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Constructal Timeline

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Abstract

This work presents a constructal timeline on the webpage umitgunes.net/timeline, which shows the evolution of constructal theory from 1996 to today. All of the most important publications and all conferences in the constructal realm, as well as the total number of citations and publications for each year, are displayed. This theory was first published in 1996. Over the following span of 22 years, constructal law has inspired more than 400 publications, 12 conferences and 8,000 citations. The timeline presented on this new platform brings all information categories (publications, conferences, events and citations) together in one place and, like a movie, provides the most up-to-date account of the emerging of Constructal realm.

Keywords: Timeline, Evolution, Constructal law, Publication, Citation

1. Constructal Law

Constructal law explains design in nature and engineering (animate and inanimate), evolution and how flow systems develop shape and structure. "Constructal" term first released in the paper titled "Street Network Theory of Organization in Nature (p. 106)" (table 1) in June 1996 as:

> "If "fractal" is an appropriate Latin-based word for breaking things, i.e. for the opposite of the direction in which natural systems evolve, then the appropriate word for the geometry and evolution of optimized and organized natural phenomena is constructal."

It was followed in November 1996 by a second paper, titled "Constructal-theory network of conducting paths for cooling a heat generating volume (p. 815)" (table 1), that described it in a comprehensive manner. As the journal had an overflow of accepted papers that year, this article was dated 1997 but was actually available in the library in 1996. This paper defines constructal law in the following terms:

> "For a finite-size system to persist in time (to live), it must evolve in such a way that it provides easier access to the imposed currents that flow through it."

After these two articles, constructal law found a place in placed in Advanced Engineering Thermodynamics (2nd edition) (table 2). Five more papers on constructal law were published in 1997 (table 1). From then until today, more than 5,700 articles and books have contained the word “constructal.”[1]

2. Timeline

Constructal law states that all currents find a better way to live. In the past, the manuscripts of scholars, and later on their books, articles, and movements were very important vehicles in terms of spreading ideas and knowledge further afield. Nowadays technological evolution is becoming the favored vehicle, for instead of change being a very smooth and perhaps centuries-long process, it is now occurring at a very rapid pace. Similarly, learning/teaching methods have also started to change.

One of the best modern ways to present any idea is to use social media, webpages, animations, and similar tools. In this work, we developed a comprehensive webpage platform (figure 1) to present constructal information. We selected 20 of the most important articles (table 1), 18 books (table 2), and 12 conferences (table 3) and added them to the constructal timeline so that both items could be seen together. This information can also be filtered by one or more categories (e.g., articles, books and conferences). In the future this webpage, which now contains basic information of the constructal field, will expand to cover all of this field’s information.

