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# BIO-INSPIRED URBAN DESIGN: SMART GROWTH AND SUSTAINABLE DEVELOPMENT FRAMEWORKS FOR A NEW URBAN UNIT IN CRACOW

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**Abstract:** In March 2012, architects João Diniz (Brazil) and Dorota Wiśniewska (Poland) answered a call to competition from the City of Cracow, submitting an entry for the re-design of 5600 ha of the Nowa Huta district in eastern Cracow, focusing on economic revitalization within a framework of smart growth and sustainable development. The scenario included an ArcerolMittal Steelworks and incorporated a strong ecological analysis for the easternmost District in Cracow. Moreover the application of principles from the nature, called bionics, was considered as well, in the presented design.

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## 1. Assumptions

The area was mostly postindustrial but earmarked for redevelopment. The first step, to develop the project, was the analysis of the existing landscape, topography, heritage and previous development stages. The analysis was done to emphasis spatial links to Cracow Old Town and to smooth the borders and edges of new development. The ring around housing districts is similar to the *Planty* ring. The dense and multifunctional structure is similar to intensive urban structure of the Old Town. The design orientation on public transportation, linking the Old Town and new development area is also worth mentioning.

The revealing of the potential of the terrain was the main concern of the presented design. Learning from nature approach was the mostly desired in a proposal design. It was a kind of process, where local nature is a source of knowledge about optimal solutions as well as an inspiration. It was possible after a deep environmental analysis and after specification of a main features and connections of ecosystem.

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### 1.1. Ecological Corridors to protect

Krakow has strong ecological potential. It is possible to connect different kind of eco networks and let them function as corridors. The networks are: European, national: based on Nature 2000 areas, regional, local, water etc. The most important eco corridors on the area of competition are:

- *Vistula Valley* – a part of European network, *Nature 2000* network and Krakow ecological stability network
- *Potok Kościelnicki Valley* – the main regional corridor on the terrain of study. In the southern part it is connected to Vistula Corridor.
- *Dłubnia Valley* – the regional eco-corridor at the border of the study area. While the S7 route is located at the axis of the corridor it is needed to consider the eco- paths and sound way protection. In the southern part it is connected to Vistula Corridor.
- Centres of biotic diversity with the function of ecological corridors are also protected. The centres are: Branice and Kościelniki mansion and parks complex, Vistula Island with allotment gardens in Przewóz, Sediment tanks in Kujawy, gravel pits in Przyłasek Rusiecki and Wolica

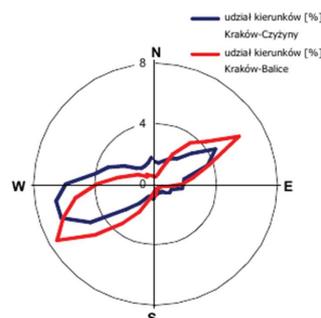


Fig. 1. Wind direction (Regional Inspectorate for Environmental Protection in Krakow 2006).

### 1.2. Landscape points as a heritage

The landscape points are the heights points on the terrain.

- *Wanda Mound* – the highest elevation in the vicinity is about 14 meters tall and 45 meters wide at the foot, surrounded by greenery complex. Dates back to the 7th – 8th century.
- *'Mogila' Fort* – in the 19th century some areas of the present District XVIII were incorporated in the Krakow Fortress and an element of the third ring of fortifications of the Krakow Fortress was built in the years 1895-96; The fort's task was to protect the foreground of the *Wanda* rampart and to control the Vistula River.

### 1.3. Climate as a design factor

Firstly, the main features of ecosystem were described by climate specification and differences. The climate is typical for tepid latitudes and has four seasons. The most concerned issue was the wind blow direction (Figure 1), number of rainfall and snowfall, evaporation cycles, an annual number of sunny days, and a daily change in and average maximum and minimum temperature.



Tab. 1. Maxi–Maxi Strategy based on a municipality’s documents (Kraków City 2005b, Kraków City 2010).

