Table 1. Average comparative skeletal development of LL and SS boys and girls during infancy and childhood.

Variable	Sex	LL	SS	t
No. hand-wrist centers at 1.5 yr	M	7.8	6.3	1.73
No. hand-wrist centers at 1.5 yr	F	18.6	15.2	2.55
No. hand-wrist centers at 3.0 yr	M	22.1	18.4	4.20
No. hand-wrist centers at 3.0 yr	F	24.4	23.5	2.64
Hand-wrist completion (age)	M	6.7	7.7	2.05
Hand-wrist completion (age)	F	7.3	8.0	2.18
Bone age at 11.0 yr	M	11.9	10.1	5.29
Bone age at 11.0 yr	F	10.0	11.1	0.21

muscularity is a normal correlate of physiological advancement during the growing period.

In a preliminary investigation, subjects were selected according to parental mating combinations. The parents were categorized, by sex, according to their bony-chest diameters as measured on posteroanterior teleoroentgenograms, as "large" (above the mean) and "small" (below the mean). Children of the LL (large × large) and SS (small × small) mating combinations were then considered. In all, there were 20 LL parental mating combinations, with 56 offspring, and 15 SS mating combinations, with 31 offspring, in the study; however, the sample size was smaller in the adolescent period.

In replicate tests, the adult bony-chest diameter exhibited excellent short-term reliability ($r = 0.98$ to 0.99) and good 5-year reliability ($r > 0.90$) as an index of physical development. The bony-chest measurement has been shown to correlate well with the fat-free mass, or "lean body weight" (*3*), and is only slightly correlated with stature ($r = 0.2$). It is therefore a useful measure of both the lean body weight and of physique.

Offspring of the LL parental mating combination were compared with offspring of the SS combination for length and weight throughout the growing period, according to data, for individuals, from the Fels Longitudinal files. As shown in Fig. 1, LL boys surpassed SS boys in both length and weight from birth through 17 years, length being significantly greater from 5 through 13 years and weight from 1 through 17 years. The same tendency was observed for the girls, though the absolute differences were smaller, and significant only from 5 through 7 years for length and 5 through 9 years and at 17 years for weight. The 56 LL children of both sexes were longer and heavier than the 31 SS children throughout the growing period.

Further comparison was made for developmental status as measured by the number of hand-wrist ossification centers present at 1.5 and 3.0 years, the age of completion of the 28 bony nuclei of the hand and wrist (*4*) and for bone age at 11.0 years in both sexes, according to the Greulich-Pyle standards (*5*). As with length and weight, the LL children tended to be advanced over the SS children. More bony centers were present in the LL boys and girls at 1.5 and 3.0 years, and the full count of 28 centers was attained earlier in the LL children (Table 1).

A check on motor skills during early childhood showed LL children to be advanced over the SS offspring in Gesell scores at 0.5, 1.0, and 1.5 years (*6*), in Merrill-Palmer scores at 1.5 and 2.0 years (*7*), and in early Stanford-Binet quotients.

Clearly, parental body build, specifically the phenotypic mating combinations LL and SS, is associated with differences in the rate of growth and speed of maturation of the offspring. Children of broad-chested parents grow faster and are developmentally advanced during the growing period. Apparently, differences in adult physique are attained through different paths of development, suggesting that genes for body build also influence the rate of maturation (*8*).

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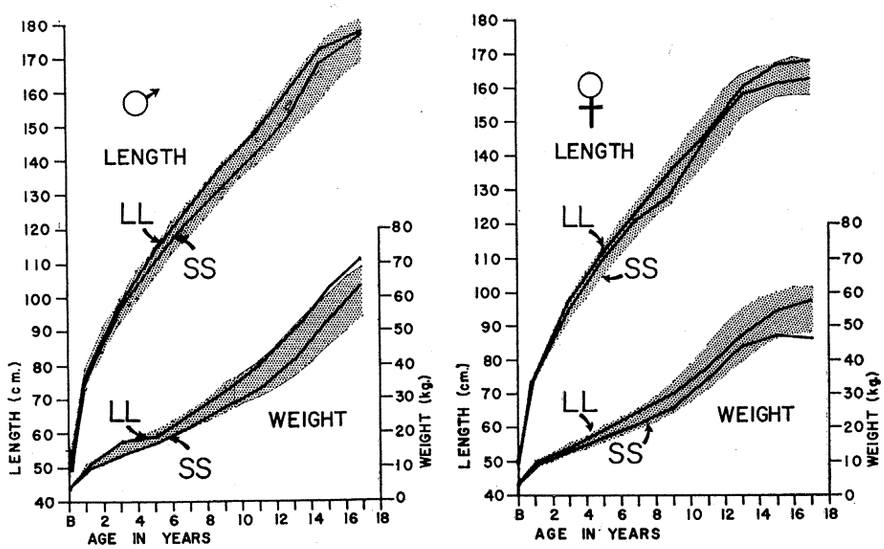

Fig. 1. Comparative growth of children of LL and SS parental mating phenotypes shown against the ± 1 σ limits (shaded areas) for the Fels Institute population. LL boys and girls tend to be longer during the growing period and heavier throughout.

