests on the following results. They found a significant difference favoring the boys in WISC Verbal IQ, postoperatively, in a design which used the Stanford-Binet Test before and after surgery. Within-group sex differences showed that for the girls the WISC Verbal IQ of 95.8 was significantly less than the WISC Performance IQ of 99.5. These findings were coupled with the fact that on preoperative testing of *another* group of children undergoing open-heart surgery, the WISC Vocabulary test scores were significantly higher for the boys than for the girls.

The case of lesser IQ's in girls would be greatly strengthened if control groups were employed, if the research method employed only the WISC before and after surgery, and if replication of the study with appropriate control groups yielded the same results.

Use of control groups of children who are hospitalized for medical (nonsurgical) illnesses would equate for the factor of hospitalization, however short it may be, before IQ testing. Similarly, such patients would control for the effects of surgery and anesthesia which may well account for the first data obtained that favored the boys' IQ determined with the WISC after surgery.

Using the postoperative WISC finding to explain, even partially, later initial differences found with another group is not the best strategy, since neither research design seems to have been addressed to the problem of sex differences prior to surgery in children with cardiac and operable cardiac conditions.

Invoking the single significant finding that the Vocabulary test was higher with the second group of boys than the second group of girls is fraught with statistical risks. Assuming that at least nine other subtest and IQ scores were compared, the most that can be said for the finding is that it is worthy of further but well-controlled investigation. If the single difference were one of several measures of IQ testing, then the one result may be a chance artifact due to the numerous other comparisons that were made. In a pilot study of effects on intellectual functioning of surgery on aged patients, using a "young" group to control for the effects of surgery and an "old" medically ill group to control for hospitalization, we found but one measure impaired, the Digit-repetition test of the Wechsler-Bellevue, Forms I and II. However, this result was one of many comparisons computed, which included psychiatric ratings, Memory for Designs, Bender Gestalt test, Critical Flicker Fusion, Archimedes spiral, and others, which led us to replicate the study. In this replication, Paolino, Wolin, Salus, and Simeone (*2*) found that the promising difference in recall of digits did not hold up, although minor changes were found in motor functions, as Gruvstadt *et al.* (*3*) had found in their excellent study of induced hypotensive surgery.

Finally, the call for investigation of the effects of early environment, sex differences in family interaction, and the "sex-associated genetic factor" might well be deferred until the more parsimonious leads are pursued by replication with control groups.

ALBERT F. PAOLINO
Laboratory of Psychosocial Research, Cleveland Psychiatric Institute, Cleveland, Ohio 44109

References

1. M. P. Honzik, D. S. Collart, S. J. Robinson, K. H. Finley, *Science* **164**, 445 (1969).
2. A. Paolino, L. Wolin, K. Salus, F. Simeone, *J. Gerontol.* **21**, 271 (1966).
3. M. Gruvstadt, L. Kebbon, B. Ax, *Acta Psychiat. Scand., Suppl.* **163** [whole suppl.] (1962).

20 May 1969

Paolino's point is well taken that replication of the study with different control groups would be desirable. Our purpose in writing the report was to stimulate just such investigations. However, we believe Paolino underestimated the consistency and probable validity of our findings for the congenital heart disease sample in his critique. We used carefully normed intelligence tests and considered the standardization samples, which resembled our sample, as the control. As can be seen in figure 1 of our report (*1*), the distribution of the Verbal IQ's of the girls undergoing open-heart surgery, with a modal IQ of 90, differs quite markedly from the standardization distribution. Not only were the girls' Verbal IQ's lower than those of the standardization sample but they were significantly lower than those of the boys. There is always the possibility that a significant finding is a chance finding, but there was great consistency in our results.

In the first analysis for 60 boys and 58 girls, we found that the girls did poorly on the Verbal subtests of the WISC: Information, Comprehension, and Vocabulary (all of which require the retrieval of learned material) but did relatively well on Similarities where the child is asked to respond to words that are provided (table 1 of the report).

Continued postoperative testing on the WISC added an additional sample of 33 boys and 20 girls. The trend held up in this later sample and figure 1 of the report shows the comparison of the Verbal IQ's of the boys and girls for the total of these two groups (93 boys and 78 girls). In order to see if the low Verbal IQ's of the girls was the effect of the surgery, we tested a third sample of 22 boys and 18 girls preoperatively on the WISC, and a similar trend was obtained. We reported for this group that the sex difference on Vocabulary was statistically significant but we should have added that in this sample, as in the two previous ones, the girls' lowest scores were on the Verbal subtests involving memory storage: Vocabulary, Comprehension, and Information. On the Similarities subtest, which is less dependent on memory, the girls' score was average according to the standardization sample and actually higher than the boys'. Additionally, the examiners were impressed that these girls appeared to grope for words and information that they could not bring to mind. Further indications that the deficit was specific were the findings that these girls performed normally on the Performance Scale of the WISC and did well on the Draw-A-Man test, earning higher scores on the average than the boys, which is the usual finding for this test. These results for children with heart disease requiring open-heart surgery may not prove definitive but they were highly consistent for (i) three subsamples, (ii) for all the examiners, (iii) for children of differing socio-economic status, and (iv) for the different cardiac diagnoses.