	<p style="text-align: center;"><b>External Opportunities(O):</b></p> <ul style="list-style-type: none"> <li>• European water rout on Vistula</li> <li>• European Funds</li> <li>• Close connection to other important European cities</li> <li>• European force for sustainable development</li> </ul>	<p style="text-align: center;"><b>External Threats (T):</b></p> <ul style="list-style-type: none"> <li>• Economy crisis</li> <li>• Future demography crisis</li> <li>• Lower EU funds</li> <li>• Low range of the city in a global word</li> </ul>
<p style="text-align: center;"><b>Internal Strengths(S):</b></p> <ul style="list-style-type: none"> <li>• Heritage</li> <li>• Tourism base</li> <li>• Knowledge base</li> <li>• Landscape</li> </ul>	<p style="text-align: center;"><b>SO "Maxi-Maxi" Strategy:</b></p> <p style="text-align: center;">Strategies that use strengths to maximize opportunities.</p> <p style="text-align: center;"><b>Integrated Urban Cells (SD+SG)</b></p>	<p style="text-align: center;"><b>ST "Maxi-Mini" Strategy:</b></p> <p style="text-align: center;">Strategies that use strengths to minimize threats.</p> <p style="text-align: center;"><b>Preservation of heritage and landscape</b></p>
<p style="text-align: center;"><b>Internal Weaknesses (W):</b></p> <ul style="list-style-type: none"> <li>• Medium business strength</li> <li>• Not enough advertising</li> <li>• Lack of green technologies</li> <li>• Lack of green grids based on metropolitan policy</li> </ul>	<p style="text-align: center;"><b>WO "Mini-Maxi" Strategy</b></p> <p style="text-align: center;">Strategies that minimize weaknesses by taking advantage of opportunities.</p> <p style="text-align: center;"><b>Slow growth with landscape preservation within sustainable development framework.</b></p>	<p style="text-align: center;"><b>WT "Mini-Mini" Strategy</b></p> <p style="text-align: center;">Strategies that minimize weaknesses and avoid threats.</p> <p style="text-align: center;"><b>Advertisement for foreign business</b></p>

#### 1.4. Strategy for bio-inspired urban design

The basis of the strategy was found after the research about socio – economic situation of an area. The postindustrial district suffers a lot of troubles like: lack of employment, lack of habitants with high education skills, lack of recreation facilities. The economic situation influences on the design of multifunctional settlements, recreation parks and good public communication together with bike ways as well as large business centre with retail and public utility area with exhibition hall. The design is called *Macroscop Cracow*. The strategy to create *IUC (Integrated Urban Cell)* structures, as a visual representation of *Macroscop* project, is described in Table 1.



## 2. Bio-inspired urban design: form, function and more

The science dealing with the application of principles from the nature in the many different products is called *bionics*<sup>1</sup>. In *Macroscope Cracow*, the bionic research work is implemented in an urban scale. The inspiration by nature is seen in an organic form of buildings (biomorphism) and in a new functional organization of a district (bionic aspect). The project resembles the *Circulatory* system and cell structure. The idea of *Macroscope Cracow* is a development of *Microcosm*<sup>2</sup> concept proposed by Leonardo da Vinci. In the *Macroscope* project, the aspect of the contemporary technology was added.

The area defined as Nova Huta of the future, according to *Macroscope Cracow* project, will be a demonstration of the positive possibility of living, connecting a middle dense city to nature, agriculture, health, culture celebration, work and leisure. The large range of a terrain will become a biologically active area to preserve the natural ecosystem features. This new urban area will be designed and grow in a bionic way considering and protecting the already existing village structures, and emphasizing the heritage of important natural points (like *Wanda Hill*). It will come from the existing industrial, agricultural and semi urban fabric, defining a new layer constructed and developed as new livable cells, named *Integrated Urban Cell* in a contemporary *macroscopic* view of the 21st century city's district named *Integrated Urban Structure (IUS)*. Those new cells will be created by different size complex spots with a multi-functional centre, sharing services, living places, cultural and educational equipment, commerce and workplaces.

All the area will be designed with a consideration of low energy concepts like solar energy and solar buildings' orientation, water recycling, together with a green roofs system with urban agriculture, electric public transportation, walkable and cyclable urban areas, usage of low energy and recycled materials. The two housing cell modules (*IUCs*) are round with diameter of 350 m and 500 m. Each has its own multifunctional centre with public services like school, health centre and shops. The idea of *Venice Transportation Model* is transformed to circular. The circulation will be made in two levels. First level is low speed roads as a ring on the border of the *IUC* with parking lot looking like a ring around *IUC* some concentric access roads for emergency and public services vehicles. Second level is walkable/cyclable paths. The round *Integrated Urban Cells* are connected with a number of bike paths and lower number of roads. The roads capacity increases near public buildings and more intensive development of *Green Towers*<sup>3</sup> business district, located in postindustrial area. The industrial site is located a short walk from a diversity of transportation

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<sup>1</sup>Bionics refers to implementation of solutions seen in nature, to the design; observation of biological systems and processes influences the form (structure) and function of a design as well as can be an inspiration for a process or a method.

