It now appears that in the dynamical case this end can be reached without the introduction of λ.

If we suppose the curvature to be zero, the line-element is

$$ds^2 = -R^2(dx^2 + dy^2 + dz^2) + c^2dt^2, \qquad (1)$$

where R is a function of t only, and c is the velocity of light. If, for the sake of simplicity, we neglect the pressure p,[2] the field equations without λ lead to two differential equations, of which we need only one, which in the case of zero curvature reduces to:

$$\frac{1}{R^2}\left(\frac{dR}{cdt}\right)^2 = \frac{1}{3}\kappa\rho. \qquad (2)$$

The observations give the coefficient of expansion and the mean density:

$$\frac{1}{R}\frac{dR}{cdt} = h = \frac{1}{R_B}; \quad \rho = \frac{2}{\kappa R^2_A}.$$

Therefore we have, from (2), the theoretical relation

$$h^2 = \frac{1}{3}\kappa\rho \qquad (3)$$

or

$$\frac{R^2_A}{R^2_B} = \frac{2}{3} \qquad (3')$$

Taking for the coefficient of expansion

$$h = 500 \text{ km./sec. per } 10^6 \text{ parsecs}, \qquad (4)$$

or

$$R_B = 2 \times 10^{27} \text{ cm.},$$

we find

$$R_A = 1.63 \times 10^{27} \text{ cm.},$$

or

$$\rho = 4 \times 10^{-28} \text{ gr. cm.}^{-3}, \qquad (5)$$

which happens to coincide exactly with the upper limit for the density adopted by one of us.[3]

The determination of the coefficient of expansion h depends on the measured red-shifts, which do not introduce any appreciable uncertainty, and the distances of the extra-galactic nebulae, which are still very uncertain. The density depends on the assumed masses of these nebulae and on the scale of distance, and involves, moreover, the assumption that all the material mass in the universe is concentrated in the nebulae. It does not seem probable that this latter assumption will introduce any appreciable factor of uncertainty. Admitting it, the ratio h^2/ρ, or R^2_A/R^2_B, as derived from observations, becomes proportional to Δ/M, Δ being the side of a cube containing on the average one nebula, and M the average mass of the nebulae. The values adopted above would correspond to $\Delta = 10^6$ light years, $M = 2.10^{11}\odot$, which is about Dr. Oort's estimate of the mass of our own galactic system. Although, therefore, the density (5) corresponding to the assumption of zero curvature and to the coefficient of expansion (4) may perhaps be on the high side, it certainly is of the correct order of magnitude, and we must conclude that at the present time it is possible to represent the facts without assuming a curvature of three-dimensional space. The curvature is, however, essentially determinable, and an increase in the precision of the data derived from observations will enable us in the future to fix its sign and to determine its value.

REPORTS

SCIENCE ESSAYS BY HIGH SCHOOL PUPILS[1]

FINANCING THE VENTURE

THERE is a committee of the American Association for the Advancement of Science on the Place of Science in Education. One of the pieces of work in which this committee has engaged related to cooperation with teachers, pupils and librarians in secondary schools. In order to carry out the proposed venture special funds were necessary. Funds were secured as follows:

Commonwealth Fund, balance remaining from a previous grant	$ 417.48
American Association Executive Committee	500.00
Harry S. Bowers	1,200.00
Newcomb Cleveland	1,200.00
John W. Harris and John W. Hegeman	1,200.00
A. Cressy Morrison	600.00
Interest on funds in hand	273.53
Total	$5,391.01

All the clerical service was done in the office of the chairman of the Committee on the Place of Science in Education. The council of the American Association for the Advancement of Science has expressed its appreciation of the committee's work, and the council, the committee, high-school teachers, pupils

[2] It seems certain that the pressure p in the actual universe is negligible as compared with the material density ρ_0. The same reasoning, however, holds good if the pressure is not neglected.

[1] We continue to receive requests from schools wanting a repetition of the cooperative work with the A. A. A. S. Committee. It has not been possible to offer this opportunity again. Furthermore, certain types of unprofitable school contests have led to the conclusion that only those which can be designated as useful should receive encouragement from school authorities. We are entirely in sympathy with that policy.—The Committee on the Place of Science in Education.