MARJORIE P. HONZIK
Institute of Human Development, University of California, Berkeley
DONNA S. COLLART
SAUL J. ROBINSON, KNOX H. FINLEY
Institute of Medical Sciences, Pacific Medical Center, San Francisco, California

References

1. M. P. Honzik, D. S. Collart, S. J. Robinson, K. H. Finley, *Science* **164**, 445 (1969).

13 August 1969

Occupancy Principle: Nonidentity with Mean Transit Time

Zierler (*1*) has asserted that tracer sojourn time (*2*), denoted occupancy (*3*), is identical to mean transit time (*4*). This assertion is true for an entire system (*5*). It is not generally true for a local region contained within a system, the situation considered by Bergner (*2*) and by Orr and Gillespie (*3*). An example where this distinction is of paramount importance is the radiation exposure of organs. The dose of radiation to an organ after a single injection of radioactive substance into the body is directly related to the sojourn time of the substance in the organ. The use of mean transit time in this connection can be very misleading. That the sojourn time can be many times greater than the mean transit time of a substance through an organ is shown as follows.

Consider a system in the steady state with a total input rate I(g/sec) of traced (mother) substance. Within the system is a region P containing the mass M_P(g) of traced substance and into which traced substance flows at total rate I_P(g/sec). Starting at time $t = 0$, a finite amount m_o (disintegrations per minute, dpm) of tracer is injected into the input channels of the system such that all portions of the traced substance are labeled in proportion to local input rate [equivalent tracer supply (*2*)]. At time t, the amount of tracer in the region P is $m_P(t)$ (dpm), the total rate of input of tracer into P is $i_P(t)$ (dpm/sec) and the total rate of output of tracer from P *is* $e_P(t)$ (dpm/sec). The tracer sojourn time for region P is defined as (*2*)

$$\theta_P = m_o^{-1} \int_0^\infty m_P(t)\, dt \qquad (1)$$

The mean transit time for region P is defined as the mean time of exit of tracer from P minus the mean time of entrance of tracer into P, or

$$\bar{t}_P = \left(\int_0^\infty t e_P\, dt \Big/ \int_0^\infty e_P\, dt \right) - \left(\int_0^\infty t i_P\, dt \Big/ \int_0^\infty i_P\, dt \right) \qquad (2)$$

It can be shown [appendix of (*6*) and reference (*7*)] that the relation between m_o and

$$\int_0^\infty i_P\, dt = \int_0^\infty e_P\, dt$$

yields

$$M_P = I\theta_P = I_P\, \bar{t}_P \qquad (3)$$

In general θ_P can be greater than, equal to, or less than $\bar{t}_P$. For example, let the region P be the human kidney and the system be the body. The total input rate I of water into the body is approximately 2.5 liter/day. The total input rate of water into one kidney, I_P, is approximately 0.7 liter/min or 1000 liter/day. For the human kidney, therefore, since $\bar{t}_P$ is approximately 20 seconds (*8*), θ_P is approximately 400 $\bar{t}_P$ or 2.2 hours. The reason θ_P is so much larger than $\bar{t}_P$ is that θ_P includes recirculation effects, but $\bar{t}_P$ does not. If the region P coincides with the entire system, then $I = I_P$, and Eq. 3 reduces to Zierler's relation (*5*). Equation 3 should prove generally useful, for example, to calculate sojourn times of substances in organs.

W. PERL
F. P. CHINARD*
Cardiorespiratory Research Laboratory and *New York University Research Service, Goldwater Memorial Hospital, Welfare Island, New York 10017*

References and Notes

1. K. L. Zierler, *Science* **163**, 491 (1969).
2. P.-E. E. Bergner, *J. Theoret. Biol.* **6** 137 (1964); *Science* **150**, 1048 (1965).
3. J. S. Orr and F. C. Gillespie, *Science* **162**, 138 (1968).
4. K. L. Zierler, in *Handbook of Physiology, Section 2, Circulation*, W. F. Hamilton and P. Dow, Eds. (American Physiological Society, Washington, D.C., 1962), vol. 1, p. 585; F. P. Chinard, R. Effros, W. Perl, M. Silverman, in *Compartments, Pools, and Spaces in Medical Physiology*, P.-E. E. Bergner and C. C. Lushbaugh, Eds. (CONF-661010, Clearinghouse, U.S. Department of Commerce, Springfield, Va., 1967), pp. 381–422.
5. K. L. Zierler, *Circ. Res.* **16**, 309 (1965).
7. P.-E. E. Bergner, in *Dynamic Clinical Studies with Radioisotopes*, R. M. Knisely and W. N. Tauxe, Eds. (TID-7678, Clearinghouse, U.S. Department of Commerce, Springfield, Va., 1964), pp. 1–18.
7. W. Perl, R. M. Effros, F. P. Chinard, *J. Theoret. Biol.*, in press.
8. R. M. Effros, J. Lowenstein, D. C. Baldwin, F. P. Chinard, *Circ. Res.* **20**, 162 (1967).
9. Supported by PHS grants HE-02492, HE-07482, HE-08147, HE-09499; by grants U-1579 and U-1761 of the Health Research Council of the City of New York, and by grants from the Life Insurance Medical Research Fund. F.P.C. was supported by a career scientist award of the Health Research Council of the City of New York.
* Present address: Department of Medicine, New Jersey College of Medicine and Dentistry, Martland Hospital, Newark 07107.

3 June 1969