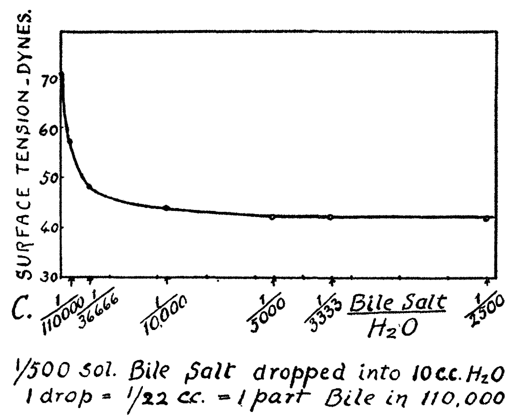

Fig. 2

(after adding bile, protein, etc.) and to toxicity in the case of the alcohol series. The experiments absorb little time, possess an intrinsic fascination and should speedily bring an apprehension of fundamental principles.

Another useful and educationally valuable piece of apparatus largely used by the same class of students is the osmometer, illustrated in the adjoining diagram. The students construct it individually according to Tamman's method (see Philip's "Physical Chemistry"), the copper ferrocyanide membrane being deposited in a film of hardened gelatin on the end of a piece of glass tubing, into which a capillary tube is fitted by means of a rubber stopper. Ease of construction combined with adequate working speed renders this type of osmometer very suitable for class work.

In its use a first approximation to the osmotic concentration of a solution may be made by comparing the unknown with a known concentration of sugar in regard to relative rates of endomosis from water (see Brown, *Ann. Bot 36*: 436) which helps toward obtaining, finally, a concentration which will balance the unknown. With care, the freezing point method may be rivalled in accuracy.

F. E. Lloyd,
G. W. Scarth
McGill University

A SIMPLE SYNTHETIC MEDIUM FOR THE CULTIVATION OF BACTERIA

In the course of studies carried out under the direction of Professor C.-E. A. Winslow in this laboratory it has seemed important to devise a highly simplified synthetic medium in which the test organism used (a strain of Bact. coli) would grow and in which the effects upon its growth of the various electrolytes could be studied without interference from impurities in the medium. After considerable study the following medium has been devised:

Ammonium tartrate, recrystallized	5 grams
Lactose (Mulford)	5 grams
Ammonium phosphate $(NH_4)_2HPO_4$	.01–.02 grams
Distilled water	1,000 cc

The reaction of the medium after sterilization is between pH 5.0 and pH 5.2. The lactose and tartrate produce no visible ash on oven treatment, but in spite of the absence of electrolytes often considered necessary the strain of Bact. coli studied has persisted with apparently undiminished vigor in this medium for twenty-three generations. No attempt has been made to study other organisms, but it has seemed worth while to describe the medium in case it may be of use to other students of similar problems.

A. F. Dolloff
Department of Public Health,
Yale School of Medicine

SPECIAL ARTICLES

THE MOTION OF A SPINNING TOP BEFORE IT REACHES THE GROUND

A good deal of interest has been taken in the motion of spinning tops of various shapes and spinning under various conditions, and a study of the problems involved has in recent years proved to be of considerable practical importance. In spite of all that has been done I have found in the literature which I have examined nothing about the motion of an ordinary top while the string is still unwinding and the top in the air. I recall as a youngster knowing that if a top is to land on its toe and spin as it should it can not always be thrown right side up. But on the other hand it often is possible to throw a top right side up, and have it stay right side up and spin merrily.

It is evident that after a top has got up a good spin any continued pull of the string is likely to introduce a torque that will cause precession and so change the direction in which the toe of the top points. But just what the conditions are under which the top should be held in a given position, just how the spin is caused to be mainly about the axis of the top, and just how the torque acts are matters that are not immediately clear. With certain simplifying assumptions it may be that a mathematical analysis of the problem would not be difficult, but the following simple treatment seems sufficient to explain the more obvious facts.

First, as to the position in which the top is actually held. If the string is sufficiently long, the top may be thrown with the toe pointing straight down, but as the string is made shorter it becomes necessary, if the top is thrown horizontally and without initial angular velocity, to tip the axis farther and farther. With a string of only moderate length I have no difficulty in spinning a top on its toe, and yet throwing it with the toe pointing straight up.

