Classics of Science: Nutrition of Germs

Pasteur by the methods here described proved that the molds and similar organisms which seem to spring up from nowhere grow from spores floating in the air, instead, as was widely supposed, of coming into being from the organic material on which they flourish. Make up culture media according to his formula, expose it in Petri dishes for a short time to the air of the room, cover and incubate at room temperature. Compare the growths on the different media. As a control, sterilize one such solution by boiling, pour into a sterile dish and cover immediately.

OEUVRES DE PASTEUR réunies par Pasteur Vallery-Radot Paris, 1922. Specially translated for the SCIENCE NEWS-LETTER.

Spontaneous Generation

In quoting here the principles of the systems of spontaneous generation which have been most widely held, my principal aim is to show that, in all, the essential role is played by the organic material of the infusions. By itself, it would act with the special properties acquired in the course of its earlier formation under the influence of life.

The albuminoids will conserve in some manner a residuum of vitality, which will enable them to organize themselves upon contact with oxygen, when the conditions of temperature and humidity are favorable.

We come to recognize that these opinions are entirely erroneous, and that the albuminoid materials are only a food for the germs of the infusoria and of the mucedins; that they have no other role in the infusions for it is possible to replace them with crystallizable material, such as salts of ammonia and phosphates.

Thus all the theories relative to the spontaneous formation of the lowest forms of life find themselves deprived of one of their essential foundations.

Inorganic Media

Experiment has shown me, in fact, that it is possible to replace, in the experiments in chapters IV, V, VI, the sweetened solution of brewers' yeast, the urine, the milk, etc., by an infusion made up in the following manner:

Pure water	100
Granulated sugar	10
Ammonium tartrate	0.2 to 0.5
Ashes from brewers' yeast	0.1

If one sows in this liquor, in the presence of calcined air, the dust which exists in suspension in the air, he sees the bacteria, the vibria, the mucedins, etc. spring up there. The

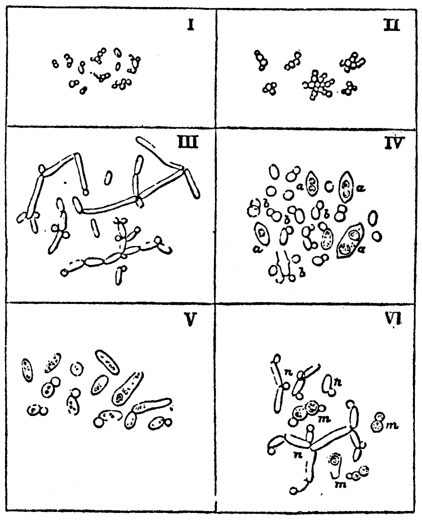

FIG. 12.

We append drawings of the *tortulae* found in the six laboratory basins (see Sketches I, II, III, IV, V, VI, of Fig. 12). The abundance of the germs of these organisms in our laboratory is very striking, and is doubtless due to the nature of the work carried on there, as well as to the power of endurance peculiar to the germs, or the minute vegetative cells of these microscopic plants—a tenacity of life which prevents them from losing their reproductive powers, even after being dried up into dust. But varied as are the formations represented in Fig. 12—and it will be observed that in IV and VI we have shown four distinct forms, marked *a, a; b, b;* m, m; n, n, respectively—it must not be supposed that they correspond necessarily to distinct species. From the ends of a compound organism like those in No. III, a little spherical cell may detach itself and then, by a process of budding, give rise to a series of other minute spherical cells reproducing the form shown in Nos. I and II.

albuminous, nitrogenous substances, the fatty substances, the essential oils, the coloring matters characteristic of these organisms, form from each bit with the aid of the elements of ammonia, phosphates and sugar.

Make up the liquor in the same manner with the addition of lime.

Pure water	100
Granulated sugar	10
Ashes of brewers' yeast	0.2 to 0.5
Carbonate of lime, pure	3 to 5 gr.

and the same phenomena will be produced, but with a more marked tendency toward the fermentations called lactic, viscous, butyric, and all the vegetable and animal ferments belonging to these fermentations will originate simultaneously or successively.

(*Just turn the page*)

Stars May Be Liquid

A new answer to the old question, "Twinkle, twinkle little star; how I wonder what you are!" is supplied by Prof. J. H. Jeans, famous British astronomer, who now proposes that stars may be largely liquid. Previously astronomers almost universally have supposed that with the high temperatures involved, stars could be nothing but great bubbles of gas.

In a communication to the Royal Astronomical Society, of which last year he was president, Prof. Jeans points out that the fact that so many stars in the sky are double favors his theory. These double, or binary, stars, consist of two separate bodies, that revolve around their center of gravity. It is supposed that many were originally single bodies, but that they divided in some way, thus producing two.

If, however, the star was made of gas, such fission would not take place, but a certain part of the gas would be expelled from the star's equator. But if the star had a liquid core, Prof. Jeans believes, such division could take place. In any condition, he believes, the outer part of the star would still be gaseous.

On the basis of this theory, Prof. Jeans has worked out a modification of the accepted ideas of the evolution of the stars. He thinks that at different temperatures the atoms of which the star consists are of different sizes. This is because they are "ionized," which means that the outermost of the rings of electrons of which they are partly made, are broken off. The star gradually contracts and gets hotter, thus stripping off more of the rings of electrons. Occasionally there may be short periods where the star is gaseous, but then the center becomes liquid again, and it is again stable for a time.

