not at all complete, yet the biological condition of the river is completely changed for some distance and fish die in the water, although cases have been quoted in which freshwater fish do not suffer from lack of oxygen when the water contains so little as 0.4 c.c. to 1.7 c.c. per litre, less than one-third of the amount necessary for saturation.

Other observers lay stress upon the effect of hydrogen ion concentration; it takes much putrefaction to reduce the *pH* of a natural water to less than 6, and some freshwater fish have been found flourishing in water of *pH* 4.4—probably an extreme case. Although changes between *pH* 6 and *pH* 8 do undoubtedly affect the nature of the fauna and perhaps of the flora, it seems unlikely that a river would be harmfully affected until the hydrogen ion concentration had risen to around *pH* 5.5. Wundsch² suggests an even lower limit.

The increase in partial pressure of carbon dioxide coincident with putrefaction may have a specific physiological effect additive to that due to a materially increased hydrogen ion concentration. Experiments by Wells³ in America suggests that this is the case when in conjunction with a low concentration of dissolved oxygen, but these experiments are inconclusive since no account is taken of the hydrogen ion concentration. The influence, if any, of this factor in the deeper water of polluted streams is really unknown.

It appeared self-evident some two years ago, when examining rivers for harmful pollution by organic matter, that lack of oxygen alone, although an excellent indication, was not the only factor giving rise to an abrupt change in stream life, but that this was brought about through the interplay of several factors. Dr. Pruthi⁴ very kindly undertook last year to investigate the possible physiological effect of the products of putrefaction upon fish. His painstaking investigation, although admittedly of a preliminary nature, shows that these products play a rôle in limiting fish life in waters where certain kinds of organic putrefaction take place, if not generally. In a 1 in 2000 solution of casein, peptone, or albumen which had undergone putrefaction, small fish quickly died, even after the solution had been thoroughly aerated and its hydrogen ion concentration had been reduced to

a normal value for natural water. This is a definite evidence of the production of toxic compounds during the process of putrefaction of these proteins.

The toxic compounds were, in part at least, volatile, for the distillate was observed to be highly poisonous to the test fish. An observation suggested that such compounds are readily oxidised, for heating a putrefied casein solution to 70° for twelve hours rendered it innocuous, whereas before heating it killed test fish in one hour. These experiments bring out the significance possessed by the toxic compounds which appear as by-products of protein putrefaction, a factor hitherto almost ignored. It will be a fruitful problem to investigate the nature and production of these compounds from various organic substances likely to be thrown into rivers, their effect upon the fauna generally, and the possibility of accelerating their oxidation.

Until knowledge has been obtained of how each factor affects not only fish but also other forms of aquatic life, particularly diatoms, attempts to deal with effluents containing dissolved organic matter must remain empirical. As soon as a sound basis of theoretical knowledge is available, the risk of expensive installations proving unsatisfactory will be greatly minimised, and firm ground will be provided for efficient legislation causing the least possible expense to the various interests involved.

In attacking problems of this nature, provided the investigations proceed without undue haste and there is some freedom allowed to follow up cognate issues which present themselves during the course of every research, it is impossible to foresee where new knowledge may in time lead. We cast away many tons of combined nitrogen and phosphorus and of fats into our rivers every year. Our inland waters are capable of yielding many more tons of edible fish annually, and it is very possible that this will become an economic possibility in the not far-distant future.

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Comets and the Law of Gravitation.

By DR. A. C. D. CROMMELIN.

ONE of the most interesting results of the discovery of the law of universal gravitation was the light that it threw on the nature of cometary movements, which had previously baffled astronomers. In classical times comets seem to have been generally recognised as heavenly bodies: this is illustrated by the remarkable prediction of Seneca: "Some day there will arise a man who will demonstrate in what regions of the heavens the Comets take their way; why they journey so far from the other planets; what their size, their nature." This prediction received a striking fulfilment some 1600 years later, when Newton's

brilliant discovery of the law of gravitation, which permits motion in any of the conic sections about a centre of attraction, made it at last possible to determine the orbits of comets.

After the time of Seneca, science in Europe underwent a remarkable retrogradation as regards the nature of comets. They came to be regarded as mere atmospheric exhalations, a supposition that their great size and rapid motion rendered plausible, but capable of easy refutation from the fact that they rise and set like the stars. The erroneous conception had two unfortunate effects: first, it led to comets being regarded as the bearers of

plague, famine, and war; secondly, it caused very little attention to be paid to their positions among the stars, so that in several cases this is far more precisely stated in Chinese and Japanese records than in European.