Fig. 1. General view of constructal timeline

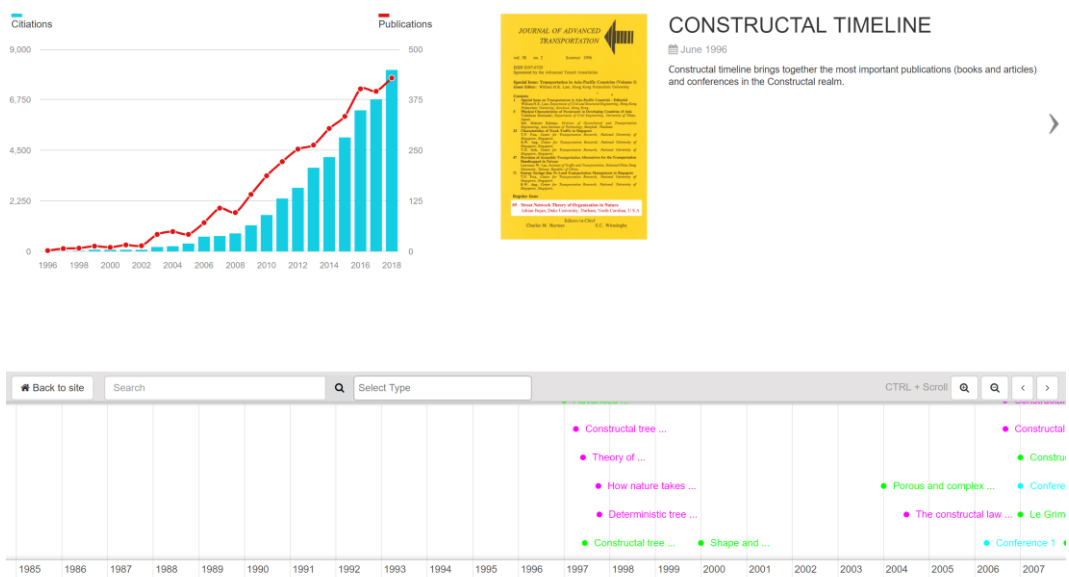

Figure 1 displays the most important information, all of which can be searched by title or author, on one page. This timeline comprises three groups: books (table 1),

articles (table 2), and conferences (table 3), each with the relevant date. It can be also used for lectures to familiarize students with constructal law and its realm.

Table 1. The most important articles in the Constructal realm [2]

1996	A. Bejan, "Street network theory of organization in nature," Journal of Advanced Transportation, vol. 30, no. 2, pp. 85–107.
1996	A. Bejan, "Constructal-theory network of conducting paths for cooling a heat generating volume," International Journal of Heat and Mass Transfer, vol. 40, no. 4, pp. 799–816.
1997	A. Bejan, "Theory of organization in nature: pulsating physiological processes," International Journal of Heat and Mass Transfer, vol. 40, no. 9, pp. 2097–2104.
1997	G. A. Ledezma, A. Bejan, and M. R. Errera, "Constructal tree networks for heat transfer," Journal of Applied Physics, vol. 82, no. 1, pp. 89–100.
1997	A. Bejan, "How Nature Takes Shape," Mechanical engineering, pp. 90–92.
1997	A. Bejan, "Constructal tree network for fluid flow between a finite-size volume and one source or sink," Revue Générale de Thermique, vol. 36, no. 8, pp. 592–604.
1997	A. Bejan and M. R. Errera, "Deterministic Tree Networks for Fluid Flow: Geometry for Minimal Flow Resistance Between a Volume and One Point," Fractals, vol. 05, no. 04, pp. 685–695.
2004	A. Bejan and S. R. Lorente, "The constructal law and the thermodynamics of flow systems with configuration," International Journal of Heat and Mass Transfer, vol. 47, no. 14–16, pp. 3203–3214.
2006	A. Bejan and S. Lorente, "Constructal theory of generation of configuration in nature and engineering," Journal of Applied Physics, vol. 100, no. 4, p. 041301.
2006	A. Bejan and J. H. Marden, "Unifying constructal theory for scale effects in running, swimming and flying," Journal of Experimental Biology, vol. 209, no. 2, pp. 238–248.
2006	A. H. Reis, "Constructal theory: From engineering to physics, and how flow systems develop shape and structure," Applied Mechanics Reviews, vol. 59, no. 5, p. 269.
2010	A. Bejan and S. Lorente, "The constructal law of design and evolution in nature," Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 365, no. 1545, pp. 1335–1347.
2011	A. Bejan and S. Lorente, "The constructal law and the evolution of design in nature," Physics of Life Reviews, vol. 8, no. 3, pp. 209–240.
2012	L. Chen, "Progress in study on constructal theory and its applications," Sci. China Technol. Sci., vol. 55, no. 3, pp. 802–820.
2013	A. Bejan and S. Lorente, "Constructal law of design and evolution: Physics, biology, technology, and society," Journal of Applied Physics, vol. 113, no. 15, p. 151301.
2015	A. Bejan, "Constructal Law: Optimization as Design Evolution," Journal of Heat Transfer, vol. 137, no. 6, p. 061003.
2017	A. Bejan, "Evolution in thermodynamics," Applied Physics Reviews, vol. 4, no. 1, p. 011305.
2018	A. Bejan, "Thermodynamics today," Energy.
2018	A. Bejan, "Constructal law, twenty years after," Proceedings of the Romanian academy, pp. 309–311.
2018	A. Bejan, U. Gunes, M. R. Errera, and B. Sahin, "Social organization: The thermodynamic basis," International Journal of Energy Research, vol. 42, no. 12, pp. 3770–3779.

