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65.3 A pi-Less Area

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Team		Goals Scored						
		0	1	2	3	4	5	$\geq 6$
Middlesbrough	Observed	11	14	12	4	0	0	1
	Expected	11	15	10	4	1	0	0
Norwich	Observed	12	15	10	4	1	0	0
	Expected	12	15	9	4	1	0	0
Nottingham F.	Observed	11	14	8	7	1	0	1
	Expected	10	14	10	5	2	1	0
Q.P.R.	Observed	11	23	4	3	0	1	0
	Expected	14	15	8	3	1	0	0
Southampton	Observed	14	14	10	3	1	0	0
	Expected	14	15	9	3	1	0	0
Tottenham H.	Observed	12	17	8	5	0	0	0
	Expected	13	15	9	3	1	0	0
W.B.A.	Observed	5	19	9	5	2	1	1
	Expected	8	13	11	6	3	1	0
Wolverhampton W.	Observed	12	20	7	2	1	0	0
	Expected	15	15	8	3	1	0	0

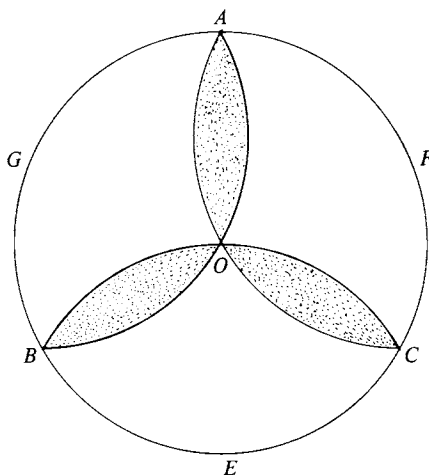
When these twenty-two sets of results are tested at the 5% level of significance using a chi-square distribution only one set, namely that associated with Q.P.R., will not support the hypothesis that the data is a Poisson distribution. However, this transgression by Q.P.R. did not go without penalty as they were relegated!

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### 65.3 A pi-less area

Although in pure mathematics elaborate pathological examples can be constructed to illustrate apparently unexpected results, it does come as a surprise, now and then, to see such results in simple cases. For example, consider the well-known example of two equal right circular cylinders whose axes intersect at right angles. What is the volume of the region common to the two cylinders? A simple calculation shows the answer to be  $16a^3/3$  where  $a$  is the radius of each cylinder. That a region surrounded by cylindrically curved surfaces should have a volume independent of  $\pi$  does come as a surprise.



Here we illustrate another example, relating to areas. The three-petal lotus shown in the figure is one which every child, learning to use the compass, is taught to draw. What is the area of the *unshaded* region within the circle? Although surrounded on all sides by arcs of circles, the answer is independent of  $\pi$ —as the simple calculation shows below.

The petal  $OA$  is bounded by the arcs of two equal circles centred at  $F$  and  $G$ . Taking the radius  $OA$  of the full circle as equal to  $a$ , the area of petal  $OA$  is given by

$$X = a^2 \left( \frac{\pi}{3} - \sin \frac{\pi}{3} \right) = \left( \frac{\pi}{3} - \frac{\sqrt{3}}{2} \right) a^2.$$

The unshaded area is therefore given by

$$Y = \pi a^2 - 3X = \frac{3\sqrt{3}}{2} a^2.$$

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*Intuition*

“I have had my solutions for a long time, but I do not yet know how I am to arrive at them.”  
(Gauss)

“It’s plain to me by the fountain that I draw from, though I will not undertake to prove it to others.” (Newton)

Quoted in W. M. Priestley, *Calculus: an historical approach* (per E. H. Lockwood).