Toward a Conception of the Holistic

Part 2 of 4[1]

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. . . that consciousness before number is born. You can see the difficulties that would exist. How, in preparing a meal, would you be able to know when you had set out enough items? If you know no number, you don't know whether it is six, or seven, or something else. The only thing you can do is to set up one-to-one correlations between one class and another, and the very first class consists of the fingers—the fingers of both hands—and therefore, and for that reason alone, we have the decimal system.

Now, this existed before a word for number was born. Now, when we came to the time when the fingers where not enough—we were moving our herd of sheep. Let us say there were 37 sheep or any other number that you could not count on the fingers of the hand—you could not set up a one-to-one correlation. One very convenient device would be to pick up a number of pebbles and carry them in a bag, and you establish—you set off one sheep and you put down one pebble; and then you get another sheep and you put down another pebble; and you go on around until you have a bunch of pebbles here that sets off a one-to-one correlation with the sheep. You put those in the bag; and if after the day of pasturing you return and you set up the one-to-one correlation and you have one pebble left over, you know one sheep is out there, one sheep may have been eaten by an enemy or at least lost. But without those pebbles you couldn't know that you hadn't all of your sheep. That method of counting isn't so old, so long ago. The Romans used it, and hence we have the word calculus which means stone. By the way, when I mention that word if you're a doctor you probably think of something quite nasty inside the human being, but if you're a mathematician you think of that great instrument of calculation developed by Sir Isaac Newton and Leibniz—the instrument that enables us to deal with motion by use of notions that are infinitely small. But the only reason why the word calculus meaning stone comes to have that meaning, and is also the root form of calculate, is because back some day among the Latin speaking people they set up their correlations with pebbles. So that is not so long ago.

Now, the modern mathematical logician defines number in relation to this primary process which we can trace back to the infant and the primitive. It is a one-to-one reciprocal correlation between two classes. Now, if you have a class *C* which we may call the fingers or our bag of stones, and you correlate those with other classes, such as pictures on the wall, so that there's a one-to-one reciprocal correlation between them—or with other objects like books, like trees, like human beings, . . . , rivers, or whatnot, ideas, objects of art, and so on, so that there is a one-to-one reciprocal correlation between the

[1] Unfortunately, part of this discourse is missing at the beginning and the end of this audio recording. The missing audio portions may be found in the Wolff Archives under the category, "Lectures, Notes & Outlines."

class *C* and these various other classes; there's no more in one than there is in the other—then number emerges as the symbol of that class *C*.

Now, that step of number emerging and then of writing signs in the earth, on rocks, later upon papyrus, upon our paper, that mean those symbols, represents a conquest in abstraction that called for genius. We do not know how long a time, how many centuries were required for this stage in evolution. We know that even after the notion of number had emerged as a definite concept and they were writing it, it took quite a long time before we evolved a scientific method of notation. Perhaps a few of you appreciate what a service our scientific notation is to you; but let me suggest to those of you who keep books, how would you handle your additions, your multiplications, and divisions if you used the Roman method of notation—let alone calculating your income tax? Actually, it took great experts to handle calculations in that form of notation. Bookkeeping was almost a job for a genius. Once the idea of symbols, a limited number of them—we use ten: 0, 1, on up to 9, with a periodic recurrence, that which is known as the Arabic notation—it gave us a real command of number. It doesn't have to be decimal. It could break, and has broken upon other numbers—like number 12. There was one people that broke on the number 60. One very interesting form is to break upon the number 2. You use only two symbols: 0 and 1—a straight line. Actually, that biennial system is the one that's used in the calculating machines; so it proves to be the most scientific of all. At last we have reached the point where number has emerged and we have a proper garb for it so we're free to act. We have seen command in our world running through the whole of science, through the whole of our industry, through the whole of our finance, and even involving our domestic accounting, that's rendered possible because of this emergence of number.

Now, starting at the foundation, which was so simple, we're preparing ourselves for an experience in soaring. We are not going to depart from the logical principle which the infant unconsciously employed. This is something that's grounded down into the very roots of our consciousness and of nature itself, but it is going to lead to a vast elaboration of structure before we're through. We propose to enter in, ultimately, the domain of the infinite; but in order to make that infinite more than just a word, first let us explore something of the meaning of the word 'finite'. Many people use the word infinite in a loose and entirely improper sense. There were poets back in the classical days who spoke of the infinity of the stars; mind you this was before telescopes, the stars that could be seen were the only stars that could be meant and there were only 3000 of them. For those poets, 3000 was infinity. How many of you when you use the word infinity really mean infinity? How many of you merely mean a big number? A big number is not infinity anymore than 1 is infinity. But we've got to become acquainted first with something of the meaning of the larger meaning of finite before we can sail out into the illimitable seas and not do so wildly.