Table 2. The most important books in the Constructal realm [3]

1997	A. Bejan, Advanced engineering thermodynamics, 2nd ed. Wiley.
2000	A. Bejan, Shape and Structure, from Engineering to Nature. Cambridge University Press.
2004	A. Bejan, I. Dincer, S. Lorente, A. F. Miguel, and A. H. Reis, Porous and Complex Flow Structures in Modern Technologies. New York, NY: Springer New York.
2006	J. Dhombres and A. Kremer-Marietti, L'épistémologie: état des lieux et positions. Ellipses.
2006	A. Bejan, Advanced engineering thermodynamics, 3rd ed. Wiley.
2007	A. Bejan and G. W. Merkx, Constructal theory of social dynamics. New York; London: Springer.
2007	P. Kalason, Le grimoire des rois: théorie constructale du changement. Paris: L'Harmattan.
2008	A. Bachta, J. Dhombres, and A. Kremer-Marietti, Trois études sur la loi constructale d'Adrian Bejan. Paris: L'Harmattan.
2008	A. Bejan and S. Lorente, Design with Constructal Theory. John Wiley & Sons, Inc.
2009	L. Rocha, Convection in Channels and Porous Media: Analysis, Optimization, and Constructal Design. Saarbrücken: VDM Verlag.
2009	A. Bejan, S. Lorente, A. F. Miguel, and A. H. Reis, Constructal human dynamics, security and

	sustainability, vol. 50. IOS Press.
2010	D. Queiros-Condé and M. Feidt, Constructal Theory and Multi-scale Geometries: Theory and Application in Energetics, Chemical Engineering and Materials. Les Presses de l'ENSTA.
2011	G. Lorenzini, S. Moretti, and A. Conti, Fin Shape Thermal Optimization Using Bejan's Constructal Theory, vol. 6.
2012	A. Bejan and J. P. Zane, Design in Nature: How the Constructal Law Governs Evolution in Biology, Physics, Technology, and Social Organization: Doubleday.
2013	L. A. O. Rocha, S. Lorente, and A. Bejan, Constructal law and the unifying principle of design. New York: Springer.
2013	A. Bejan, Convection heat transfer, 4th ed. New York: Wiley.
2016	A. Bejan, Advanced engineering thermodynamics, 4th ed. Hoboken: John Wiley & Sons Inc.
2016	A. Bejan, The physics of life: the evolution of everything. New York: St. Martin's Press.

Table 3. Constructal Law Conferences

2006	Constructal Theory of Social Dynamics, Durham, NC, USA
2007	Constructal Theory of Social Dynamics, Durham, NC, USA
2008	Constructal Human Dynamics, Security and Sustainability, Evora, Portugal
2008	Shape and Thermodynamics, Florence, Italy
2009	Constructal Theory and Multi-Scale Geometries, Paris, France
2010	Constructal Theory Symposium, Design in Nature 2010, Pisa, Italy
2011	Constructal Law Conference, Porto Alegre, RS, Brazil
2013	Constructal Law Conference, Nanjing, China
2015	Constructal Law Conference, Parma, Italy
2017	Constructal Law & Second Law Conference, Bucharest, Romania
2018	NSF Workshop, Villanova, PA, USA
2019	Constructal Law Conference, Porto Alegre, RS, Brazil

3. Conclusions

In this paper we explained the new method of constructal timeline, which is used to present publications and conferences in the Constructal realm. At the present time this timeline, which enables viewers to see all of the information together, includes only the most important publications and conferences. In the future, it will be extended to include all of the publication and events in this realm [4].

4. Acknowledgements

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5. References

[1] A. Bejan, "Constructal law, twenty years after," Proceedings of the Romanian academy, pp. 309–311, 2018.
[2] Table 1. The most important articles in the Constructal realm
[3] Table 2. The most important books in the Constructal realm
[4] Gunes, U., 2018, "Performance and Size Optimization of Energy Systems: Constructal Law" PhD Thesis Report, Graduate School of Natural and Applied Sciences, Yıldız Technical University.