V. Use of the term "tissue engineering"

CHI has conducted an analysis of the use of the term: "tissue engineering" in the research literature. This work was undertaken using a set of papers downloaded from PubMed . The papers were found by searching for the term "tissue eng*" in titles or abstracts.[5] Table 2 reports the results of this work. The table reports the number of papers by year overall, for research and review papers, and by subject matter. The subject matter section is ordered by year of first appearance, which is reported in the "1st year" column.

At the time the search was conducted, in mid-2001, 685 papers were identified that used the term tissue engineering, or a variant, in their titles or abstracts. 68% of the papers were research papers and 29% were review papers.[6] The abstracts and titles were read, and the papers were classified by contents. Thus we can see that bone & cartilage and more basic research, not associated with any particular body part, are the two dominant categories, each accounting for about 20% of the papers. Only 6% of the papers concerned skin, which might seem low since skin is a rather well developed application. The skin papers also begin rather late, in 1995. We hypothesize that work on skin was an independent stream, going much farther back in time, and only in 1995 did someone draw the connection to work on other tissues by using the term "tissue engineering." 7% of the papers were found to be outside the field. This frequently occurred in review articles which described the available, not very satisfactory, options for treating a medical condition and then held out the hope that tissue engineering would provide better solutions in future.

There seem to be three phases to the use of the term "tissue engineering." In 1984/85 JR Wolter and RF Meyer imagined the possibility of tissue engineering after removing from an eye a prosthesis that had been in place 20 years. Their abstract reads as follows:

> *Clinical observation and cytological study of a reasonably successful keratoprosthesis removed along with a corneal button about 20 years after its implantation in an aphakic eye revealed an acellular epithelium-like film on its outer surface, firm anchoring of its supporting skirt by stable fibrous connections to the corneal stroma, and a continuous separating membrane composed of a homogeneous proteinaceous film and fibroblast-like cells of macrophage origin on its inner surface. The significance of the successful adaptation of the plastic materials of the prosthesis to the tissues of the cornea and the fluids of the inner eye for the future of tissue engineering in the region of the eye is discussed.*

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[5] This paper set was one input to the filtering process described above, but is really a different set of papers. Some of these papers are in the final analysis set and some are not.

[6] The other 3% were classified as "other." Examples include: a discussion of recent patents in tissue engineering, or a discussion of recent regulatory changes relevant to tissue engineering.

After a gap of a few years, a second phase began in 1989 and lasted through 1997, during which time the term "tissue engineering" began to be used regularly in abstracts and titles. During this period, the term was applied to work concerning all the main organs closely connected to tissue engineering: bone, cartilage, blood vessels, liver, skin, neurons and also to biomedical materials.

The third phase began in 1998 and continues. Recent years have seen dramatic growth in the use of the term "tissue engineering". 1998 saw more than a doubling of papers using the term as compared to 1997, and the number almost doubled again in 1999. In this phase we also see a few papers concerning other organs, and in fact the return of papers concerning eyes.
Overall, the growth in the use of the term "tissue engineering" in titles and abstracts seems not unlike the growth in number of core papers fundamental to tissue engineering that is reported in Figure 1.

Table 2 – Papers using the term "tissue engineering" in their titles or abstracts

Category	1st year	Papers	% Share	1984	1985	…	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
All papers	1984	685	100%	1	1		1	1	8	9	7	11	14	30	30	79	153	214	126
Research	1984	466	68%	1	1		1	1	3	3	4	2	8	18	18	55	103	137	111
Review	1991	199	29%						4	5	3	8	6	11	11	23	46	71	11
Other	1991	20	3%						1	1		1		1	1	1	4	6	4
Ophthalmology	1984	6	1%	1	1												3	1	
Cardiovascular	1989	77	11%				1		1	2	2	2	1	1	2	11	15	28	11
General	1990	83	12%					1	2	4	2	3	2	3	6	9	13	27	11
Bone & Cartilage	1991	149	22%						2			4	3	5	5	18	38	49	25
Basic	1991	147	21%						1	2	3	1	3	11	7	19	24	42	34
Outside field	1991	48	7%						1			1	1	2	1	5	10	13	14
Liver	1991	15	2%						1	1			1	1	1		2	5	3
Skin	1995	38	6%										2	2	3	8	8	10	5
Pancreas	1995	4	1%										1			1	1		1
Neural	1996	16	2%											1		2	2	7	4
Dentistry	1996	14	2%											1	1	1	3	6	2
Tendon & Ligament	1996	10	1%											1			7	2	
Kidney	1996	7	1%											2	2	2	1		
Muscle	1997	9	1%												2	1	4	2	
Genitourinary	1998	27	4%													2	5	13	7
Gene Therapy	1999	9	1%														7	2	
Other tissue	1999	9	1%														3	4	2
Meniscus	1999	6	1%														4		2
Stem Cells	1999	4	1%														1	3	
Digestive	1999	4	1%														2		2
Lung	2001	3	0%																3