The French Plan for Genomic Medicine 2025

In 2016, to prepare for the deployment of genome sequencing as a routine technology in healthcare, the French State launched a plan entitled Genomic Medicine France 2025. Genopole was among the architects of this plan, the objective of which is to organize the various public and private participants for the creation of a French genomic medicine sector. Cancers, often-misdiagnosed rare diseases, and chronic conditions such as diabetes are the priority targets of the plan. Genopole's Évry campus will be home to CRefIX (CEA - Inria - Inserm), the center of reference, innovation, expertise and transfer. CRefIX will be responsible for harmonizing procedures across the 12 high throughput sequencing facilities envisioned by the plan. Two facilities have already been opened, including the Paris Région platform SeqOIA (Sequencing, Omics, Information Analysis), which chose the Genopole company IntegraGen for the implementation of its pilot projects.

The computational challenge of genomics

Although sequencing costs and delays have been greatly reduced by the continuing advances in instrumentation, the analysis and storage of the phenomenal quantity of generated data remains a challenge in genomics. The simple interpretation of a sequence represents sometimes millions of raw data. Sequencing data is not only voluminous but also heterogeneous, reflecting the complexity of genomes. Indeed, at the most, only about 10% of these latter are genes. The remaining 90%, comprising «non-coding DNA», is a disparate series of still-mysterious sequences, that, nonetheless, are worth exploring: every day, genomics research adds new evidence of their role in controlling gene expression. Thus, genomics needs not only biologists but also mathematicians and bioinformaticians capable of inventing new tools (statistical methods, algorithms, etc.) for identifying genes, interpreting intraspecies variations, elucidating the role of non-coding DNA or sequence repetitions and much more. Biomathematics and bioinformatics are an integral part of Genopole's strategic orientations and the biocluster already benefits from the presence of such key players as the Évry Mathematics and Modeling Laboratory (LaMME) and the Informatics, Bioinformatics and Complex Systems Laboratory (Ibisc).

The Tara Oceans Expedition

Metagenomics is bringing the great explorers back to study entire but still unknown ecosystems. Case in point, the schooner Tara took to the seas in 2009 and spent three years collecting 35,000 samples of marine plankton. These microscopic organisms represent the first link in the food chain of the earth's oceans, produce half of the oxygen we breathe and participate in maintaining climatic stability. To decipher their collective genome, the Tara Oceans Expedition called upon Genoscope's sequencing capacities. The initial analyses have revealed unimaginable genetic diversity: no less than 117 million genes have been identified, with more than half of them supplying yet unknown functions!

When genes become treatments

Gene therapy builds upon knowledge of DNA abnormalities that cause disease. Treatment involves furnishing the affected cell with a functional gene to compensate for the dysfunctional one. At G to either silence, replace or enopole, gene therapy is advancing decisively thanks to pioneering research at its internationally-statured laboratories Généthon and Integrare. Today, these labs are reaching major milestones in clinical trials and presenting their first successes for rare genetic diseases. Human trials are underway in the settings of immune deficiency, neuromuscular disease, liver disease and vision disorders. Gene therapies will also bring progress to more frequent pathologies such as cancer, cardiovascular disease, inflammatory disease and more.

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Genopole thanks its members:

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INNOVATION TODAY, EVERY DAY

Building a genomics sector at Genopole

Some of the links in the value chain:
laboratories, businesses and technological platforms

SUPPLIERS/ SERVICES
- **GENOSAFE:** quality and safety of innovative therapies
- **NEW ENGLAND BIOLABS:** reagents
- **TEXCELL:** viral safety tests

SEQUENCING TECHNOLOGIES
- **ILLUMINA:** high throughput sequencers

SEQUENCING/ GENOME EXPLORATION
- **CNRGH:** human diseases
- **EPGV:** research in plant genome polymorphisms
- **GENOSCOPE:** biodiversity, environment
- **INTEGRAGEN:** analyses and diagnostics

FUNCTIONAL EXPLORATION
- **CERITD:** diabetes
- **GENHOTEL:** rheumatoid arthritis and complex diseases
- **LGRK:** cutaneous stem cells
- **METABOLIC GENOMICS:** diversity and chemistry of life

ANALYSES TOOLS
- **EVRYRNA:** tools for the study of non-coding RNA
- **GENOSPLICE TECHNOLOGY:** services in bioinformatics
- **IBISC:** research in bioinformatics
- **LAMME:** mathematical and statisical tools
- **MICROSCOPE:** bacterial metabolism
- **TRAASER:** software solutions

DEVELOPMENT/ INNOVATION
- **ABOLIS BIOTECHNOLOGIES:** bioproduction of molecules for industry
- **ALGENTECH:** plant genome editing
- **ART-TG:** accelerator of research technologies for genomics-based therapies
- **ENTEROME:** intestinal microbiota and new medicines
- **EUKARYS:** gene therapies for liver diseases
- **GENÉTHON:** gene therapies for neuromuscular diseases
- **INTEGRARE:** gene therapies for rare diseases