When holding the top with the toe pointing up, I find that if I am throwing it with the right hand it is easier to get it to spin if the string is wrapped like the thread of a left-handed screw, and when throwing it with the left hand to have the string wrapped like a right-handed screw. I then try to throw the top so that its initial motion is horizontal and without angular velocity and so that the pull of the string is horizontal. The string does not usually pull in a direction exactly opposite to the initial velocity, but is wrapped a little farther around the top. The angle between the initial direction of the string and the initial motion of the top may vary a good deal—it may run from 90° up to 180°.

In order to understand what happens consider first the more difficult case where the string is fairly short and the top is held with the toe pointing upward. In Fig. 1 the motion of the top is referred to a system

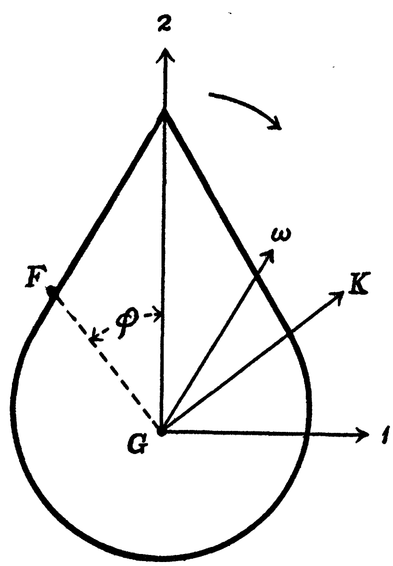

FIG. 1. Spinning top and various axes.

of three mutually perpendicular axes, 1, 2 and 3, which are fixed in the body and meet at the center of mass G. The axis 3 is to be thought of as coming straight toward us, so that the system is right-handed. Let the string be wrapped left-handed, and let the free end come straight toward us at F. After the top leaves the hand two important forces act on it. One is its weight W, and the other is the pull F exerted by the string. F is equivalent to an equal and parallel force F' through G, and a certain torque K. Since both F' and W pass through the center of mass they have nothing to do with rotation of the top, and we are not concerned with them.

At first the top has by hypothesis no rotation, but K immediately begins to produce angular momentum about its own axis. Since the moment of inertia in an ordinary spinning top is less about axis 2 than about axis 1, the axis of resultant angular velocity lies above K in some such position as is indicated by ω. For the top that I have used the most, the moments of inertia about the axes 1 and 2 are approximately $A = 100\ g{\cdot}cm^2$ and $B = 60\ g{\cdot}cm^2$, and the string is wrapped to a point such that the angle φ is about 51°. Under these circumstances it is easy to show, if ω_1 and ω_2 stand for the component angular velocities about axes 1 and 2, that we have initially

$$\frac{\dot{\omega}^2}{\dot{\omega}_1} = \frac{A}{B} \tan \varphi = 2.1.$$

Since the initial value of $\dot{\omega}_2$ is only a little more than twice that of $\dot{\omega}_1$ it is not at first clear how the string can set up an angular motion in which ω_2 becomes large without ω_1 becoming large. The explanation appears to be that as the top begins to turn about axis 2 it carries the axis 1 back behind the plane of the paper without producing much change in the position of K. The result is that the part of K which produces angular velocity about axis 1 rapidly decreases, while the part which produces angular velocity about 2 is not greatly changed. A considerable angular velocity is soon produced about axis 2, and without any great velocity about either axis 1 or axis 3. Thus as the top turns faster the axis of resultant angular velocity approaches the axis of the top, and at the same time, since less and less string is still wrapped on the top, the axis of the torque becomes more nearly perpendicular to the axis of the top. It follows that a larger and larger part of the torque is used in producing precession, and by some one of the rules for the sense of precession we see that the toe of the top must turn in the direction indicated by the curved arrow. When the top is thrown in the manner I have indicated it turns over slowly enough for the direction of turning to be observed, and the direction is in fact that which we have just found.

When a long string is used, the axes of torque and angular velocity are at first both of them close to axis 2. As the string unwinds from the top the torque swings farther and farther away from axis 2 and the angular velocity, and precession is set up as in the other case. But in this case the angular velocity about axis 2 is large before any considerable part of the torque is used in producing precession, so that the precession is slow and the top does not turn over very far before the string is entirely unwound. Thus when the string is long enough the top may be thrown with the toe pointing downward.

