Who was Fibonacci?

The "greatest European mathematician of the middle ages", his full name was Leonardo of Pisa, or Leonardo Pisano in Italian since he was born in Pisa (Italy), the city with the famous Leaning Tower, about 1175 AD. Pisa was an important commercial town in its day and had links with many Mediterranean ports. Leonardo's father, Guglielmo Bonacci, was a kind of customs officer in the North African town of Bugia now called Bougie where wax candles were exported to France. They are still called "bougies" in French, but the town is a ruin today says D E Smith (see below).

So Leonardo grew up with a North African education under the Moors and later travelled extensively around the Mediterranean coast. He would have met with many merchants and learned of their systems of doing arithmetic. He soon realised the many advantages of the "Hindu-Arabic" system over all the others.

D E Smith points out that another famous Italian - St Francis of Assisi (a nearby Italian town) - was also alive at the same time as Fibonacci: St Francis was born about 1182 (after Fibonacci's around 1175) and died in 1226 (before Fibonacci's death commonly assumed to be around 1250).

By the way, don't confuse Leonardo of Pisa with Leonardo da Vinci! Vinci was just a few miles from Pisa on the way to Florence, but Leonardo da Vinci was born in Vinci in 1452, about 200 years after the death of Leonardo of Pisa (Fibonacci).
Leonardo of Pisa is now known as **Fibonacci** [pronounced fib-on-arch-ee] short for **filius Bonacci**.

There are a couple of explanations for the meaning of **Fibonacci**:

1. Fibonacci is a shortening of the Latin "filius Bonacci", used in the title of his book *Libar Abaci* (of which more later), which means "the son of Bonaccio". His father's name was Guglielmo Bonaccio. Fi'-Bonacci is like the English names of Robin-son and John-son. But (in Italian) Bonacci is also the plural of Bonaccio; therefore, two early writers on Fibonacci (Boncompagni and Milanesi) regard Bonacci as his family name (as in "the Smiths" for the family of John Smith). Fibonacci himself wrote both "Bonacci" and "Bonaccii" as well as "Bonacij"; the uncertainty in the spelling is partly to be ascribed to this mixture of spoken Italian and written Latin, common at that time. However he did not use the word "Fibonacci". This seems to have been a nickname probably originating in the works of Guillaume Libri in 1838, according to L E Sigler's in his Introduction to Leonardo Pisano's *Book of Squares* (see Fibonacci's Mathematical Books below).

2. Others think Bonacci may be a kind of nick-name meaning "lucky son" (literally, "son of good fortune").
Other names

He is perhaps more correctly called Leonardo of Pisa or, using a latinisation of his name, Leonardo Pisano. Occasionally he also wrote Leonardo Bigollo since, in Tuscany, bigollo means a traveller.

We shall just call him Fibonacci as do most modern authors, but if you are looking him up in older books, be prepared to see any of the above variations of his name.

[With thanks to Prof. Claudio Giomini of Rome for help on the Latin and Italian names in this section.]

Fibonacci's Mathematical Contributions

Introducing the Decimal Number system into Europe

He was one of the first people to introduce the Hindu-Arabic number system into Europe - the positional system we use today - based on ten digits with its decimal point and a symbol for zero:

1 2 3 4 5 6 7 8 9 0

His book on how to do arithmetic in the decimal system, called Liber abbaci (meaning Book of the Abacus or Book of Calculating) completed in 1202 persuaded many European mathematicians of his day to use this "new" system.

The book describes (in Latin) the rules we all now learn at elementary school for adding numbers, subtracting, multiplying and dividing, together with many problems to illustrate the methods:

\[
\begin{array}{cccc}
1 & 7 & 4 & + \\
2 & 8 & & \\
\hline
2 & 0 & 2 & \\
\end{array}
\quad
\begin{array}{cccc}
1 & 7 & 4 & - \\
2 & 8 & & \\
\hline
1 & 4 & 6 & \\
\end{array}
\quad
\begin{array}{cccc}
1 & 7 & 4 & \times \\
2 & 8 & & \\
\hline
3 & 4 & 8 & 0 \\
\hline
1 & 3 & 9 & 2 \\
\end{array}
\quad
\begin{array}{cccc}
1 & 7 & 4 & \div 28 \\
2 & 8 & & \\
\hline
6 & \text{remainder 6} & \\
\end{array}
\]

Let's first of all look at the Roman number system still in use in Europe at that time (1200) and see how awkward it was for arithmetic.

Roman Numerals

The Numerals are letters

The method in use in Europe until then used the Roman numerals:

\begin{align*}
I &= 1, \\
V &= 5, \\
X &= 10,
\end{align*}
L = 50,  
C = 100,  
D = 500 and  
M = 1000  
You can still see them used on foundation stones of old buildings and on some clocks.  