[3] *Bull. Astronom. Inst. Netherlands, Haarlem,* 6, 142 (1931).

and librarians appreciate the fine generosity of the individuals who made such substantial contributions to the committee's work. The executive group of the A. A. A. S. Committee consists of J. McK. Cattell, E. R. Downing, I. W. Howerth, B. E. Livingston, Otis W. Caldwell, chairman.

Announcement of Plan

Announcements of the plan were made in educational magazines, and letters regarding it were sent to high-school principals. High-school students were invited to write essays that might possibly be of such quality as to be of interest and value to other students and to the public, or to any one who is interested in the affairs and thought of modern life. It was hoped that the preparation of the essays would be of interest and use to the authors. It was hoped that the effort to prepare superior essays might lead some high-school students to find fields for their own later interests, studies and occupations. It was hoped that an opportunity for attractive and useful juvenile authorship would thus be offered and that the plan would be welcomed by the superior pupils. The best essays would be made the basis of important personal recognitions; also contributions of science books would be made to the libraries of the schools represented by the successful pupils. It was desired to give recognition and encouragement to those young persons who possess unusual interest and capacity for constructive work of high quality.

There were 49 topics announced, upon any one of which work might be done. It was also stated that schools might suggest added topics which could be used if approved by the executive committee. Topics suggested for approval might relate to any science subject or to any applied use of science knowledge or method of work in science. It was thus planned to place before young people the array of modern science, no one science subject being stressed at the expense of any other. It was science, not the sciences, and the appeal of science's ways of working which were placed before the secondary schools. Obviously the committee accepted much more difficult tasks than are involved when a single topic or a few topics in one science subject are offered for competitive essays.

Ways of Working

One pupil might work alone, or a group might cooperate in production of an essay. Advice might be sought from teachers of science, of history, of English, or from the librarian. Books, magazines and personal experiments could be used. The plan of work was reported to the committee chairman. Then, when the pupils registered their intention of entering the competition, when the essay was finally submitted, the administrative head of each school concerned was asked to submit a signed statement as to the persons and methods used in producing the essay. It was therefore hoped to encourage rather than discourage pupil cooperation in prolonged and earnest intellectual effort. It is regarded as entirely honorable for two or more pupils to work together in scholarly effort, rather than to pretend that intellectual production must be wholly individual. Entire frankness as to how work was accomplished was urged. No case was reported in which objection was caused by this procedure.

Benefits Possible to Competing Pupils

The satisfactions and encouragement resulting from worthy achievements must be noted as the chief outcomes from preparation of good pieces of work. Then, each of the twenty winning essays won for the school represented a sum of money ranging from $200 to $50 from which to purchase science books for the school's library. These books carry the names of the winning pupils as the persons whose efforts secured the books for future use in the school. Each winning pupil has received a set of the Wells and Huxley's two volumes entitled "The Science of Life." Also each pupil has received a page of autographs of past presidents of the A. A. A. S. This may be inserted in the pupil's prize volumes, or kept by him in some other way, and may possibly become one of his most valued possessions. These pages now carry 11 signatures of presidents of the A. A. A. S. Above all, the pupil through his own directed intellectual efforts may place himself in line for continued growth in scientific interests.

