B7x (also known as B7-H4 or B7S1) is a member of the B7 protein family that inhibits T-cell functions by binding to a hitherto unidentified receptor. The levels of the B7x mRNA are much higher in peripheral non-lymphoid organs than in their lymphoid counterparts, which is in marked contrast with the levels of mRNAs coding for the conventional B7 proteins B7–1 and B7–2. B7x is hardly detectable on the surface of immune cells but is expressed on epithelial cells and other cell types in non-lymphoid including the lung and pancreas. Therefore, B7x exhibits an unique expression pattern. This has important implications for the biological functions of the B7x signaling pathway.

The literature on B7x expression by human cancers and its links with clinical outcome has grown considerably. B7x is overexpressed by a variety of human neoplasms, including cancers of the brain, esophagus, lung, breast, pancreas, kidney, gut, skin, ovary and prostate. Furthermore, increased B7x expression levels in many cases correlate directly with disease outcome in cancer patents, until recently it was unclear whether such an association would be causative or merely correlative. Furthermore, the functions of B7x (be it expressed by malignant or stromal cells) in vivo, in the context of oncogenesis, tumor progression and response to therapy had not been elucidated. To address these issues, we took advantage of mice lacking the B7x-coding gene (Vtcn1−/−) and of 4T1 metastatic breast cancer cells (which do not express B7x) and investigated the effect of host B7x in tumor progression. Strikingly, 18 d after the intravenous injection of 4T1 cells, the average number of tumor nodules in the lungs of the wild-type (WT) mice was 9-fold higher than that of Vtcn1−/− animals. In addition, Vtcn1−/− mice exhibited an enhanced survival and memory responses that provided protection against a subsequent challenge with 4T1 cells.

Mechanistic experiments revealed an interesting link between B7x and myeloid-derived suppressor cells (MDSCs). T cells infiltrating neoplastic lesions in Vtcn1−/− mice were indeed more responsive to malignant cells as compared with those isolated from cancers growing in WT mice. These results are consistent with the notion that B7x functions as a T-cell co-inhibitor. In addition, tumors growing in Vtcn1−/− mice exhibited a markedly decreased infiltration by immunosuppressive cells, notably CD11b+GR-1+MDSCs. MDSCs represent a heterogeneous group of myeloid cells and are emerging as a major immunosuppressive force during tumor progression. We therefore took a closer look at the phenotype and functions of MDSCs in our model.

MDSCs can be divided into 2 cell subsets based on the expression of Ly6C and Ly6G: CD11b+Ly6G−Ly6Cchomingocytic MDSCs (g-MDSCs) and CD11b+Ly6G+Ly6Cstim monocytic MDSCs (m-MDSCs). We observed that g-MDSCs account for the majority of MDSCs infiltrating 4T1 lung metastases. To further characterize these g-MDSCs, we isolated them by FACS and found that they exhibit morphological features that are typical of neutrophils, including...
In summary, we have shown for the first time that B7x promotes cancer growth in vivo and that MDSCs express B7x receptor(s). Although the mechanisms whereby B7x functions as a protumorigenic factor and the precise identity of B7x receptor(s) remain to be elucidated, it is likely that B7x enables cancer cells to escape antitumor immunity by binding not only to immune effector cells (such as CD4+ and CD8+ T cells) but also to immunosuppressive cells (such as MDSCs) (Fig. 1). Therefore, targeting the B7x signaling pathway holds great promise for anticancer immunotherapy.

Disclosure of Potential Conflicts of Interest
No potential conflicts of interest were disclosed.
References

1. Zang X, Loke P, Kim J, Murphy K, Wairz R, Allison JP. B7x: a widely expressed B7 family member that inhibits T cell activation. Proc Natl Acad Sci U S A 2003; 100:10388-92; PMID:12920180; http://dx.doi.org/10.1073/pnas.1434299100

2. Sica GL, Choi IH, Zhu G, Tamada K, Wang SD, Tamura H, et al. B7-H4, a molecule of the B7 family, negatively regulates T cell immunity. Immunity 2003; 18:849-61; PMID:12818165; http://dx.doi.org/10.1016/S1074-7613(03)00152-3

3. Prasad DV, Richards S, Mai XM, Dong C. B7S1, a novel B7 family member that negatively regulates T cell activation. Immunity 2003; 18:863-73; PMID:12818166; http://dx.doi.org/10.1016/S1074-7613(03)00147-X

4. Wei J, Loke P, Zang X, Allison JP. Tissue-specific expression of B7x protects from CD4 T cell-mediated autoimmunity. J Exp Med 2011; 208:1683-94; PMID:21727190; http://dx.doi.org/10.1084/jem.20100639

5. Lee JS, Scandiuzzi L, Ray A, Wei J, Hofmeyer KA, Abadi YM, et al. B7x in the periphery abrogates pancreas-specific damage mediated by self-reactive CD8 T cells. J Immunol 2012; 189:4165-74; PMID:22972920; http://dx.doi.org/10.4049/jimmunol.1201241

6. Tringler B, Zhuo S, Pilkington G, Torkko KC, Singh M, Lucia MS, et al. B7-h4 is highly expressed in ductal and lobular breast cancer. Clin Cancer Res 2005; 11:1842-8; PMID:15756008; http://dx.doi.org/10.1158/1078-0432.CCR-04-1658

7. Hofmeyer KA, Scandiuzzi L, Ghosh K, Pirofski LA, Zang X. Tissue-expressed B7x affects the immune response to and outcome of lethal pulmonary infection. J Immunol 2012; 189:3054-63; PMID:22855708; http://dx.doi.org/10.4049/jimmunol.1200701

8. Barach YS, Lee JS, Zang X. T cell coinhibition in prostate cancer: new immune evasion pathways and emerging therapeutics. Trends Mol Med 2010; 17:47-55; PMID:20971039; http://dx.doi.org/10.1016/j. tmm.2010.09.006

9. Abadi YM, Jeon H, Ohaegbulam KC, Scandiuzzi L, Ghosh K, Hofmeyer KA, et al. Host b7x promotes pulmonary metastasis of breast cancer. J Immunol 2013; 190:5806-14; PMID:23455497; http://dx.doi.org/10.4049/jimmunol.1202439

10. Condamine T, Gambir D. Molecular mechanisms regulating myeloid-derived suppressor cell differentiation and function. Trends Immunol 2011; 32:19-25; PMID:21067974; http://dx.doi.org/10.1016/j. tir.2010.10.002