MODELING TUMOR GROWTH AS THE EVOLUTION OF A BIOLOGICAL COMPLEX SYSTEM WITH VARIABLE FRACTAL DIMENSIONS .

Caterina Guiot[†1,2,*], Pier Paolo Delsanto[2,3,*], Nicola Pugno[4]

and Thomas S. Deisboeck[5,*]

Affiliations: [1]Dip. Neuroscience, Università di Torino, Italy; [2]INFM, sezioni di Torino Università e Politecnico, Italy; [3]Dip. Fisica, Politecnico di Torino, Italy; ; [4]Dip. Ing. Strutturale e Geotecnica, Politecnico di Torino, Italy ; [5]Complex Biosystems Modeling Laboratory, Harvard-MIT (HST) Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA 02129, USA.

* cVit supported by the NIH-National Cancer Institute through the Integrative Cancer Biology Program (CA113004), the Division of Engineering and Applied Sciences at Harvard University and IBM Corporation.

[†]**Corresponding Author:**

Caterina Guiot, Ph.D., Dip. Neuroscienze, 30, C. Raffaello, 10125 Torino

tel: +39.11.670.7710, fax: +39.11.670.7708, e-mail: caterina.guiot@unito.it

Universal growth laws, as proposed by West and collaborators for all living organisms (West et al, *Nature* **413**: 628-631,2001), may be extended to describe the growth of tumors *in vivo, provided the* scaling exponent *p* (assumed by West et al. to be equal to 3/4) varies according to the tumor and its vascular network evolution (Guiot et al, *J. Theor. Biol.* **225**: 147-283, 2003, Delsanto et al, *Appl Phys Lett*. **85**: 4225-4227,2004).

In fact, the idea of a fractal topology of the tumor vasculature has already been proposed by Baish (*Microvasc. Res.* **51**: 327-346,1996) and Baish & Jain (*Cancer Res.* **60**:3683-3688, 2000), and in-vivo estimates of the fractal dimensions of planar vascular networks based on the box-counting method were performed. The evolution of cancer topology during the growth of tumors implanted in mice has been studied by Gazit et al. (*Microcirculation* **4**:395-402,1997) ,in the chick embryo

by Vico et al (*J. Theor. Biol.* **195**:525-532,1998) and after delivering docetaxel to cultured HUVEC cells in Matrigel by Guidolin et al (*Microvasc. Res.*, **67**: 117-124, 2003) .

In a completely different context, Carpinteri and Pugno (*J. Appl. Mech.* **69**: 854-856, 2002) have developed universal scaling laws for energy dissipation during the fragmentation of solids, by assuming a self-similar size distribution of fragments. It is interesting to note that, according to an interpretation based on their analysis, the exponent *p* should be strongly related to the fractal nature of cancer topology and thus susceptible of independent measurements. It could possibly also be applied for diagnostic purposes to mark the emergence of a functionally effective neo-angiogenetic structure.