Judging the Essays

How may essays be judged when written in different ways either by individuals or by groups? Many contests have been judged subjectively or superficially, and the A. A. A. S. Committee desired to contribute to improvement in this matter. An unusually competent judging committee was secured to develop a special technique for handling this task. This committee consisted of Dr. G. M. Ruch, University of California, *chairman;* Dr. M. F. Carpenter, University of Iowa; Miss Claudia Crumpton, Detroit High Schools; Mr. N. B. Hammond, Yonkers High Schools; Dr. F. G. Lyman, University of Chicago; Dr. P. M. Symonds, Columbia University, and Miss Lucy Terrell, Cleveland High Schools. No member of the A. A. A. S. Committee on the Place of Science in Education judged any of the essays. The essays were numbered, the author's names being removed. The judging committee's well-organized scheme included the various points of merit or demerit, and assigned numerical values to each element. It is hoped that the scheme for judging will be published as a separate magazine article. After the plan of judging had been developed, two well-trained teachers, one in science and another in English, were employed to make independent studies of all the essays, and to score each essay according to the points agreed upon. Each one of these teachers made detailed record of the numerical score of each essay upon each point of the judging scheme. Finally each teacher-reader summed up his ratings for each essay, then arranged all the essays in order of their rank according to their numerical scores. The essays were then divided into five groups according to their scores. Then a full set of copies of all essays that received scores placing them in the first, second or third groups was sent to each of the seven members of the judging committee. Each member made his independent scoring and mailed his report to the chairman. These scores were combined. The resulting rankings determined the 20 ranking essays. It is thought that such a system of judging does much to eliminate any objectionable features of such contests, and increases confidence that science essays may be judged more accurately than is common, almost scientifically.

THE WINNING ESSAYS

A boy and girl cooperated in more than a year's experimental work, library study and consultation with adults, and produced the highest ranking essay entitled "Rats *vs.* Polyneuritis." Another boy, working alone, won second place with the topic, "My Scientific Experiments—Why I Made Them—What I Gained from Them," and in doing so made for himself and for many others an interesting record of some things that one may do with intellectual profit. Another boy wrote on "The Importance of Protozoa and My Observations of Them," and his essay tied for third place with one entitled "Crystals and Crystallization," which was done by seven pupils who cooperated with their pupil chairman in their chemistry class in the production of their essay. The fifth essay was upon "The Water Supplies of Ancient and Modern Peoples." Other winning topics are: "My Experiments with Hydra"; "A Home in Crude Petroleum"; "The Life and Inventions of Thomas A. Edison"; "The Study of Rats and Mice"; "What Modern Science Means to Me and My Community"; "How Science has Helped Man Overcome his Limitations"; "A Hero of Science—Dr. Jacques Loeb"; "Inventions in Astronomy"; "How has Science Changed my Daily Life?"; "The Relation of Science to the Art of Music"; "Rayon"; "Science and the Home"; "Cellulose and Rayon"; "Products of the Electric Furnace"; "Radium and its Uses." These and many other topics which were submitted prove a wide range of genuine interest in scientific studies. Seventeen states were represented in the whole list of essays submitted, and ten states were represented in the twenty winning essays.

Some mature scientists may argue that secondary school pupils can not deal with topics such as those selected. It is true that some of the winning essays are not highly valuable, though some are quite remarkable in their fine quality. Good essays were desired and some good ones were secured. May I merely comment that during a meeting of the American Association, some papers are presented which do not meet with strong approval by those who hear them, and there have been times when a careful search had to be made to discover productions worthy of the association's annual prize.

LIBRARY REPORTS

Before a school's library could actually secure the funds for purchase of books, the school was asked to send the committee a report on the science books already in the library, what their library needs seem to be, and what they wish to do with the funds when secured. The Enoch Pratt Free Library of Baltimore had prepared an excellent list of science books which the committee sent to each winning library. These library reports are all now in hand except one, and will be published separately.

Science can help itself and its devotees by giving more attention to its recruits at the lower levels. The cooperative essay contest is but one of several ways of making early discovery and giving needed guidance to young persons of unusual capacities and interests.

A LIST OF THE WINNING PUPILS, THEIR TOPICS AND THE SCHOOLS REPRESENTED BY THEM

Rank	Student	School
	GROUP I	
1.	Jane B. Sill Edward H. Reisner	The Lincoln School of Teachers College, New York City
	Topic: Rats vs. Polyneuritis	
	GROUP II	
2.	Daniel Eisler	Glenville High School, Cleveland, Ohio
	Topic: My Scientific Experiments—Why I Made Them—What I Gained from Them	
3.	Ralph Lawrence	The Lewis & Clark High School, Spokane, Washington
	Topic: The Importance of the Protozoa and My Observations of Them	
3.	Lincoln School Chemistry Class	The Lincoln School of Teachers College, New York City