Tycho Brahe made it clear, by the absence of appreciable parallax, that comets were at least several times more remote than the moon, and so restored them to the status of heavenly bodies. When Kepler, from a study of Tycho's observations, demonstrated the elliptical character of the planetary orbits, the idea occurred independently to Hevelius, Borelli, Löwer, and Dörfel that comets might also have elliptical paths of a much more elongated character than those of the planets, so that they remained invisible for the greater part of their period of revolution. These ideas remained merely conjectural until Newton had demonstrated that the law of universal gravitation, varying inversely as the square of the distance, gave a full explanation of the lunar and planetary movements, and indicated the possibility of motion in conic sections of any eccentricity.

Thus at last it became possible to calculate the orbits of comets. Many difficulties arose in the practical work, owing to the roughness of the observations and the small arc covered by them. It has needed long experience and the continued work of a long series of mathematicians to reduce the calculation to its simplest form. At first it offered great difficulties even to Newton. He was unfortunate in choosing as one of his examples the great comet of 1680-81, which had the very small

perihelion distance 0.006. It will be remembered that the 'daylight' comet of January 1910, which also had a small perihelion distance, baffled the orbit computers in the early days of its apparition. So Newton is stated to have lost two months in 1685 in attempting to deduce the orbit of the 1680 comet, though he ultimately succeeded in obtaining a tolerable result, and in proving that the morning comet of November 1680 was the same body that was seen in the evening in the following January.

Newton has freely acknowledged in the "Principia" the great debt that he owed to Halley for carrying the cometary computations much further than he himself had the leisure or inclination to do. As is well known, Halley took up the application of the law of gravitation to comets with the greatest enthusiasm, and calculated the orbits of 24 of them from observations extending over two centuries, which he had collected with much diligence. He was rewarded for this great labour by the discovery of the periodic comet that bears his name, which he found to have appeared in 1456, 1531, 1607, 1682. He thus reduced these wandering bodies to recognised members of the solar system, his work being afterwards vindicated by the return of his comet in 1759, in almost exact accordance with his prediction. Thus it may be said that Newton's discovery, vastly useful as it was for the prediction of lunar and planetary motions, produced a still more revolutionary advance in the world of comets.

Dwelling-places, Portraits, and Medallion Illustrations of Newton.

THE particulars concerning the birth and upbringing of Newton, as well as his domiciliary situation and circumstances while at Cambridge, are so well known that they need no further narration. But his eventful and full life in London, in east and west, covering a period of thirty years, and when in the zenith of fame, may perhaps receive some attention. It suffices, as a preliminary, to recall that, in 1701, Newton resigned the Lucasian chair at Cambridge. He had earlier (1696) been appointed Warden of the Mint, and later (1699) Master.

DWELLING-PLACES.

Towards the close of 1697, Newton went into residence in Jermyn Street, where he stayed until 1710. From here he wrote to Flamsteed, under date 1698, whilst Bentley addressed a letter to him, so late as 1709, in this wise: "Sir Isaac Newton, at his house in Jermin Street, near St. James's Church, London." After a short stay in Chelsea, "near the College," Sir Isaac removed about the end of September 1710 to a large and commodious house in St. Martin's Street, Leicester Fields, occupying this as tenant during the rest of his life. Actually, however, he ceased to live in it from 1725, for, owing to indifferent health, he had gone into quarters at Kensington, dying there in 1727. It was in that year that his name was erased from the

books of his former parish. The identification of the house in Kensington where Newton lived was established and recorded in 1852 by Mr. Joseph Jopling, an architect, who thereupon received the thanks of the president and council of the Royal Society. It was probably in early days within sight of Kensington Palace.

Newton had procured (with the active assistance of Wren), in the very year of the acquisition of a new domicile for himself, a home for the Royal Society in Crane Court, Fleet Street. Possibly, in determining this abode, he was mindful of the claims imposed upon his time by the weekly meetings of the Society. He would not have far to go from Leicester Fields to Crane Court.

In St. Martin's Street Newton lived in excellent style, kept a carriage, and maintained an establishment of three male and three female servants. Ample hospitality was proffered without ostentation or vanity, his niece, the accomplished Catherine Barton, presiding at the philosopher's table. She married John Conduit in 1717, who, in later years, wrote "nobody ever lived with him but my wife, who was with him near twenty years." Eminent foreigners visiting London were always sure of a warm welcome. Newton built a small observatory on the roof of his house. At the moment of writing, the foundations of a spacious new building are in progress on the site of the