Now, our universe is believed to be finite for certain definite reasons: one of them is that if there was an infinity of stars, it can be proven that the whole sky would be as bright as the sun is; and for another reason, the theory of relativity, which is the best integrating conception for what we know today, definitely delimits the universe to a finite universe. It is possible to come to some estimate as to the diameter of that universe. While it is a complex notion of finiteness, for a first approximation you think of it as a sphere a certain distance across, not saying or not meaning that it is literally such a sphere, and based upon the theory of Einstein it is possible to state a good many facts or a good many things that are implied by this theory concerning this universe. One of the problems which Eddington tackled was the counting of all the protons in the galactic universe. I don't mean that he took a spaceship out there and set up a one-to-one correlation with his fingers or with his stones. He calculated it indirectly.

Now Peter and Joel if you will take down this; I'll show you the number of protons in the universe—not one more not one less according to Eddington: 136×2^{256}, which when written out is this number up here down to here—eighty places. Now, you can challenge that number in one way, by devising a theory that is more successful in explaining the facts of the universe than Einstein's theory, and if you can do that you are good. I don't know how you would name this number. It can be written in this short way; that means exactly this.

Sometime ago some mathematicians were making experiments with kindergarten children and in a very short time, though the children came with only an understanding of numbers up to 100, they were able to expand their consciousness to certain very big numbers—numbers bigger than a good many non-mathematical scientists are able to comprehend. The point is that this understanding is latent or innate and it can be guided to articulation or apprehension even in the kindergarten child. One of the kindergarten children wrote down 1 with a 100 zeros after it, and a nine year old boy christened it the 'googol'.[2] I've written down the googol, 10^{100}, and here written out in the long way with all of these zeros. You can count them to see if I missed any or not. That goes to a 100 zeros, and this number eighty places, but if it were written 1 with zeros after it would be seventy-nine zeros. This number has twenty-one zeros more in it than the number of that order. That means it's 10^{21} times as big as the number representing all the protons in the galactic universe. I have to say 10^{21} because I don't know what whether—it's probably septillions or octillions. I have to figure that out. It's easier to say 10^{21} times. That means it's not a billion times bigger; it's not a trillion time bigger—see a billion would be only nine zeros, a trillion 12 zeros, quadrillion 15 zeros, a quintillion 18 zeros, a sextillion 21 zeros; in other words, it's a sextillion times larger than this number that represents, according to Eddington, the number of protons in the universe. But it's a finite number. It is not infinite—not any closer to being infinite than the number 1 is.

Now, here's where we're going to have some real fun. The nine year old boy gave a name 'googolplex' to the number 10 raised to the googol power. That's $10^{10^{100}}$. Now we're going to see how many zeros there would be in that googolplex. Now you're going to get a real expansion. No measly 100 zeros you can write down in a few minutes. We're going to find out how much space it's going to take to write down that number. Let us assume that we have an unlimited supply of ticker tape and that we start writing on it with zeros quarter of an inch across. Now I'd like to have some estimates as to how long that ticker tape would have to be to write that number. Now you give me some estimates.

Audience: About a million light-years.

[2] Edward Kasner and James Newman, *Mathematics and the Imagination* (New York: Simon and Schuster, 1940), 23-25.

Wolff: A million light-years, all right that's an interesting estimate. All right, 10^6 light-years. Anybody else have any ideas on it? If you think he's too fantastic, tone it down a bit. What would be your estimate?

Audience: I have no conception.

Wolff: Have no idea about it? How long would this tape have to be? Hugh?

Audience: About all I'd say is infinity.

Wolff: No, no. Now you're going off the deep end. That's just the thing we're driving against. We're dealing with a finite number.

Audience: When you commence to multiply like that you run into numbers.

Wolff: You do run into a lot of numbers, but now we're going to keep definiteness as far as we can. We're only going off into the indeterminate when we have to. See this is our expansion here.

Audience: [Difficult to hear.]

Wolff: What did you think? Come on don't be afraid. Don't be afraid to be fantastic now.

Audience: I want to bring it down to fifty miles.

Wolff: Fifty miles, all right. Anyone else estimate?

Audience: It would go all the way around the earth.

Wolff: Around the earth—that's 25,000 miles.

Audience: I'd say twice around the earth.

Wolff: Twice? All right that's on the same order—two times. Anyone else? Anyone want to have . . . ?

Audience: [Difficult to hear.]

Wolff: Far as the sun?

Audience: Yes.

Wolff: Ninety-two million miles. Joel is giving a bigger number than that though. Let's see 92×10^6 miles. Want to try your luck doctor? Anyone else? Now let's see what your intuitions or hints for mathematical quantity is? No one else?

Audience: [Difficult to hear.]

Wolff: Hmm?

Audience: [Difficult to hear.]

Wolff: You would what?

Audience: [Difficult to hear.]

Wolff: It has as many zeros as the value of this number—googol. See, googol has a 100 zeros but the quantity represented by that is the number of zeros which the googolplex has. Well now, anybody who wants to be wild and fantastic whether he believes in it or not—believes that his answer is real—give us an estimate. Let's see how far you can jump in fantasy now.