Winston Hurd, *chairman,* Ernest Landsteiner, Frederick Forsch, Kim Plockman, John Steinman, Eugene Williams, Jane Winternitz

Topic: Crystals and Crystallization

GROUP III

5. Byrne C. Manson — John Muir Tech. High School, Pasadena, California:
Topic: The Water Supplies of Ancient and Modern Peoples

6. Dunbar Triplett, Jr. — The Lewis and Clark High School, Spokane, Washington
Topic: My Experiments with the Hydra

7. Wm. Stewart — Beverly Hills High School, Beverly Hills, California
Topic: A Home in Crude Petroleum

8. Katharine Marie Hall — University High School, Ann Arbor, Michigan
Topic: The Life and Inventions of Thomas Alva Edison

GROUP IV

9. John Winslow French — Pawling, New York
Topic: The Study of Rats and Mice

10. Virgil Bolen — Academy of the Western Illinois State Teachers College, Macomb, Ill.
Topic: What Modern Science Means to Me and My Community

11. Rose Auerbach — Washington Irving High School New York City
Topic: How Science has Helped Man Overcome His Limitations

12. Robert Ray — University High School, Oakland, California
Topic: A Hero of Science—Dr. Jacques Loeb

13. David Putnam — High School, Keene, N. H.
Topic: Inventions in Astronomy

14. Jean Elizabeth Boling — Shortridge High School, Indianapolis, Ind.
Topic: How has Science Changed my Daily Life?

GROUP V

15. Matillda Diorio — S. Phila. High School for Girls, Phila., Pa.
Topic: The Relation of Science to the Art of Music

16. John Alloways — Central High School, Kalamazoo, Michigan
Topic: Rayon

17. Freda Becker — S. Phila. High School for Girls, Phila., Pa.
Topic: Science and the Home

18. Omer Widmoyer — Central High School, Kalamazoo, Michigan
Topic: Cellulose and Rayon

19. Wade Allen — Central High School, Kalamazoo, Michigan
Topic: Products of the Electric Furnace

20. Benjamin Richman — Lyndhurst High School, Lyndhurst, N. J.
Topic: Radium and its Uses

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A RAPID METHOD FOR OBTAINING SINGLE SPORE CULTURES OF MOLDS

IN the course of a cultural study of a large number of molds it became desirable to procure as rapidly as possible single spore cultures of certain of the hardy, saprophytic molds.

With a modified Chambers micromanipulator[1] a comparatively large number of ascospores of *Aspergillus fischeri* were individually isolated on drops of malt extract agar[2] made on sterile cover slips. The mode of isolation in brief is as follows. A standard research microscope with mechanical stage is mounted on a metal base. To this base, properly aligned, are attached in front of the microscope movable, vertical arms designed to hold the micropipettes with which spore isolation is accomplished. These arms have vertical and lateral fine adjustments, enabling the operator to manipulate the pipettes as desired. The pipettes are made up just before use by drawing out sterile 3 mm glass tubing to the desired fineness in a micro-flame. The extreme tips of the pipettes are bent at right angles to the rest of the shaft. A moist chamber with an aperture on its upper side is placed in the mechanical stage. Two sterilized square cover slips are fitted with edges together over the open top of the moist chamber. On the under side of one cover slip has been placed a drop of sterile agar medium, on the other, a drop of spore suspension. The pipettes, as they are made up, are clamped in the arms in a horizontal position, and their vertical tips are then, by means of the movable pipette arms, brought into the moist chamber and centered under the low power objective. By means of the vertical

[1] For details as to the use of this micropipette method in the isolation of single cells, see W. H. Wright and E. F. McCoy, "An Accessory to the Chambers Apparatus for the Isolation of Single Bacterial Cells," *Jour. Lab. and Clin. Med.*, 12, 795, 1927.

[2] The nutrient agar used was made up on the basis of 25 g malt extract (Trommer's Analyzed), 15 g agar, 1,000 cc distilled water. The malt broth was made with 25 g malt extract, 1,000 cc water. These media were filtered through asbestos for clarification, but a clear agar is scarcely necessary when germinated spores are picked, as their development may be readily followed on the hanging drop slide.