

LETTERS TO THE EDITOR

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ON PRIMES WITH MAXIMUM RECURRING PERIODS FOR THEIR RECIPROCAL

1. It is well known that the reciprocal of a prime number q , when expressed in decimals, has a pure recurring period of p digits where p is a factor of $(q-1)$. When $p=q-1$, the prime is said to be one with maximum period for its reciprocal. The first six such primes are given by Hardy and Wright¹ with the remark that very little is known about them. In 1945, I gave a necessary and sufficient set of conditions² for q to be such a prime, viz., that $10^{(q-1)/p} \equiv 1 \pmod{q}$ for all prime factors p of $(q-1)$ and reduced this set to a single condition in the particular case where q is a prime of the form $1+2^\alpha 3^\beta$. It is regrettable to note that in 1947 a false criterion was published by R. V. Iyer in the Bombay University Journal³ which may, however be rectified thus: For $q=1+2^\alpha p$ where p and q are primes $q \neq 137$, $\alpha \leq 22$, necessary and sufficient condition for $1/q$ to have a maximum period is $10^{(q-1)/2} \equiv -1 \pmod{q}$. This follows from the fact that prime factors of 10^m-1 (when $m \leq 21$) of the form $1+2^\alpha p$ are 3, 7, 23, 53, 137, p being a prime.⁴ This single criterion suffices to show that 233, 263, 269, 383 and 389 are primes whose reciprocals have maximum recurring periods.

2. We now give a single necessary and sufficient condition applicable to all cases in the form of a theorem:

If $q=1+2^{\alpha_0} p_1^{\alpha_1} p_2^{\alpha_2} \dots p_r^{\alpha_r}$, $P=p_1 p_2 p_3 \dots p_r$, $Q=(p_1-1)(p_2-1) \dots (p_r-1)$ and $10^{(q-1)/2} \equiv t \pmod{q}$, where q, p_1, p_2, \dots, p_r are odd primes, then a necessary and sufficient condition for q to be a prime with a maximum recurring period for $1/q$ is that t satisfies a cyclotomic congruence equation of degree Q and order $2P$.

The proof of this is immediate from my criterion² if we remember that $t^{2P} \equiv 2 \pmod{q}$ but $t^f \neq 1 \pmod{q}$ for any factor f of $2P$. For example; when $q = 2^\alpha 3^\beta 5^\gamma + 1$ and $10^{(q-1)/2} \equiv t \pmod{q}$, $1/q$ will have a maximum recurring period or not according as t satisfies or does not satisfy the cyclotomic congruence equation

$$x^s + x^7 - x^5 - x^4 - x^3 + x + 1 \equiv 0 \pmod{q}.$$

For the prime 151, $10^5 \equiv 38 \pmod{151}$ but 38 does not satisfy the above congruence equation. In fact the period for $1/151$ is 75. For the prime 61, $10^2 \equiv 39 \pmod{61}$ and 39 satisfies the congruence equation, and therefore $1/61$ has a maximum recurring period of 60 digits. In fact, the recurring decimal for $1/61$ is 01639344 262295081967213114754098360655737704918032 7868852459.

3. Lastly we note that $10^{(q-1)/2} \equiv 1 \pmod{q}$ is the necessary and sufficient condition for

the recurring period to be odd for $1/q$, while $10^{(a-1)/2a} \equiv -1 \pmod{q}$, ($1 \leq a \leq a_0$) is the necessary and sufficient condition for the period of $1/q$ to be even.

A. A. KRISHNASWAMI AYYANGAR.

Mysore,
September 3, 1948.

1. Hardy, G. H., and Wright, E. M., *An Introduction to the Theory of Numbers*, 2nd Edition, 1945, 114.
2. Krishnaswami Ayyangar, A. A., and Kaprekar, D. R., *Journal Bombay University*, 1945, 14, part 3, 8.
3. Venkatachalam Iyer, R., *Journal Bombay University*, 1947, 15, part 5, 9.
4. Rollett, A. P., *Math. Gazette*, 1937, 21, 411.

