to be more hurried than is wise, but I am rather slow to make this statement because after a considerable experience I realize that there are a great many factors other than the mere acquisition of the information which must be taken into account. Let us say that a research laboratory has developed a method on a small scale for making a product which promises to be very profitable. The directors of the company believe that by an expenditure of a million dollars and provided they can begin production in six months they can obtain a handsome return on their investment. Plans for the plant must be rushed, but plans depend, in the case of chemical plants, on the equipment to be housed and the equipment depends on the details of the process as carried out on a large scale. Naturally the research necessary to put the process into shape for large scale production is rushed to an unhealthy extent and in consequence it is not unusual to find that a good deal of the equipment has to be scrapped later. But this does not mean that the hurry was unwise. It may be that in the long run the stockholders benefit more by the speed with which the work goes forward, even counting the loss of the equipment, than they would if time were taken to put the process into excellent shape. One must remember that to do a thing perfectly from one point of view is not necessarily the best commercial procedure.

Of that work which is done in the research institutions of the country I am unable to say much because I have no direct experience. I believe that an institute like that founded by Rockefeller is one of the nation's greatest assets, largely because its contributions to medicine are international and tend to draw together the peoples of the world. As long as such institutes are in the hands of scientists of genius they will be of the utmost importance to us. They are expensive only when looked at from the narrow point of view of dollars and cents.

The professional men of this country are doing a great deal of good research. They do this by observing carefully during their contacts with conditions as they find them. They are taking the place, to some extent, of the rich amateur who at one time was the large contributor to scientific progress. The difference is that the work of these men of to-day is more directly related to the practical use of science than was the work of men like Cavendish. Work of this kind carried out by physicians may flower into research work as richly endowed as that carried out at the Mayo Foundation, which has become a center of biological chemical research.

In looking over the whole field of research in this country we should be satisfied that we are putting so much effort into so useful an endeavor. We should not, however, be satisfied with things as they are and research, like everything else, must grow, must develop, if it is to mean all that it should to us. What we should strive to bear in mind is the truth of the statement made by John Milton:

> Our greatness will appear
> Then most conspicuous, when
> great things of small,
> Useful of hurtful, prosperous of adverse,
> We can create.

R. E. ROSE

WILMINGTON, DELAWARE

A LITER AND A HALF OF BRAINS[1]

A LITER and a half is our portion: so much of it water that Hippocrates called the brain the metropolis of humidity and Sir Thomas Browne noted that, in consequence, skulls are less consumed by fire than other bones.[2] Doubtless there are other functions of the brain for us to consider than that of rescuing the skull from a fiery oblivion.

How greatly we extol ourselves above the brutes which perish. Each of us, lords of creation, maintains within his skull as much brains as would fill the heads of three gorillas. And very gravely we are told that for our bulk one third of all this mass would suffice; the rest is sheer intellect "which some suppose the soul's frail dwelling house."[3] But this is mere convention and with the times conventions change. In Aristotle's day the brain was not, as some have said, the seat of sensation and of thought: it is required rather to cool the blood and by thus tempering its heat to make sensation possible. Because man is the hottest of animals therefore he has the largest brain.[4]

> I talk of dreams,
> Which are but children of an idle brain,
> Begot of nothing but vain fantasy,
> Which is as thin of substance as the air,
> And more inconstant than the wind.[5]

But enough. Aristotle was born about 384 B. C., when Plato was already forty-three and Socrates had been dead fifteen years. The foundations of a study

[1] An address delivered at the annual banquet of the American College of Physicians, Cleveland, February 24, 1927.

[2] Sir Thomas Browne, "Hydriotaphia." D. Lloyd Roberts, ed. London, 1898, p. 277.

[3] King John, V. 7. 3.

[4] Stocks, J. L., "Aristotelianism." London and New York, 1927, p. 76.

