Driving cancers extinct - Translating the causes of species extinction into the extinction of tumor cell populations

Viola Walther

Cancer is defined as a disease in which abnormal cells divide without control. Further, they are able to invade other tissues (metastasis). When cells become damaged or changed they mutate, which influences normal cell division and growth. Then, cells do not die when they should and new cells are still produced, forming a cell tissue called a tumor. Tumors start from a single cell and conclude with billions of dangerous (malignant) cells that have accumulated mutations. It results in tumor heterogeneity, in which tumors consist of many different tumor subpopulations. The problem in cancer therapy has been to drive a heterogenic tumor extinct. Unfortunately, conventional chemotherapies often fail, because tumors evolve resistance and patients relapse with more resistant tumor cells that evolved from the cells that survived the therapy.
However, 99.9% of all species that have ever lived have gone extinct. We would like to achieve that level of success with tumor cell populations. In principle, driving a tumor extinct is analogous to driving a species extinct. In both phenomena, a genetic diverse population mutates and evolves through natural selection. This analogy suggests that there are lessons to be learned from paleontology. Under what conditions does a species go extinct? Can we replicate those conditions to improve and measure the characteristics for prognosis? Is there an analogy between the characteristics of species and tumors that make them resistant to extinction? Which causes of species extinction could be translated into cancer therapy? To answer these questions, we looked into the causes of species extinction and how we can translate this information to cause extinction in tumor cell populations.
There are two types of extinction: Background extinction, which is the normal rate of replacement of one species by another, and mass extinction, which is the extinction of large numbers of species during a relatively short period of geological time. From both mass and background extinction, causes of what drives species extinct could be derived. These include biotic factors, such as overexploitation, human overkill, invasive species, a lack of evolvability, and abiotic factors, such as habitat destruction and environmental changes. From the identified causes we derived general patterns: Extinction events were causes by more than one selective pressure, there were large rapid changes in the environment, the duration of environmental change covered many generations.
Paleontologists have found characteristics that make species go extinct. These are large body size, immobility, narrow geographic ranges, low/no dispersal potential, long generation times, and being a specialist. Measures of these features might be useful for tumor prognosis.
Moreover, I looked at parallels between the causes of species extinction and cancer therapies, aiming at finding analogies of what has already been done in cancer biology and take inspiration from paleontology for future directions of research. We have learned that we should apply different pressures by targeting the different microenvironments in a spatially heterogeneous tumor. Further, we should apply multiple pressures simultaneously, such as nutrient restriction, hyperthermia (treating tumors with heat), anti-angiogenesis agents to control for blood vessel growth, metronomic chemotherapy (long term chemotherapy at low doses with no drug-free breaks), as well as combinations of chemotherapies and radiation.

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Supervisor: Dr. Carlo C. Maley and Prof. Dr. Jacob Höglund