**The Additive rule**  
The simplest system would be merely to use the letters for the values as in the table above, and add the values for each letter used.  
For instance, 13 could be written as XIII or perhaps IIX or even IXI. This occurs in the Roman language of Latin where 23 is spoken as tres et viginti which translates as *three and twenty*. You may remember the nursery rhyme **Sing a Song of Sixpence** which begins  
*Sing a song of sixpence  
A pocket full of rye  
Four and twenty blackbirds  
Baked in a pie...*  
Above 100, the Latin words use the same order as we do in English, so that whereas 35 is quinque et triginta (5 and 30), 235 is ducenti triginta quinque (two hundred thirty five).  
In this simple system, using addition only, 99 would be 90+9 or, using only the numbers above, 50+10+10+10 + 5+1+1+1+1 which translates to LXXXVIII and by the same method 1998 would be written by the Romans as MDCCCCLXXXXVIII. But some numbers are long and it is this is where, if we agree to let the order of letters matter we can also use *subtraction*.  

**The subtractive rule**

The Roman language (Latin) also uses a subtraction principle so that whereas 20 is viginti 19 is "1 from 20" or undeviginti. We have it in English when we say the time is "10 to 7" which is not the same as "7 10". The first means 10 minutes before (or subtracted from) 7 O'clock, whereas the second means 10 minutes added to (or after) 7 o'clock. This is also reflected in Roman numerals. This abbreviation makes the order of letters important. So if a smaller value came *before* the next larger one, it was *subtracted* and if it came after, it was *added*.  
For example, XI means 10+1=11 (since the smaller **one** comes after the larger **ten**) but IX means 1 less than 10 or 9.  
But 8 is still written as VIII (not IIX). The subtraction in numbers was only of a unit (1, 10 or 100) taken away from 5 of those units (5, 50 or 500 or from the next larger multiple of 10 (10, 100 or 1000).  
Using this method, 1998 would be written much more compactly as MCMXCVIII but this takes a little more time to interpret: 1000 + (100 less than 1000) + (10 less than 100) + 5 + 1 + 1 + 1 + 1. Note that in the UK we use a similar system for time when 6:50 is often said as "ten to 7" as well as "6 fifty", similarly for "a quarter to 4" meaning 3:45. In the USA, 6:50 is sometimes spoken as "10 of 7".  
**Look out for Roman numerals used as the date a film was made, often recorded on the screen which gives its censor certification or perhaps the very last image**
Arithmetic was not easy in the Roman system:

   CLXXIIII added to XXVIII is CCII
   CLXXII less XXVIII is CXXXXVI

For more on Roman Numerals, see the excellent Frequently Asked Questions on Roman Numerals at Math Forum.

The Decimal Positional System

The system that Fibonacci introduced into Europe came from India and Arabia and used the Arabic symbols 1, 2, 3, 4, 5, 6, 7, 8, 9 with, most importantly, a symbol for zero 0.

With Roman numbers, 2003 could be written as MMIII or, just as clearly, it could be written as IIIIM - the order does not matter since the values of the letters are added to make the number in the original (unabbreviated) system. With the abbreviated system of IX meaning 9, then the order did matter but it seems this system was not often used in Roman times.

In the "new system", the order does matter always since 23 is quite a different number to 32. Also, since the position of each digit is important, then we may need a zero to get the digits into their correct places (columns) eg 2003 which has no tens and no hundreds. (The Roman system would have just omitted the values not used so had no need of "zero".)

This decimal positional system, as we call it, uses the ten symbols of Arabic origin and the "methods" used by Indian Hindu mathematicians many years before they were imported into Europe. It has been commented that in India, the concept of nothing is important in its early religion and philosophy and so it was much more natural to have a symbol for it than for the Latin (Roman) and Greek systems.

"Algorithm"

Earlier the Persian author Abu 'Abd Allah, Mohammed ibn Musa al-Khwarizmi (usually abbreviated to Al-Khwarizmi) had written a book which included the rules
of arithmetic for the decimal number system we now use, called Kitab al jabr wa'l-
muqabala (Rules of restoring and equating) dating from about 825 AD. D E Knuth (in
the errata for the second edition and third edition of his "Fundamental Algorithms")
gives the full name above and says it can be translated as Father of Abdullah,
Mohammed, son of Moses, native of Khwarizm. He was an astromomer to the caliph at
Baghdad (now in Iraq).

Al-Khowârizmî is the region south and to the east of the
Aral Sea around the town now called Khiva (or Urgench) on the Amu Darya river. It was part of the Silk
Route, a major trading pathway between the East and
Europe. In 1200 it was in Persia but today is in
Uzbekistan, part of the former USSR, north of Iran,
which gained its independence in 1991.