[5] "Romeo and Juliet," I, 4, 95.

of the brain were laid by Herophilus, who was born in the closing part of the fourth century, B. C., and flourished at Alexandria during the reign of the first Ptolemy. He discovered the nerves, distinguished them from sinews and thought the brain the center of the nervous system.[6] This idea was elaborated by Galen in the second century, A. D., who attacked Aristotle's theory of the heart as seat of the sensitive soul and the source of nervous action. According to Galen sensation and movement are stopped and even the voice and breathing affected by injuries to the brain; moreover, injury to one side of the brain affects the opposite side of the body.[7]

Augustine, in the early fifth century, speaks of three cells in the brain, of which the second is the seat of memory and the third of motor activity.[8]

Costa ben Luca about 862 A. D. distinguishes between spirit and soul. The spirit is a "subtle body," unlike the soul, which is incorporeal. It passes from one cell to another and operates the vital processes of the body.[9] The clearer and more subtle this spirit is, the more readily it lends itself to intellectual processes. Hence intellectual processes are inferior in women and children and in races subjected to undue heat and cold like the Ethiopians and the Slavs. We must not smile at this conception too broadly: it is reproduced almost word for word in the great Paris discussions of last century regarding Negro brain and cranium.[10] According to Costa ben Luca the opening between the first and second cells is closed by a sort of valve, "a particle of the brain similar to a worm" (the choroid plexus). When a man recalls something to memory the valve opens and the speed with which it opens explains why some men are slow of memory and others answer a question much sooner.

In the eleventh century Constantinus Africanus amplifies Augustine's conception of the three cells and puts imagination with sensation in the first, reason in the second and memory in the third.[11] The first is hot and dry, the second cold and moist and the third cold and dry. Mania is an infection of the anterior cell and melancholia a disease of the middle one.

In the twelfth century Petrocellus tells us definitely that good and evil are distinguished in the second cell and that the soul resides in the third.[12]

In spite of Galen's teaching medieval scientists still clung to the conception of the brain being secondary to the heart. Hildegard of Bingen, who died in 1180, A. D., speaks of the attenuation of humors in the chest whereby "the phlegm is dry and toxic and ascends to the brain. There it produces headache and pain in the eyes and wasting of the marrow, and thus if the moon is defect he [the man] may develop the falling evil."[13]

Remember Jacques' joyful account of the fool he met in the forest, how

> "in his brain
> Which is as dry as the remainder biscuit
> After a voyage, he hath strange places cramm'd
> With observation, the which he vents
> In mangled forms."[14]

Adelard of Bath, "a dim and shadowy figure in the history of European learning," who according to the Pipe Roll of 1130 received four shillings and six pence from the sheriff of Wiltshire, states that it was discovered experimentally which portion of the brain is devoted to the imagination and which to reason and memory through a case in which a man was injured in the front part of the head.[15] The famous specimen in the Warren Museum is therefore antedated by some seven hundred years.

In the following century, about 1230, A. D., Bartholemew the Englishman cites Constantinus' division of mania from melancholia as diseases of first and second cells, respectively, and tells of a nobleman whom he knew, suffering from melancholia and imagining himself to be a cat, who insisted on sleeping under the bed to watch the mouse holes.[16]

And a little later, about 1292, Arnold of Villanova in the Breviary of Practice, discussing the treatment of mania, advises as a last resort that the skin be cut in the form of a cross and the skull perforated so that the noxious vapors may escape from the brain.[17] "I'll ne'er believe a madman," says the clown in Twelfth Night, "till I see his brains."[18]

In the Bodleian Library at Oxford is a small quarto parchment in a fine Italian hand, the first complete treatise on anatomy in the vernacular, written in

[6] Thorndike, L., 1923, "A History of Magic and Experimental Science," Vol I, p. 145.

[7] *Ibid.*, p. 146.

[8] *Ibid.*, p. 660.

[9] *Ibid.*, pp. 658–9.

[10] Gratiolet, P., for example, 1856, "Mémoire sur le développement de la forme du crâne de l'homme," etc. Compt. rend. de l'acad. des Sc. T. 43, pp. 428–431.

[11] Thorndike, L., Vol. I, p. 660.

[12] Thorndike, L., Vol. I, p. 735.

[13] Singer, C., 1917, "The Scientific Views and Visions of Saint Hildegard. Studies in the History and Method of Science." Vol. 1, Oxford, p. 47.

[14] "As You Like It," II, 7, 38.

[15] Thorndike, L., Vol. ii, p. 39.

[16] *Ibid.*, p. 408.

[17] *Ibid.*, p. 860.

[18] "Twelfth Night," IV, 2, 126.

