heard them, and that they may therefore be regarded as faithfully reflecting the Pawnee character. As genuine documents, throwing light on the ideas and habits of a primitive people, the stories are of some scientific value; and students of anthropology will find in them a good deal that is interesting and suggestive. Mr. Grinnell adds various notes, in which he gives much well-arranged information as to the history, racial affinities, and institutions of the Pawnees.

LETTERS TO THE EDITOR.

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The Influences at Work in producing the Cerebral Convolutions.

DR. G. JELGERSMA, of Meerenberg, has recently published two remarkable papers,[1] in which he endeavours to explain the influence which leads to the production of the convolutions on the surface of the cerebrum and cerebellum. Many theories have been advanced to account for these. Several authorities have ascribed their presence to mechanical forces operating upon the brain from without, whilst others have sought to explain them by the supposition of different degrees of growth-tension acting upon the brain-surface; but in every case these theories, when submitted to the test, have broken down, in so far that it is impossible, by means of any of them, to show how it comes about that small animals have smooth brains, and large animals convoluted brains; how, in short, we should find in the beaver—an animal remarkable for its intelligence—a cerebrum almost entirely smooth, and in the sheep—an animal, shall we say remarkable for its dullness?—a brain with a high convolutionary system. Jelgersma not only explains this, but makes the apparent discrepancy the strongest pedestal of support to his theory. Briefly put, his views are as follows:—

The grey cortex of the cerebrum, which in different forms of the same animal group preserves a tolerably constant thickness, increases by surface extension. Now, if we extend the surface of a smooth-brained animal say four times, we must provide eight times as much white matter to fill the interior of the grey capsule, if we desire to keep the surface even; or, to put it in different terms, if we lengthen out the radius of the brain say ten times, we acquire a surface extension one hundred times greater, and an internal capacity one thousand times greater. The geometrical law involved is simply this, that in the growth of a body the surface increases with *the second*, but the interior with *the third* power of the radius.[2]

Such being the case, it is very evident, seeing that the proportion of internal white matter and external grey matter is in all cases a uniform one, that in the evolution of a large animal out of a small animal, a disproportion between the grey capsule and the white core of the cerebrum must result. This is compensated for by the extended cortex placing itself in folds or puckers, and thereby reducing the capacity of the capsule to a degree which brings it into correspondence with the white contents. Consequently, "the formation of the convolutions and furrows is simply the result of the tendency on the part of the superficial layer to increase by surface extension and of a mutual space-accommodation (*Raumaccommodation*) of the grey substance and of the white conducting paths."

I have not written this short account of Jelgersma's views—important though they be—simply for the purpose of giving them a wider circulation through the pages of NATURE, but with the object of stating that the theory advanced has received independent testimony in its favour at the hands of my colleague, Prof. George F. Fitzgerald. For two years or more I have been engaged in a research bearing upon the growth of the cerebral hemispheres, and have constantly had occasion to appreciate the unsatisfactory nature of the current theories as to the formation of the convolutions of the brain. Consequently, in February last, before I had read Jelgersma's first article, and before the appearance of the second, I explained to Prof. Fitzgerald, as far as I could, the conditions of cerebral development, and asked him if he could offer any geometrical explanation which would account for the appearance of the convolutions. The views which he then advanced were identical with those of Jelgersma, and further, they were expressed in very similar terms. I feel that this adds greatly to the weight of the hypothesis.

But Prof. Fitzgerald went further than Jelgersma, because the latter states that he is unable to explain why the fissures and convolutions should, within certain limits, assume the same formation in different animals. Fitzgerald, however, saw the importance of his theory in regard to the localization of function in different areas of the cerebral cortex. The surface extension of the cerebrum cannot be a uniform one: the bulgings out in the shape of the convolutions must necessarily be connected with the functions which the areas involved have to perform. Therefore if a given area of grey matter increases it must pucker out, unless an undue quantity of white matter grows all over the inside of the grey cortex.

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May 24.

[1] "Über den Bau des Säugethiergehirns," *Morphologisches Jahrbuch*, June 1889; "Das Gehirn ohne Balken; ein Beitrag zur Windungstheorie," *Neurologisches Centralblatt*, March 1890.

[2] It is right to state, although, indeed, Jelgersma does not mention it, that many years ago Baillarger ascribed the increase of the convolutions with the increase in the size of the animal to the same geometrical law.

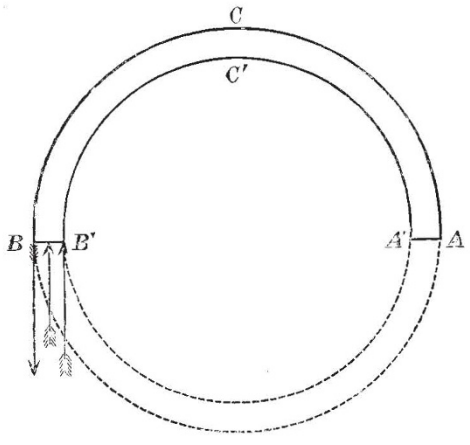
The Bourdon Gauge.

FROM Prof. Greenhill's letter on this subject in NATURE, vol. xli. p. 517, as well as from that of a writer in *Engineering*, I gather that I did not succeed by my letter (NATURE, vol. xli. p. 296) in making quite clear the point of my explanation of the action, since Prof. Greenhill argues that consideration of the longitudinal stresses in the walls leads to the conclusion that the tube would curl up under internal pressure rather than uncurl.

Towards the top of the second column on p. 296 in my letter I used the words "Consider now the equilibrium of any portion . . . when the internal pressure is applied and before uncurling takes place." Perhaps it would have been clearer to have written "*after the internal pressure has been applied*," &c. In the last figure on the same page the tension T is that exerted by the outer wall *of the already distended gauge* as it contracts, while P is the thrust of the inner wall, each on the part BC supposed solidified.

I desire specially to emphasize the words italicized, for my method of explanation amounts to an artifice for taking the distension into account. It is because Prof. Greenhill has overlooked this that he arrives at an opposite conclusion, and wishes apparently to reverse the forces in the figure referred to.

I hope to make this clear by putting the argument again in a slightly different form.



Starting, as before, with a tube of rectangular section, with the end AA' fixed and BB' free, we arrive at the uncurled condition by taking the tube in imagination through the following series of steps:—

(1) Remove the ends AA' and BB', and complete the annulus as indicated by the dotted lines of the figure.