Prof Don Knuth has a picture of a postage stamp issued by the USSR in 1983 to
commemorate al-Khowârizmî 1200 year anniversary of his probable birth date.
From the title of this book Kitab al jabr w'al-muqabala we derive our modern word
algebra.

The Persian author's name is commemorated in the word algorithm. It has changed
over the years from an original European pronunciation and latinisation of algorism.
Algorithms were known of before Al-Khowârizmî's writings, (for example, Euclid's
Elements is full of algorithms for geometry, including one to find the greatest common
divisor of two numbers called Euclid's algorithm today).

The USA Library of Congress has a list of citations of Al-Khowârizmî and his works.
Our modern word "algorithm" does not just apply to the rules of arithmetic but means
any precise set of instructions for performing a computation whether this be a
method followed by humans, for example:

a cooking recipe;
a knitting pattern;
travel instructions;
a car manual page for example, on how to remove the gear-box;
a medical procedure such as removing your appendix;
a calculation by human computors : two examples are:
William Shanks who computed the value of pi to 707 decimal places by hand last
century over about 20 years up to 1873 - but he was wrong at the 526-th place when it
was checked by desk calculators in 1944!
Earlier Johann Dase had computed pi correctly to 205 decimal places in 1844 when
aged 20 but this was done completely in his head just writing the number down after
working on it for two months!!
or mechanically by machines (such as placing chips and components at correct
places on a circuit board to go inside your TV)
or automatically by electronic computers which store the instructions as well as data to work on.


The Fibonacci Numbers

In Fibonacci's Liber Abaci book, chapter 12, he introduces the following problem (here in Sigler's translation - see below):

How Many Pairs of Rabbits Are Created by One Pair in One Year

A certain man had one pair of rabbits together in a certain enclosed place, and one wishes to know how many are created from the pair in one year when it is the nature of them in a single month to bear another pair, and in the second month those born to bear also.

He then goes on to solve and explain the solution:

Did Fibonacci invent this Series?

Fibonacci says his book Liber Abaci (the first edition was dated 1202) that he had studied the "nine Indian figures" and their arithmetic as used in various countries around the Mediterranean and wrote about them to make their use more commonly understood in his native Italy. So he probably merely included the "rabbit problem" from one of his contacts and did not invent either the problem or the series of numbers which now bear his name.

D E Knuth adds the following in his monumental work The Art of Computer Programming: Volume 1: Fundamental Algorithms errata to second edition:

Before Fibonacci wrote his work, the sequence $F(n)$ had already been discussed by Indian scholars, who had long been interested in rhythmic patterns that are formed from one-beat and two-beat notes. The number of such rhythms having $n$ beats altogether is $F(n+1)$; therefore both Gospala (before 1135) and Hemachandra (c. 1150) mentioned the numbers 1, 2, 3, 5, 8, 13, 21, ... explicitly.

Knuth refers to an article by P Singh in Historia Mathematica vol 12 (1985) pages 229-244.

Naming the Series

It was the French mathematician Edouard Lucas (1842-1891) who gave the name Fibonacci numbers to this series and found many other important applications as well as having the series of numbers that are closely related to the Fibonacci numbers - the Lucas Numbers: 2, 1, 3, 4, 7, 11, 18, 29, 47, ...
Fibonacci memorials to see in Pisa

He died in the 1240's and there is now a statue commemorating him located at the Leaning Tower end of the cemetery next to the Cathedral in Pisa. [With special thanks to Nicholas Farhi, an ex-pupil of Winchester College, for the picture of the statue.]

References

D E Smith's *History of Mathematics* Volume 1, (Dover, 1958 - a reprint of the original version from 1923) gives a complete list of other books that he wrote and is a fuller reference on Fibonacci's life and works.

There is another brief biography of Fibonacci which is part of Karen Hunger Pashall's (Virginia University) *The art of Algebra from from al-Khwarizmi to Viète: A Study in the Natural Selection of Ideas* if you want to read more about the history of mathematics.

*Eight Hundred Years Young* by A F Horadam (University of New England) in *The Australian Mathematics Teacher* Vol 31, 1985, pages 123-134, is an interesting and readable article on Fibonacci, his names and origins as well as his mathematical works. He refers to and expands upon the following article...


*Della vita e delle opere di Leonardo Pisano* Baldassarre Boncompagni, Rome, 1854 is the only complete printed version of Fibonacci's 1228 edition of *Liber Abaci*.

The Math Forum's archives of the *History of Mathematics discussion group* contain a useful discussion on some of the controversial topics of Fibonacci's names and life (February 1999). Use its next>> link to follow the thread of the discussion through its 6 emailed contributions. It talks about the uncertainty of his birth and death dates and his names. It seems that Fibonacci never referred to himself as "Fibonacci" but this was a nick-name given to him by later writers.