1490. It is the Anothomia of Hieronymo Manfred.[19] Here is a pretty accurate description of the cerebral ventricles not greatly bettered until Leonardo made his ventricular casts.[20]

> "To the side of this [the foramina of Monro] is another thing like a subterranean worm, red as blood, yet tethered by certain ligaments and nervelets. And this worm when it lengthens itself closes these passages, and thus blocks the path between the first ventricle and the second. Nature has wrought it thus, so that when a man wills he may cease from cogitation and thought; and similarly when, on the other hand, he would think and contemplate, this worm contracts itself again and opens these passages." . . .
>
> "It will be apparent that when the back part of the head is injured, the memory immediately suffers; when the middle part is injured, the estimative and cognitive faculties suffer; and when the anterior part is injured, the faculties of common sensation and imagination suffer. And thus it is that the doctors have become aware of the location of these powers."

But why continue. Descartes and others, by gradual degrees have laid the sure foundation of modern study of the brain and we may pass lightly by this phase to explore more recent fancies in which Reserve has had her part. The philosophic conception of three primary vesicles was written into scientific anatomy by Leonardo and remains there in current descriptions. So hard does tradition die.

In recent years there have been numerous efforts to prove or disprove the hypothesis that head size is related to brain volume, in the present state of our knowledge a perilous task unless the brains are out and the man is dead.[21] People do not really like having their heads measured and if they suspect that the measurement is undertaken with a view to estimating brain volume something very like active rebellion ensues. When Professor Karl Pearson's assistants endeavored to make this determination upon Cambridge undergraduatees, the students, by playing tricks on the observers, almost brought the work to nought.[22] It reminds one of Falstaff's exclamation, "Well, if I be served such another trick, I'll have my brains ta'en out and buttered, and give them to a dog for a new year's gift."[23]

There is a common tendency to compare, or rather contrast, the average brain volumes in different classes of society. This must be done only with the greatest care; it is doubtful if it is ever a valid method, for differences of environment and nurture have a profound influence upon head size. For the comparison to be apt one must take a fairly homogeneous sample of approximately the same nurture and habits.[22]

Of one thing I am very certain, namely, that class distinction in our highly artificial and fluctuating society to-day is not the crowbar wherewith to pry open this problem of brains. And so we have tried another tool put into our hand by luck. Ever since 1913 we have kept a steady watch upon head size and brain volume of those unfortunates who, having ended their days already, terminate their corporeal existence under our care. Reserve occupies a unique position in this matter, having long enjoyed to an extraordinary degree the spirit of cooperation with the city. Dr. Hamann's statesmanship and Mr. Leonhart's tact have resulted in our acting as a kind of permanent morgue in which is represented a fair cross section of Cleveland's outmaneuvered victims in the struggle for existence.

The average brain volume for the adult white man is generally accepted as about 1,500 cc, perhaps a few cc more, probably no less. Among the diners here to-night, who may be classed as highly intellectual, the mean value is probably 1,550 cc. The average among Cleveland's social ineffectives from 1913 to 1917 was quite constantly within 10 cc of 1,480 cc. This difference made no impression upon us until in 1918 a strange thing happened. Our average fell to 1,410 cc. Now during that year none but the veriest fool was left destitute: the others were all in the army or earning good wages in civilian life. Still we were not stirred to attention. But in 1919 when, after the armistice, industrial stagnation set in and threw out of work many who had recently found jobs; and when, moreover, the disbanding army disgorged a glut of men upon a society which could not immediately absorb them, the average brain volume of our social failures rose to 1,520 cc. That looked serious to us and with great interest we read the prognosis of bankers and captains of industry regarding the future. According to prediction the situation improved in 1920 and our mean brain volume sank once more to near the pre-war level. But the feeling of satisfaction soon gave place to apprehension, for a second and much worse industrial

[19] Singer, C., 1917, "The Anothomia of Hieronymo Manfredi (1490)"—"Studies in the History and Method of Science," Vol. I, Oxford.

[20] Hopstock, H., 1921, "Leonardo as anatomist"—"Studies in the History and Method of Science," Vol. ii, Oxford.

[21] "Macbeth," III, 4, 79.

[22] Pearson, K., 1902, "On the Correlation of Intellectual Ability with the Size and Shape of the Head," Proc. Roy. Soc., Lond. Vol. 69, pp. 333–342; also 1906, "On the Relationship of Intelligence to Size and Shape of Head," *Biometrika*, Vol. 5, pp. 105 to 146.

