"Leo Taxil" with Conan Doyle's belief in fairies. Under "Magic and Marvel" he groups ideas about the devil and the not-so-strange case of Madame Blavatsky. Under "Transcendence" he places the various marvels that psychical researchers research into. Under "Prepossession" figure believers in that Aryan genius, the horse *Kluge Hans,* in clairvoyants and similar instruments of the will-to-believe. Under "Congenial Conclusions" the mysteries of palmistry and numerologies are revealed. Under "Cults and Vagaries," Mr. Jastrow expounds speculations, from phrenology to eccentric theories of various scientists and pseudoscientists. Under "Rationalization" he pays disconcerting attention to "od," "n-rays," auras, vibrations and ectoplasms.

The tale of these adventures of the mind is, as Mr. Jastrow tells it, a picaresque epic, pointing a rationalist moral, and told with the incisiveness and epigrammatic pith which distinguishes Jastrow's psychological writing from most of his colleagues'. From his standpoint of classical materialistic determinism, he designates these systems of belief as "pseudologies" or "thobbings," and, if I understand him correctly, attributes them to the event that "the logical occupation is beset by intrusions from other human interests." They are to him waves of the continuous flow of belief through folklore and doctrine: there survive in them ancestral wish and traditional wisdom whose root is subjectivism and whose heart is the inveterate habit of jungle magic. He regards the various categories of wish as the forms of intrusion upon "the logical occupation." He thinks that the intrusions can occur because the thought involved is essentially vague, implemented by analogy and symbol and resting on a feeble sense for fact.

All of which is undoubtedly correct. But it is also correct that Mr. Jastrow's judgment upon the vagaries of belief is made retrospectively and externally; that it derives from a set of premises the believers do not share, and that these premises are themselves no less objects of faith than the propositions they contradict. The "scientific" concepts which he employs as his standard of judgment seem to me to differ only in content and consequence, not in mood and method from the vagarious concepts he judges. Analogy and symbol are as inseparable from science as from faith, a fantasy can be as articulate and precise as a fact, a scientific notion as vague as a fantastic one. Neither logical structure nor laboratory procedure can convincingly validate our beliefs; only developing consequences can do that. As Mr. Jastrow himself observes, the history of science is a history of the outgrowth of error. But what makes any belief an error is not its intrinsic character but its displacement by another belief which enables a better control of the same field. "Error" is a retrospective judgment of cognitive value. Like truth, it has no intrinsic criteria. If it had, nobody could any longer be a Christian or a Mohammedan or a Judaist, to say nothing of a vagarist in any other field. Mr. Jastrow's deliverances seem harsher and less tolerant than his excellent demonstration of his case requires.

H. M. KALLEN

NEW SCHOOL FOR SOCIAL RESEARCH

THE STRENGTH OF MATERIALS

Elements of the Strength of Materials. By S. TIMOSHENKO and GLEASON H. MAC CULLOUGH. Cloth; 6 × 9 in.; pp. 350. Line drawings and tables. Published by D. Van Nostrand Company, Inc., New York City. $3.25.

ENGINEERING text-books on strength of materials may be roughly divided into three classes: (1) drill books which develop the simple formulas used by structural engineers and machine designers and which emphasize the immediate practical application of the formulas to the commoner units of design—beams, shafts and columns; (2) books which emphasize the mathematical development of formulas, which take up more elaborate analyses than do the books of the first class, and which, in their advanced chapters at least, approach the outer courts of the mathematical theory of elasticity, and (3) text-books which emphasize the structure and mechanical properties of actual materials of construction, as well as the ordinary formulas for stress analysis of parts assumed to be made of the ideal homogeneous and isotropic material assumed in the mathematical theory of elasticity.

This book is an excellent example of the second class. As might be expected (and welcomed) from the name of the senior author, it has a distinct European flavor in its symbols, its nomenclature and its general approach to problems. In saying that this book emphasizes mathematical development of stress analysis the reviewer does not intend to convey the idea that it is one-sided. It contains a chapter on the properties of materials with a brief discussion of theories of failure, and a short, but interesting, discussion of working stresses.