After the string leaves it the top is no longer subject to any appreciable torque, and so falls without further precession but maintaining the direction it had when the string left it. In spite of this last fact being so well known, it may possibly be worth mentioning that I have been able to spin a top on a table only a few centimeters below my hand, and have also thrown a top a number of times from a window more than ten meters above the ground. Every time that the top was thrown from the window spinning it fell without turning over and landed on its toe, whereas when it was dropped from the window without spin it usually turned over on the way down.

ARTHUR TABER JONES
SMITH COLLEGE

A VITAMIN B DEFICIENCY MANIFESTING ITSELF FOR THE FIRST TIME IN THE SECOND GENERATION

Two years ago the author was engaged in a series of feeding experiments in which it was desired to determine as far as possible the results upon reproduction of feeding a diet which was considered adequate in all respects except a possible deficiency or excess of the vitamins contained in cod liver oil and butter fat.

The diet used was uniform throughout, except for variations in the content of cod liver oil or other fat soluble vitamin containing foodstuffs. It was composed as follows:

Casein (purified)	18 per cent
Steenbock's No. 40 Salt	4 " "
Agar agar	8 " "
Dextrine	65 " "
Crisco	5 " "

Whatever of vitamin-containing fat was added was done by replacing an equivalent amount of Crisco. The drinking fluid was made up to contain:

Water	86.4 per cent
Lemon juice	12.0 " "
Fleischman's yeast (dry)	1.6 " "

The lemon juice was added as a carrier of Vitamin C. This was done because, in my experience, better results were obtained when the anti-scorbutic was used than when it was not. It has been maintained in this laboratory that as long as the anti-scorbutic vitamin is so plentifully supplied in practical dietaries it is necessary to include it also in synthetic diets in order that experimental conditions may compare as closely as possible to natural ones. Yeast was added at a level of 1.6 per cent. because it was noted that at this level a rat ingested the equivalent of 200 mgs per day, the amount which Osborne and Mendel[1] found sufficient to carry a rat through life at a normal rate in all respects.

Although the bulk of the data from these experiments is being reserved for a more complete report, it is desired at this time to state that the reproductive ability of the animals on these diets varied greatly. Cod liver oil was fed at levels varying from 0.25 per cent. to 5.0 per cent. On the diets containing enough cod liver oil to insure reproduction, the death-rate was very high. The clinical and pathological findings seemed to group the deaths in more than one class according to the most outstanding features. It is the purpose of this communication to submit evidence concerning one of these groups and the dietary changes that were necessary to obviate this difficulty in raising young on synthetic diets.

In experiment 60 four females and one male were receiving the above basal ration containing 2.0 per cent. cod liver oil. In order to conserve space, the history of only one female will be given. When female No. 279 was 168 days old (on the diet 140 days) she delivered six young, one of which died within a few hours. The young averaged 5.6 grams in weight, which is within normal limits. The young were adequately nursed, for they grew normally for fifteen days, at which time four suddenly showed paralysis of the hind limbs, shivering and an extreme diarrhea. Past experiences indicated that this was polyneuritis, and the diagnosis was so made in face of the fact that the mother showed no symptoms of polyneuritis and that her diet contained 1.6 per cent. yeast. As soon as one of the young died its sciatic nerve was carefully removed, stained in osmic acid and examined. Extensive myelin degeneration was found. Thus the diagnosis was confirmed. The yeast was immediately increased to 8.0 per cent. One of the young remained in good condition throughout the period of nursing and was successfully weaned. Of the remaining three animals suffering from polyneuritis, one died within a few days after the yeast addition; one recovered completely and was weaned and the remaining one improved sufficiently to have its life prolonged for several days.

The mammary glands of the mother showed histological evidence of active secretion. The stomachs of the young that died were filled with milk. Because of these facts and since the animals gained steadily in weight except at the very last (the diarrhea was very severe) it was concluded that starvation could not be a contributing factor. It was also considered that this was good evidence in favor of separating Vitamine B into two factors, one growth promoting and one preventative of polyneuritis.

There is thus demonstrated a dietary deficiency which is not manifested until the appearance of the second generation. As far as the writer knows, this

[1] Osborne and Mendel, *Jour. Biol. Chem.*, 54: 739, 1922.