The final state of the star is what is called a white dwarf. In such a star all of the rings of electrons have been removed, and consequently there can be no further contraction. "This state of complete ionisation," says Prof. Jeans, "provides a sort of 'cold storage'—if the metaphor is not too inappropriate to a temperature of about a thousand million degrees—in which stellar atoms, no matter how great their normal generating capacity, are preserved from decay."

"Possibly," he continues, "the nuclei of the spiral nebulae constitute vast storehouses of such matter which only begins to undergo

(*Just turn the page*)

Liquid Stars

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annihilation and to emit radiation when it is first formed into stars." The life of a particular star, known as Plaskett's star, one of the white dwarfs, he says, "can hardly have been more than some 100,000,000,000 years, but the atoms of which it is composed may have previously lived an infinitely longer life, completely ionized at the center of a nebula, and therefore stagnant and immune from annihilation. As a corollary, it would be difficult to deny that all the matter of the universe may have been created at the same instant."

Though the normal evolution of a star seems to be from one stage to another, Prof. Jeans thinks it possible that a star may slip, and fall down several steps at once. "It is slightly disconcerting," he says, "to notice that our sun is perilously near to the dangerous left-hand edge of the main sequence, so that its collapse into a feebly-luminous white dwarf may start at any instant."

Science News-Letter, January 14, 1928

A wooden wardrobe found at Pompeii is the first well-preserved wooden furniture from the ruins of the buried city.

Nutrition of Germs

(*Continued from page 29*)

I shall publish shortly a detailed work on the results that I have obtained in these studies, which have always seemed to me to offer a great deal of interest on the question of the so-called spontaneous generations.

It is on this account that I have been led to undertake the following experiments the success of which has exceeded my expectations.

In pure distilled water I dissolve a crystallized salt of ammonia, some granulated sugar and some phosphates obtained by calcining brewers' yeast; then I sow in the liquid some spores of *penicillium* or some other mucedin.[1] These spores germinate easily, and soon, in only two or three days, the liquid is filled with flocs of mycelia, of which a large number are not slow to spread out on the surface of the liquid where they reproduce. The growth is far from feeble. By the precaution of using an acid salt of ammonia, one may prevent the development of the infusoria, which, by their presence, soon arrest the progress of the little plants, by absorbing the oxygen of the air, which the mucedins are not able to take from them. All the carbon of the plant is borrowed from the sugar which disappears completely little by little, its nitrogen from the ammonia, its mineral matter from the phosphates. There is therefore in this point of the assimilation of nitrogen and the phosphates a complete analogy between the ferments, the mucedins and the plants of complicated organization. This the following work will succeed in proving in a definite manner.

Three Elements Necessary

If, in the experiment which I have just recounted, I omit one or another of the substances in solution, the growth is arrested. For example, the mineral matter is that which seems the least indispensable for beings of this nature. Indeed, if the liquor is deprived of phosphates, no more growth is possible, whatever may be the proportion of sugar and ammoniacal salts. Scarcely would the germination of the spores begin on account of the importance of the phosphates unless the spores themselves, which have been sown, introduced an infinitely small quantity. Similarly if one omits the salt of ammonia, the plant is able to experiece no development. It makes only a puny beginning of growth on account of the presence of albuminous material of the spores sown, even though there is no abundance of free nitrogen in the air about or in solution in the liquid. Finally, it is still the same if one omits the sugar, the carbon food, even though there may be in the air or in the liquid any proportion of carbonic acid. All shows indeed that, in respect to the source of carbon, the mucedins differ essentially from the phanerogamous plants. They do not decompose carbonic acid; they do not liberate oxygen. The absorption of oxygen and the liberation of carbonic acid are on the contrary necessary and permanent activities of their life.

These facts give us precise ideas of the method of nutrition of the mucedins, with regard to which science has never before possessed connected observations.

[1]This is the composition of some of the liquors which I have used:

20 gr. granulated sugar
2 gr. bitartrate of ammonia
0 gr. 5 ashes of brewers' yeast
1 liter of pure water
20 gr. granulated sugar
1 gr. tartaric acid
1 gr. potassium nitrate
0 gr. 5 ashes of yeast
1. liter of pure water

It is on the surface of these liquors or other similar ones that I sow the spores of the mucedins.

It is possible to replace the salt of ammonia by a salt of ethylamine. But I have not had growth of the little plants by substituting arsenates for phosphates. I have exhibited before the Academy, at its session of November 12, 1860, various examples of these results.

Louis Pasteur was born December 27, 1822, at Dôle in Franche-Comté, and died in a suburb of Paris, September 28, 1895. At the age of 26 he was appointed Professor of Physics at Dijon, then in the same year he became Professor of Chemistry at Strasburg. At that time he was greatly interested in the problems of stereo-isomerism in organic compounds, and particularly in the fact that, while both right-hand and left-hand crystals are formed in equal quantities in the laboratory, the natural products, for instance tartrates from grapes, may contain one sort without the other. He found, too, that certain minute organisms are able to use up, from a mixture of the two sorts of crystals, only one, as the right-hand variety, leaving the left-hand salt unchanged in the solution. This work led Pasteur directly to studies of minute organisms such as yeasts and ferments, then widely believed to form spontaneously from decomposing organic material. Pasteur was able to discover and make clear the whole field of microscopic life. He founded the science of bacteriology and invented its technique.

Science News-Letter, January 14, 1928

The Babylonians told time by sundials as far back as 2000 B. C.

The largest black diamond ever found was about the size of a baseball.