PRODUCTION/ INDUSTRIALIZATION
- **ANOVA-PLUS, AGDIA EMEA:** diagnostics for crop diseases
- **ENALEES:** veterinary diagnostics
- **GLOBAL BIOENERGIES:** biological production of hydrocarbons
- **PHARMING:** production of recombinant proteins
- **PYMABS:** plant-based production of proteins
- **WIRATECH:** medical diagnostics
- **YPOSKESI:** production of gene therapies

Training

UNIVERSITY OF ÉVRY - PARIS-SACLAY:
- Master's in life sciences and health:
  M2 Biotherapies - M2 Systems & Synthetic Biology
- Bachelor's in life sciences and informatics
- Master's in bio-informatics: M2 Geniomhe - M2 Data Sciences

ILLUMINA: training for sequencing technologies

GENOPOLE: Summer School:
Bioinformatics and biostatistical tools in medical genomics

Groupe IMT:
careers in bioproduction for the cosmetics and pharmaceutical industries

Genopole: an ecosystem to speed progress in bio-technology

Genopole is unique in France. Located at Évry-Courcouronnes, within the greater Paris area, it unites academic research laboratories, innovative businesses, university-level training programs and a hospital. As France's leading biocluster, Genopole valorizes life sciences in all the sectors concerned by it: health and healthcare, food & agriculture, industry, the environment, etc.

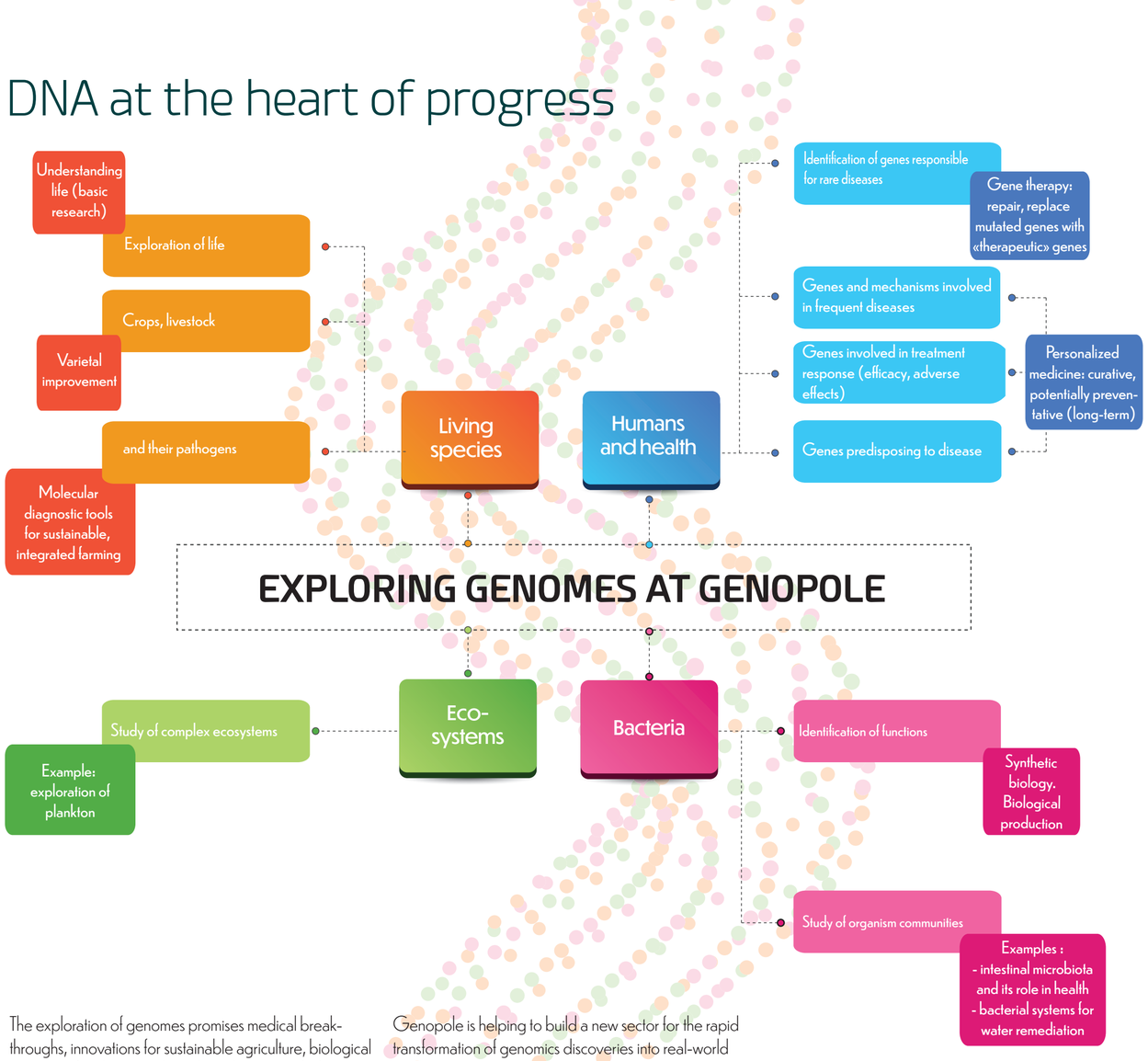
GENOMICS STUDIES THE ENTIRE DNA OF AN ORGANISM: ITS «GENOME»