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8. Data analysis was supported in part by grants M-1260 and A-3816 from the National Institutes of Health.

6 June 1960

Machine Retrieval of Pharmacological Data

The retrieval of pharmacological data from the literature has been reported by several workers in the field of science information. G. Congdon Wood (*1*) has devised a detailed code for storing, retrieving, and correlating chemical-biological data. Admittedly, the methodology of abstracting and filing

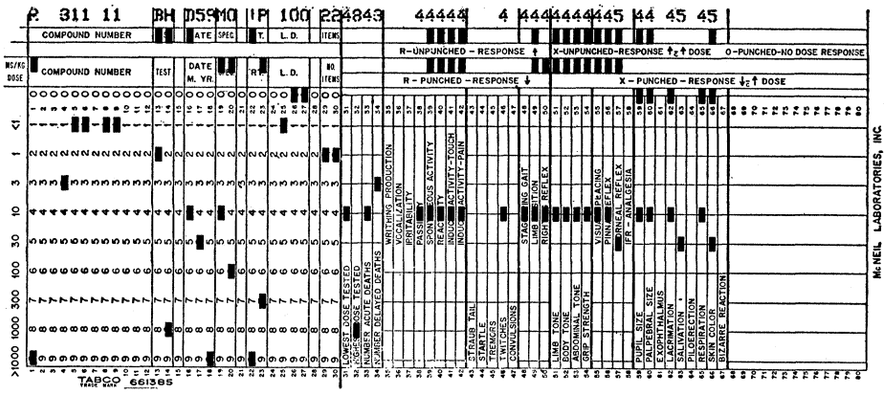

Fig. 1. Card punched with the results obtained from screening the action of chlorpromazine in mice.

is complex and covers most of the biological sciences. A unique system of indexing and searching pharmacological literature has been reported by H. E. Rockwell *et al.* (*2*) which frees the scientist from many hours of library searching. Isaac Welt (*3*) has developed the Cardiovascular Literature Project for collecting, classifying, and disseminating experimental and clinical information concerning the effects of chemical agents upon the cardiovascular system. Again, this is a rather complex system which involves journal abstracting and indexing the medical literature. All of these efforts are directed toward the published reports.

Our effort, on the other hand, is concerned with the raw data in the laboratory. With data retrieval becoming a problem of increasing magnitude which besets research laboratories dealing with a large volume of screening, it occurred to us that punched cards, with machine sorting, should serve as a research tool in making possible correlation of research far beyond that achievable by any amount of searching by hand. This report describes our experiences in the coding and recording on I.B.M. cards of a multiparameter screen —namely, a modification of the quantitative observational behavior assay as developed by Irwin *et al.* (*4*). It shows that the application of this idea to practice is entirely feasible.

Coded information was punched into a specially imprinted I.B.M. card. Each column represented a specific parameter or was used for general code such as compound number designation, type of screen, and species, as shown in Fig. 1.

The development of a code whereby punching could be accomplished required a knowledge and understanding of the data to be coded, a knowledge of the machine limitations for sorting, and anticipation of the type of questions to be asked of the cards. In general, the code adopted is based on the concept that a given activity is present at any given dose of a compound if this activity is still present at the succeeding dose. This concept eliminates a certain number of false data attributable to uncertainty of the observer. It may be seen from Fig. 1 that a logarithmically increasing dose scale appears on one edge of the card. Figure 1 also illustrates the various parameters employed in this screen.

Although each response is quantitated on an eight-grade scale on the original work sheet, we found it would not be feasible to attempt to record the magnitude of response of all of these parameters on the I.B.M. card. We have, therefore, resorted to the concept mentioned above. This provides what amounts to estimation of a minimal effective dose. The three zone punch areas of the I.B.M. card (*R*, *X*, and *O*) are used, as designated in Fig. 1.

After the source data had been translated to the cards, it was found advisable to challenge the code with a representative sample of cards. For example, we asked for a list of all the compounds in the sample which caused stimulation of the central nervous system at 1.0 mg/kg but which did not produce convulsions at 100 mg/kg, or less, when injected intraperitoneally in the mouse. By such challenges it was possible to discover and correct the inevitable mistakes that occur in the formative stages of developing a satisfactory retrieval system.

As stated above, we do not consider machine retrieval of screen data a replacement for a file system when it is desired to bring together all of the known information on a known compound. In the latter case, a numerical file is probably more satisfactory. Machine retrieval, however, is a very useful research tool and timesaver. We consider it important, since the most expensive part of data processing is the transcribing of source data to cards; a responsible individual with adequate scientific knowledge is required for intelligent coding and transcription.

Limitation of space prevents discussion here of the method used for transfer of data from the source document to the card. We feel that it is a mistake to code the investigator's judgment of the activity of a compound, since the interpretation of data changes with the development of new drugs. We consider it much more useful and of more lasting value to code, as nearly as possible, the raw data (*5*).

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5. I welcome correspondence with investigators interested in machine retrieval of data. I wish to thank Dr. William M. Govier for his valuable guidance and advice in the preparation of this report.

6 July 1960