Two features of the book strike the reviewer as especially worthy of study—the treatment of beams made of material which does not follow Hooke's law and the section on yielding and buckling of columns. An excellent mechanical feature of the book is the arrangement in self-contained sections of alternate methods of mathematical treatment of the deflection of beams, and of stress analysis of statically indeterminate beams, so that, if lack of time makes it necessary for the teacher to omit the study of any particular method, it can be done without interfering with the study of other methods. Special subjects treated in the book include curved beams, eccentric loads on columns and a study of energy of strain with special application to determination of stress under impact.

The book is a worthy addition to the text-books on the mechanics of materials and is especially recommended to the attention of teachers and scholars who wish to emphasize the mathematical development of stress analysis in their beginning courses in strength of materials. It would make an excellent book for the use of "honor sections" of students of outstanding ability.

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SPECIAL ARTICLES

THE AGGREGATION OF ORTHIC TETRAKAIDECAHEDRA

A MODIFICATION of the regular octahedron in combination with a cube, a figure with fourteen sides, eight hexagonal and six square, all the edges of all the hexagons and of all the squares being equal, was well known to the crystallographers of the eighteenth century. This figure was called the tetrakaidecahedron by Lord Kelvin[1] in a theoretical essay "on the division of space with minimum partitional area." In recent years, with increased emphasis on problems of morphogenesis, this figure has come to be of renewed interest.

The biological significance of Kelvin's figure has been demonstrated by Lewis,[2] who has shown the tetrakaidecahedron to be a fundamental shape for both plant and animal cells (pith cells of elder and rush, epidermal cells of cucumber and tradescantia, human oral epithelial and adipose tissue and precartilage cells from the toad), when the cells are aggregated into tissues.

The shape of cells may be the result of various factors, such as surface tension phenomena, the law of bipartition, contact and pressure, cell and tissue differentiation and possibly organ configuration. Among the fewer-celled organisms especially, the principle of bipartition is obviously of great significance. And in the higher plants the shape and the arrangement of the cells may well be influenced, in a measure at least, by the adjustments that result from the operation of the law of bipartition in its relation to the ultimate stacking of the tetrakaidecahedra.

It is obvious that fourteen orthic tetrakaidecahedra can be stacked around a central one to produce an aggregate of fifteen. Thus the first layer contains fourteen members surrounding a central one. By stacking paper models of the type described by Matzke,[3] it was found that 50 tetrakaidecahedra can be stacked around these fourteen. The second layer has 50 members, making an aggregate of 65 for the whole mass. Similarly, it was determined that 110 tetrakaidecahedra can be stacked around these 50. The third layer accordingly has 110 members and the aggregate is 175; the fourth layer has 194 members and totals 369. From these data two formulae may be derived, one for the number of members in any given layer, and the other for the total number of members in the aggregate at any given layer. If T_n denotes the number of members in any layer where n represents the number of the layer, then $T_n = 12 \cdot n^2 + 2$. If S_n equals the total number of members in the aggregate at any layer where n is the number of the layer, then $S_n = 4\ n^3 + 6\ n^2 + 4\ n + 1$. Thus for example if $n = 2$, then $T_n = 50$, and $S_n = 65$. Table I gives the aggregate per layer for some of the layers in the tetrakaidecahedron series and also gives the bipartition series.

TABLE I

Tetrakaidecahedron series		Bipartition series
Layer no.	Aggregate per layer	Aggregate
1	15	2
2	65	4
3	175	8
4	369	16
5	671	32
6	1105	64
7	1695	128
8	2465	256
9	3439	512
10	4641	1024
11	6095	2048
12	7825	4096
13	9855	8192
14	12209	16384
15	14911	32768
16	17985	65536
17	21455	131072
18	25345	262144

It is apparent that bipartition and economy of surface relations (the latter illustrated by stacking tetrakaidecahedra) result in series of cells that do not aggregate at the same rate, but converge at first and diverge afterward. Attention is called to numbers in one series which are approximated by a number in the other, such as 15–16 and 65–64. The failure of these series to coincide may well have morphogenetic significance—for instance, in the establishment of polarity—in the development of the organism from the unicellular egg to the multicellular adult.

Additional data and the proof of the formulae given above will be presented in a subsequent publication.

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[1] Lord Kelvin, *Phil. Mag.*, 5s. 24: 503–514, 1887.

[2] F. T. Lewis, *Proc. Amer. Acad. Arts and Sci.*, 58: 537–552, 1923.

[3] E. B. Matzke, *Torreya*, 31: 129–136, 1931.