<sup>2</sup>In *Microcosm* concept, the design should be based on nature approach while a human being is a miniature of whole Earth ecosystem. That is why mirroring the nature helps to keep the human being in a good shape and health. This approach is strictly connected to human aspects of design and design based on connection to nature. It was deeply discussed in Renaissance.

<sup>3</sup>The three proposed *Green Towers* grow from shared lower floors; higher level walkways connect upper functions. The lower functions include a retail centre, a sport and education centre, and a conference hall and exhibition area; office areas comprise the physically separated upper structures. The towers each contain an atrium and green roof, providing publicly accessible new green spaces to all visitors.



nodes, as well as from the *Special Economic Zone* and its *Technology Incubator*. Thus, mutual cooperation opportunities will strengthen these related entities' public events, exhibitions and conferences. In this new urban area the constructions will be an extension of the natural and agricultural landscape having a proper mimetic with the existing surrounding appearing as living urban hills.



Fig. 2. From Brownfields into the Greenfields: Infill development strategy for investment area; the *IUC* is shown on top and towers in business district on the bottom.

### 3. Smart growth and sustainable development frameworks

The *Smart Growth* and *Sustainable Development* frameworks are combined in an *Integrated Urban Cell* idea. The bio-inspired urban design is an answer for the smart and green way of development. The *Green Towers* are inspired by *meiosis* process<sup>4</sup> and the *Integrated Urban Cells* together with a transportation system is inspired by Circulatory system. All together can be the answer for rational growth considering ecology and socio-economic aspects of city development.

<sup>4</sup>A type of cellular reproduction, in which crossing over occur, shaping a new form combined of two source genetic codes; this concept was chosen to emphasis that biodiversity seen in nature can be transposed to multifunctional urban structure



Tab. 2. The evaluation to enable, encourage and qualify the implementation of presented policies.

Scale	Policy	Sustainable Development	Smart Growth
Regional	Mobile nodes and corridors		+
	Ecological Corridors	+	
	Social cohesion	+	+
	Special district	+	+
	Affordable housing	+	+
	Smart energy grids		+
	Technology parks	+	
	Innovation		+
District	Destination needs	low	medium
	Green energy production		+
	<b>Effective Parking</b>	+	+
	Community Unit	+	
	<b>Design Speed</b>	low	medium
	<b>Pedestrian Shed</b>	+	
	Public spaces		+
	Mixed use	+	+
Block	Infill development	+	+
	Base density	low and medium	medium and high
	<b>Design Speed</b>	low	medium
	Mobility	low	many transportation nodes
Brownfields (re)development	Landscape	accessible for pedestrians in 10 minutes	accessible by public transportation
		+	+

Table 2 shows the role of the new design patterns in different urban scales: from regional to the urban block and also explains, how those patterns based on the knowledge of sustainable development and smart growth contribute to the project. The study shows the influence of a regional planning on the urban block as well as opposite process where small changes in an urban block are the regional changes. The concept of *Integrated Urban Cell* is described in Figure 1.



## 4. Summary

The retention and use of existing natural and built features can give a sense of maturity and of individual place. In the *Macroscope* project this sense is given by a connection of landscape and heritage, based on the form and a Celtic origin of *Wanda Hill*. That is why the *Macroscope Cracow* shows the ranges of issues involved retaining landscape features, enhancing biodiversity, maintaining historic buildings and their setting, and using *Sustainable Urban Systems* and *Smart Growth* idea.

The method used in the presented design is called biology influencing design. Deep, multilayered analysis for the purposes of the project, considering features of the natural environment, helped to prepare a complex, bionic urban design. Inspired by nature and an organization of human body cycles, the design allows preserve the harmony between constructed and existed environment, balance the existing obsolete development and start a health process of urban renewal and pollution reduction, as well as shows how to decrease the unnecessary energy consumption.

The ability to live with a feeling of comfort and safety in the residential area is an essential component of sustainable communities. Local parks are located to be within not more than 10 minutes' walk of the majority of homes in the area. The building's greenery, bionic form, and intelligent technology solutions will increase its attractiveness to investors, inhabitants and visitors. This is a huge advance toward changing the image of Nowa Huta. This district is combination of structural and visual biomimetism with high consideration of climatic approach.

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Fig. 3. *IUC* as an answer for the proposed policies.