REPLACEMENT OF TEETH IN GAVIALIS

IN *Current Science* for April 1943 reasons were given for the belief that the teeth of *Gavialis gangeticus* were seldom lost and replaced and the presence of many damaged teeth in old crocodiles likewise suggests that replacement does not occur in old age.

It is contended that this point of view overlooks the presence of dental germs and takes note merely of the three macroscopic rows of teeth as seen in the dissected jaw of mature specimens, but the assumption of constant succession still requires experimental proof.

Professor L. Berner of Marseilles has directed my attention to the arresting of growth of the canines by gastration of the wild boar, *Sus serofo* L., and animals where the primary teeth are shed immediately after they erupt or are lost early in life, as in most Mammals.

It would appear that the existence of other rows of teeth than the three commonly noted in crocodiles and gavials has fostered the conception of constant succession and there is need for teeth to be marked in other specimens and kept to determine how long they function.

Britannia Buildings, F. G. CAWSTON.
Durban,
August 5, 1948.

1. Cawston, F. Gordon, *Current Science*, 1943, 12, 114.

PHOSPHATE FROM BAGASSE ASH

BAGASSE has been largely used as a fuel, but its ash is discarded. It contains phosphate in an unavailable form. The present investigation was undertaken to find out how the phosphate could be converted into an available form for use as a phosphatic manure.

The bagasse for this work was obtained from the Kolhapur Sugar Mills. 1 Kg. of it yielded 40 gm. of ash.

On chemical examination, the ash was found to contain nearly 1.6 per cent. phosphate (calculated as P_2O_5); calcium, magnesium, potassium, and aluminium and iron (the last two calculated together as oxides) being respectively, 3.38, 0.0021, 0.0031, and 0.008 per cent. The rest was silicious matter.

The phosphate content of ash treated with hot water under pressure, with alkalis, and with mineral acids were estimated.

Quantities of distilled water were added to known weights of the ash in different test tubes, and heated in an autoclave at $120^\circ C$. at 15 lbs. for half an hour. The filtrates from these gave no test for phosphate.

Known weights of the ash were also treated with mineral acids and with sodium carbonate. The phosphate content of the filtrates are given in the following table.

TABLE

Wt. of ash gm.	Treated with	Treatment	Percentage of phosphate as P_2O_5 in filtrate
1	2 c.c. H_2SO_4 con.	No heating. Only	} 1.60
1	3 ,, ,,	kept aside for	
1	5 ,, ,,	24 hours.	
1	5 ,, ,,	Heated on water bath for 1 hour	
25	50 c.c. HCl (1 : 1)	Refluxed for 2 hours	1.60
5	5 gm. Na_2CO_3 in 100 c.c. water	Boiled for 15 minutes	0.55
5	2 gm. solid Na_2CO_3	Fused, and extracted with water	1.59

The phosphate was estimated by precipitating it as ammonium phosphomolybdate. The precipitate, after filtering and washing, was treated with a known excess of an alkali solution, the excess of which was determined by back-titration with standard acid.

These experiments suggested the possibility of using bagasse along with firewood rich in potash as a mixed fuel in boiler furnaces so that the resultant ash may contain soluble phosphate, and hence serve as a valuable fertilizer.

Accordingly, 1 part of bagasse and 3 parts of *Justicia picta*, locally known as "adulsa" were burnt together and subjected to prolonged heating for about 4 hours in the laboratory.

The mixed ash extracted with hot water contained 0.343 per cent. phosphate, in the filtrate.

A possible setback in such a procedure would be the presence in firewood of minerals yielding interfering ions. Similarly, the heat obtained from the petrol gas in the present instance may not have been enough to bring about the necessary fusion. But these experiments have shown a possibility which may turn out to be of importance.

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30th May 1948.

NUCLEIC ACID AND BACTERICIDAL ACTION OF PENICILLIN

THE remarkable antibiotic properties of penicillin have caused attention being directed towards a study of its mode of action,¹⁻⁵ but hitherto, a correct explanation of its action is not available. The recent reports of Pandalai