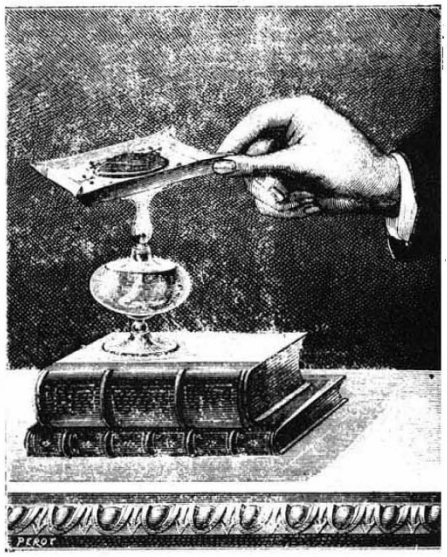
100 years ago

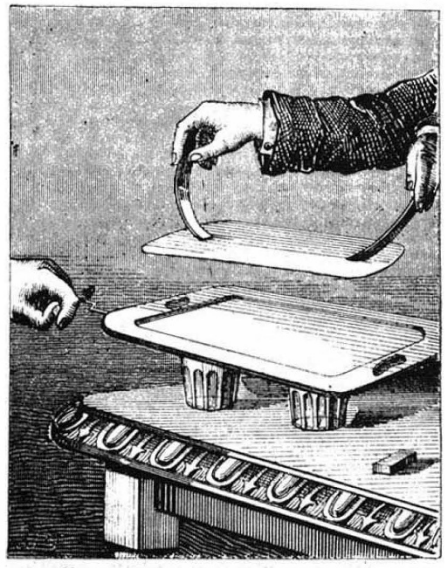
PHYSICS WITHOUT APPARATUS



Melting lead on a playing card

A pretty experiment which is easily performed is that of boiling water in a sheet of paper. Take a piece of paper and fold it up, as schoolboys do, into a square box without a lid. Hang this up to a walking-stick by four threads, and support the stick upon books or other convenient props. Then a lamp or taper must be placed under this dainty cauldron. In a few minutes the water will boil. The only fear is lest the threads should catch fire and let the water spill into the lamp and over the table. The flame must therefore not be too large. A small taper will give a flame quite large enough. The paper does not burn, because it is wet; and even if it resisted the wet it still would not burn through, because the heat imparted to it on one side by the flame would be very rapidly conducted away by the water on the other. Another experiment of a similar nature, but perhaps even more striking, is as follows: — Twist up the edges of a common playing-card or other bit of eardboard, so as to fashion it into a light tray. On this tray place a layer of small shot or bits of lead, and heat it over the flame of a lamp. The lead will melt, but the card will not burn. It may be charred a little round the edges, but immediately below the lead it will not be burned, for here again the lead conducts off the heat on one side as fast as it is supplied on the other. Lastly, we give an experiment which, like the two preceding, proves that a good conducting substance may protect a delicate fabric from burning by conducting away the heat rapidly from it. Lay a piece of muslin quite flat upon a piece of metal. A live coal placed on the muslin will not burn it, for the metal takes away the heat too fast. If the muslin is however laid on a bad conductor, such as a piece of wood, it will not be protected, and the live coal will kindle the muslin.

A certain way to obtain an electric spark we have found with what we may call a *Tea-tray Electrophorus*. A common tea-tray of metal is supported on two dry glass tumblers. A piece of common brown paper cut so as to be a little smaller than the tray, and with rounded corners, is warmed, laid on the table and rubbed briskly with a piece of indiarubber, or with a clothes-brush. It is then laid down for an instant on the tray and the tray is touched with the hand. The brown paper is then lifted a few inches above the tray. If at this juncture some person presents his knuckle to the tray he will receive a birght spark, which under favourable circumstances may be a couple of inches long. By simply putting the paper down, touching the tray,



The Tea-tray Electrophorus.

and again lifting up the paper the tray is again charged: and a large number of sparks may be thus drawn one after the other in rapid succession. The paper may be lifted by the hands, but it will be found better if a couple of ribbons or strips of paper be fixed on with wax to serve as handles, as shown in our figure.

From *Nature* **22**, 9 & 16 September, 440 & 464, 1880.

recognized by their electrophoretic mobility in acrylamide gels. By such means the 3′ end of the gene could be deleted to between +80 and +83 of the gene sequence before correct initiation failed. Together with the previous result this defines the region in *X. borealis* somatic 5S DNA which is required for transcription as lying between positions +50 and +83 of the gene sequence.

An internal promoter is certainly unexpected and different in location from the 5′ flanking promoters of bacterial genes, but is it a general rule for all polymerase genes? The answer is probably yes since there is significant homology of a sequence AGCAGGGT found between base pairs +55 and +62 of the 5S gene and a similarly (±2 base pairs) located sequence in other polymerase III genes — Adenovirus VA I gene and *Bombyx mori* $tRNA^{tyr}$.

Moreover, similar deletion and transcription studies on tRNA genes (Telford *et al. Proc. natn. Acad. Sci. U.S.A.* **76**, 2590; 1979) show that deletion of 5′ flanking sequences to within −20 base pairs of the transcription initiation site does not impair transcription of the *Xenopus laevis* $tRNA_1^{met}$ gene. However, a mutation (Ad5d1309, a dimer deletion) occuring outside the gene between pairs −21 and −24 of the 5′ flanking sequence of adenovirus 5 VA I gene does prevent synthesis of one of the two alternate VA I RNAs (Thimmappaya, Jones & Shenk, *Cell* **18**, 947; 1979). The two VA I RNAs are both transcribed from the same gene but differ by three nucleotides at the 5′ end, VA IA begins with pAGCG . . . while VA IG begins at the second G. The Ad5d1309 mutant produces only the VA IG RNA. The two base pair deletion thus alters the 5′ flanking sequence sufficiently to suppress initiation at A but not at G, demonstrating, in an *in vivo* situation, that local sequences influence the exact site at which transcription begins.

Clearly if the same polymerase III enzyme transcribes a wide variety of genes some of which are independently regulated there must be other factors interacting with the gene–polymerase complex to regulate transcription. One such factor has recently been purified from soluble extracts of *Xenopus* ovaries (Engelke, Ng, Shastry, & Roeder *Cell* **19**, 717; 1980). It had been noticed that 5S genes in chromatin from oocytes were transcribed by a purified polymerase III preparation but a cloned 5S gene was not (Ng, Parker & Roeder *Proc. natn. Acad. Sci. U.S.A.* **76**, 13; 1979). Activity could be restored to the purified polymerase III/cloned 5S gene system by addition of an ammonium sulphate fraction of soluble ovary proteins. Such restoration assays made it possible to purify a 37,000 molecular weight protein which allows faithfull transcription of both *Xenopus* somatic and oocyte cloned 5S genes in a defined reconstituted transcription system using purified polymerase III. The factor, which appears specific for 5S genes, has no activity on a cloned *Xenopus* $tRNA_1^{met}$ gene. The factor binds independently of polymerase III to a region of the 5S gene between +45 and +96 base pairs completely overlapping the region identified by deletion mapping as essential for transcription in 5S DNA. Thus there is a possibility that this factor acts in a positive way by directing polymerase III to the 5S gene. It seems certain that this is the first of many factors which will be found to specifically modify the interaction between polymerase III and its genes.

Thus the dogma generated by studies of gene regulation in prokaryotes is breaking down with the demonstration of an internal promoter and regulatory sites for 5S RNA transcription in *Xenopus*. These studies have not yet defined the nature of developmental regulation of these genes, but they have gone a long way towards that goal. □

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