The first step in genomics, called «sequencing» is to decode, for each chromosome, the specific order of the four molecules composing DNA: adenine (A), thymine (T), guanine (G) and cytosine (C). The second step, called «functional genomics», is to explore the resulting sequence with the goal of identifying the functional units, called genes, and determine their roles.

A biocluster built upon world-renowned discoveries in genomics

In 2000, Genoscope made a name for itself by stating that the human genome counted at most 30,000 genes. That prediction, founded on the study of the genome of a small tropical fish, went against the estimations made up to that time— but proved to be true. Genoscope participated in the international Human Genome Project and published the sequence for chromosome 14 in 2001. Since those early days, Genopole takes pride in having sequencing capacities among the most important in Europe. The National Center of Human Genomics Research (CNRGH) specializes in the exploration of the human genome to better understand diseases, whereas Genoscope focuses on the genomes of plants (wheat, etc.), animals (Anopheles mosquitos, etc.) and microorganisms.

DNA at the heart of progress

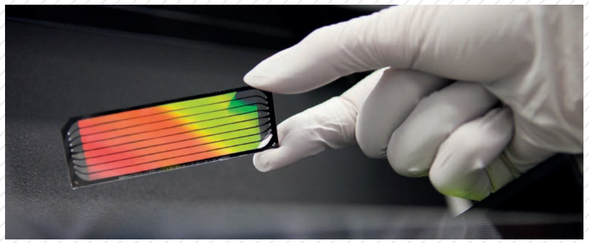


The exploration of genomes promises medical breakthroughs, innovations for sustainable agriculture, biological processes for cleaner industrial production, and a better understanding—and thus better protection—of ecosystems.

Genopole is helping to build a new sector for the rapid transformation of genomics discoveries into real-world applications.

Genomics scales up!

Today's high throughput sequencers create considerable quantities of genomics data. Thousands of genomes have been decoded, those of microorganisms, plants and animals alike. Genomics specialists and bioinformaticians are meeting the challenge of interpreting these sometimes immense sequences and progressively unveiling their secrets. By sounding the very essence of life, genomics gives basic research new keys for understanding. Genomics can detect organisms invisible to all other methods of observation. Perhaps even more impressively, with a single analysis, it can reveal the DNA of communities of organisms in their natural environments. In that manner, genomics shines light on complex ecosystems and discovers new species in diverse environments: water, soil, or even the human body (the intestinal microbiota for example).



Genomics: soon a part of our daily lives

We are beginning to discover what the world of bacteria has to offer. Although large swaths of bacterial metabolism remain a mystery, their genomes are already revealing genes that supply functions useful for human activity. One of the major promises of genomics is to replace synthetic chemistry with biologically-based molecular production via enzymes or microorganisms. Similarly, the sequencing of the plants and animals we eat will contribute to increasing the sustainability of farming. Crop breeders in particular will use the fine understanding of genetic potential brought by genomics to create varieties better suited to climate changes and more resistant to diseases, reducing thus the need for irrigation and fungicides, for example. Farmers will be able to optimize pesticide use thanks to innovative tools for pathogen detection. Nearly all of a sequenced genome will be shared across a species, but a fraction of it—about 0.1%—is specific to the individual. That fraction results from mutations and gives individual features, but it may also prove dysfunctional. Medical genomics describes close to 8,000 rare human genetic diseases, and every day brings its lot of genes newly identified as playing a role in them. Resultantly, the field of gene therapies is reporting its first clinical successes for these heretofore incurable diseases. Although frequent diseases have complex causes partially tied to modern lifestyles, our genome can nonetheless predispose us to them. The identification of genes implemented in human pathologies will provide new highly-pertinent targets for the development of novel and better-performing treatments and diagnostics. By bringing together knowledge on the mechanisms of disease and the genes that condition any one patient's response to treatment, genomics will provide new means for personalized therapeutics.

In the long-term, genomics may even be able to predict a patient's susceptibility to disease. Medicine is thus becoming «precise.»