[23] "The Merry Wives of Windsor," III, 5, 7.

depression set in, distress growing steadily more acute during the months of 1921. Then indeed we watched our steadily mounting average volume. Day by day, like obscene demons from the pit itself, we chalked up the rising score until it reached the appalling level of 1,550 cc. Here was a new class of men entering our portals and they came by a different route. Here were the men who could think for themselves, who knew and resented their fate. The pneumonia of the shiftless, the tuberculosis of the over-wearied struggler, the heart disease of the adventurer no longer acted alone as our receiving agents. Instead men shot themselves, or each other, threw themselves into the lake; poisoned themselves with morphine or raisin jack; perished of cold, listlessly lost in despair. All through that year and into the early months of 1922 the steady shuffle of feet on the doorstep of the Associated Charities swelled its monotonous dirge. Agitation was rife. Russia and Germany were pointed out as members of the community of nations who had passed that way before. And then, suddenly as it had begun, while yet the Charities were deluged with the throng, these expectant ghouls in anatomy saw the barometer of brain volume begin to fall, steadily, steadily down. Relief had come: though it was not apparent to the city we knew the end was in sight. Hope was restored again in those whose nervous system had been shattered by defeat. Never again have we seen the like. Slight fluctuations from year to year and an average somewhat above the pre-war mean have been our lot but never that alarming rise which we experienced in the year of intense depression.

Now these things sent us back to examine our data anew and we soon found that of two heads of the same size one might have as much as 200 cc of brain more than the other. It was not that we got larger heads in 1919 and 1921, but we got bigger brains among our social ineffectives. In normal times our pauper population is recruited from that flotsam and jetsam of humanity which idly drifts along the shores of these great lakes. "Here's Agamemnon, an honest fellow enough, and one that loves quails; but he has not so much brain as ear wax."[24] When, however, industrial distress overclouds the city new recruits appear, the honest industrious poor with too little margin for the rainy day, "purse and brain both empty; the brain the heavier for being too light. . . . O, the charity of a penny cord! It sums up thousands in a trice . . . your neck, sir, is pen, book and counters; so the acquittance follows."[25] Then there rush in, as if impatiently, the men who in indifferent times can do indifferent well, but owing to some frailty of their intellect are crushed down by a sudden galloping destitution. "Your hearts I'll stamp out with my horse's heels, and make a quagmire of your mingled brain."[26]

That, ladies and gentlemen, is the romance of the liter and a half. It is not the quantity but the quality that matters. It is not the quality of the whole but of the last small wine glassful. Taking mean values, 1,480 cc are needed for a fool, 1,500 cc for an honest man. And on the average a lady's cocktail saves us from inanity.

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[24] "Troilus and Cressida," V, 1, 58.

[25] "Cymbeline," V, 4, 166.

[26] "I King Henry VI," I, 4, 109.

SCIENTIFIC EVENTS

BRITISH ROYAL COMMISSION ON MUSEUMS AND GALLERIES

THE London *Gazette* announces the appointment of a Royal Commission on Museums and Galleries, with wide terms of reference. The members of the commission are Lord D'Abernon (chairman), Mr. Evan Charteris, K.C., Sir Thomas Little Heath, Sir Lionel Earle, Sir Richard Tetley Glazebrook, Sir George Macdonald, Sir Courtauld Thomson, Sir Martin Conway, Sir Henry Miers, Sir Robert Witt and Dr. A. E. Cowley.

The terms of reference are as follows:

(1) To inquire into and report on the legal position, organization, administration, accommodation, the structural condition of the buildings, and general cost of the institutions containing the national collections situate in London and Edinburgh—namely, the British Museum and the Natural History Museum, the National Gallery and the National Gallery of British Art (Tate Gallery), the National Portrait Gallery, the Public Record Office, the Victoria and Albert Museum, the Bethnal Green Museum, the Science Museum, the Geological Museum, the Wallace Collection, the Royal Botanic Gardens, Kew, the London Museum, the Imperial War Museum, the Royal Scottish Museum, the National Galleries, Scotland, the Scottish Museum of Antiquities and the National Library, Scotland, the Record Department of the Registry House, Edinburgh.

(2) To investigate the existing conditions of the various collections and their growth in former years and to report in the case of each institution what is likely to be the growth of its collections and what the consequential increase in expenditure in the next fifty years if the present practice regulating acquisitions remain unaltered.

(3) To consider in what way, if any, expenditure may be limited without crippling the educational and general usefulness of the institutions, and in particular, having regard to the financial condition of the country, whether