Audience: How far up can you go?

Wolff: Any distance. Any distance that you can name.

Audience: A limit to the finite universe.

Wolff: A limit to the finite universe. That is—estimates seem to run on the order of three billion light-years: 3×10^9 light-years. Do you really believe it?

Audience: I guess I don't.

Wolff: Well, as a matter of fact you're the only individual who's sufficiently warm to get a little bit less cold than absolute zero . . . if you're looking up a little with Joel.

All right, now we're going to show you what that'll take. Can we turn this around? I've figured out, at a quarter of an inch to the zero: 253,440 zeros in a mile; 47 billion odd in a light-second; let's see, billions, trillions, quadrillions—1 quintillion plus in a light-year; and in 3,000 light-years, that's 3×10^9, we get this number which has 27 places past the first 4. Let us give the fellow credit who has been writing that and perhaps pinched his zeros a little bit and got a little more in, so we'll allow him credit for about 5 with a lot of zeros after it. Jump back across the universe and could raise that up to 10, that would add 1 zero to it you see. You'd have 10 with 28 zeros after it which you write that way. That's as far as we've gotten. But to get a googol of zeros—this is the number of zeros—we've got to get 10^{100} and you've only got 10^{28} going across the galactic universe and back again. When you get into this, you're going to swim. This is finite, and I keep emphasizing it; they're all in the finite domain. Now, let's see just about how much we'd have to do here. Let us suppose that we can make our tape as thin as gold leaf and only a quarter inch wide—still keeping our zeros quarter inch in size—and you fold it back and forth in the galactic universe. And by that I don't mean our galaxy, the stars and so forth that we see, which is about 150,000 light-years across, and is composed, various estimates running from 30 to 100 billion stars. I don't mean that. But out beyond that perhaps a million light-years or more you get to other universes and they keep on extending as far as our biggest telescopes can go for hundreds of millions of miles. And the total distance supposed across that whole galactic universe you know on the order of 3 billion light-years. Now let us imagine that we can make our tape only a quarter of an inch across and as thin as gold leaf, how much of that universe would we have to use, folding it back and forth, to get the whole number written down?

Audience: All of it.

Wolff: Yes, you'd have to use all of it and you couldn't get it all in. All right. Now, the only way we can get that number into this universe is in this: now then some estimates have been made as to the number of electrons that could be packed into this universe if they were all packed tight. Now, the protons that I'd given in the other figure which had only something like eighty digits represent those that actually exist and the distance between the protons and the electrons is simply enormous. Now, let us suppose we had electrons packed tight instead of being planetary distances from each other as they are in our matter, even in our densest matter; suppose they were tight together? In certain stars, they approach that condition and the weight of a piece of matter from such stars is such that a piece the size of a pea would weigh a ton. Well—or if we took the matter that's in one of our human bodies, were to compress it so that all of the electrons and protons were tight together instead of distances between them, there'd be just about enough matter in one of our bodies to make a flyspeck. Now, then, if the electrons—if the electrons were packed like that, packed so close that the matter of a human body would make about a flyspeck, throughout the entire galactic system, the estimated number of them is 10^{110}. That's a number with—1 with 110 zeros after it. In other words, a number that's 10 billion times as big as our googol. This 10 has the effect of making it 10 billion times as big as the googol. Well now it's quite clear from that that if we made our zeros as small as electrons we wouldn't need all of the galactic universe for writing our number. We could make our zeros a littler larger. We couldn't make them as large as atoms. The size would come somewheres intermediate between an atom and an electron, and then with those little objects, which would take a very good engraver to make, you could write out that number by using the whole galactic universe. And that's a finite number. Finite!

If we're going to get on to the meaning of the symbol for the Holistic that has been suggested, its vastitude, this magnitude in the end must become so insignificant that it would scarcely make a watch-fob. You've got to be able not to swim off the deep end with mere bigness. By finite numbers we may say we represent the possibility of all evolution, but an evolution developing throughout any finite time however large could not possibly exhaust finitude. We're seeking to transcend finitude as a conception. Now, working with mere bigness is laborious and so forth, but using our techniques it's not too difficult. The question arises, how are we going to transcend mere bigness?

Oh by the way, before we leave the big numbers. While this number, the googolplex, is very large, there is one number still larger that has use. It's known a Skewes' number and has something to do with the distribution of primes. It's written this way. It looks quite innocent. That's enormously greater than that googolplex we've been talking about. It has been estimated, or calculated rather, by Hardy, an English mathematician, that if the universe were a vast chessboard and the chessmen were the protons in it and you counted every interchange of protons a move, the total of all possible interchanges that could exist would be represented by this number. Head swimming?

Audience: [Difficult to hear.]

Wolff: That number has use even bigger than the googolplex. It's still finite.