Why DYNALIFE?

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Main challenge of DYNALIFE

The main scope of DYNALIFE is to turn the conceptual, qualitative metaphor of information in the biological sciences into a quantitative holistic view that encompasses the different kinds of biological information and their dynamical exchange mechanisms.

The ultimate challenge is to produce a sound rationale for the development of a quantitative theoretical biology informed by results and methods arising from the hard sciences.

WHY DYNALIFE? VENICE 2023

80, 70, 20 Conference: (Historical Introduction)

Towards Excellence and Convergence Research in Theoretical Biology

Dates: May 2 - 4, 2023

Venue: Aula Magna of the Ca Foscari University, Ca' Dolfin, Venice, Italy

COST Action CA21169

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Funded by the European Union

Historical Introduction, 80, 70, 20,
before -80

Gregor Mendel
Rigorous mathematical analysis of the experiments designed and performed by himself

Versuche über Pflanzen-Hybriden
Brno, 1866

"My scientific studies have afforded me great gratification; and I'm convinced that it will not be long before the whole world acknowledges the results of my work."

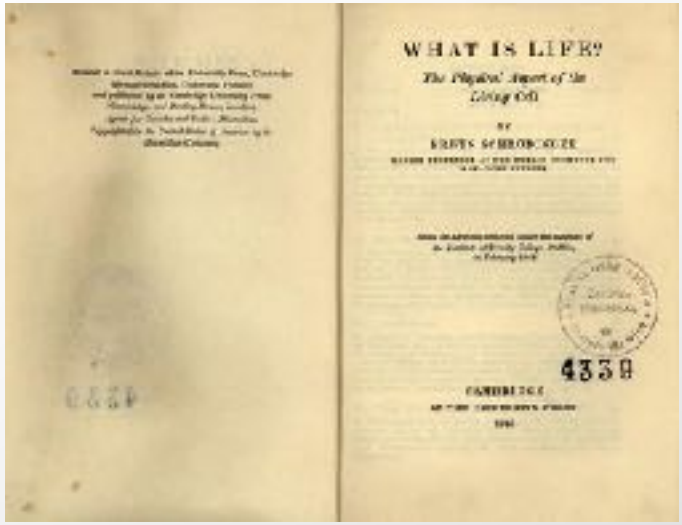
Hugo de Vries
Carl Erich Correns
Erich von Tschermak

1900, 34 years after Mendel's publication

Historical Introduction, 80, 70, 20, -80

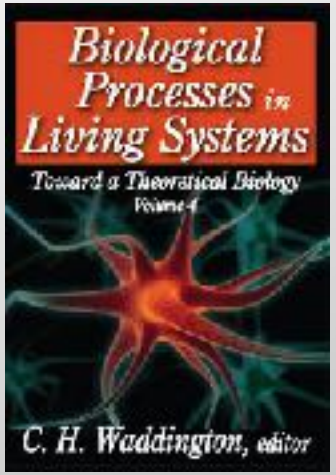
Erwin Schrödinger

Nobel Prize 1933
Pioneer of Quantum Mechanics
What is life?
The Physical Aspect of the Living Cell (Cambridge, 1944)
*This book contains lectures given by Schrödinger in 1943, **80 years ago**, where he introduces the idea of an "aperiodic crystal" containing genetic information in covalent chemical bonds.*
This idea anticipated by 10 years the discovery of the double helix structure of DNA.



Conrad Hal Waddington

Developmental biologist, palaeontologist, geneticist, embryologist and philosopher
*Pioneer of systems biology and epigenetics; he invented that term **80 years ago***
He was the editor of:
Towards a Theoretical Biology 4 vols.
Edinburgh 1968-1972.



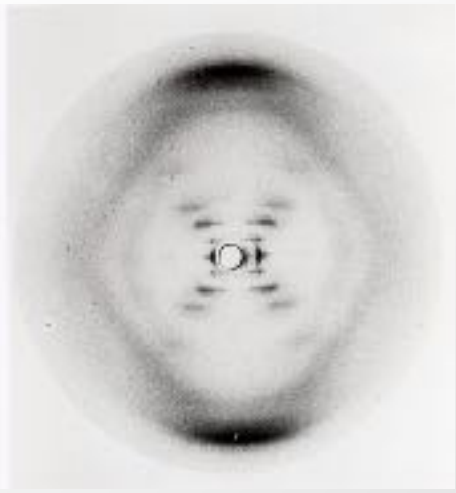
Bellagio Center, Villa Serbelloni

Rockefeller Foundation

These volumes were the proceedings of four International Union of Biological Sciences (IUBS) meetings that Waddington organized in the late 1960s and early 1970s at the Villa Serbelloni in Bellagio, Italy, on Lake Como.

Historical Introduction, 80, 70, 20, -70

James Watson and Francis Crick
Nobel Prizes
Discovery of the double helix
Structure of DNA
Nature, 171, 737–738 (1953)



Rosalind Franklin and Maurice Wilkins
DNA analysis by X-ray diffraction

George Gamow
Proposer of the Big Bang theory
(hypothesis about the genetic code)

Max Delbruk
Salvatore Luria
Nobel Prizes

Giorgio Parisi
Nobel Prize
Statistical Physics and Biology

After changing their research fields, they worked in the same way as other biologists and used their physics training to a reduced extent.

Historical Introduction, 80, 70, 20, -70

Stanley Lloyd Miller and Harold Clayton Urey
Nobel Prize
Famous experiment of Miller-Urey on the synthesis of amino acids in a primitive ocean-atmosphere

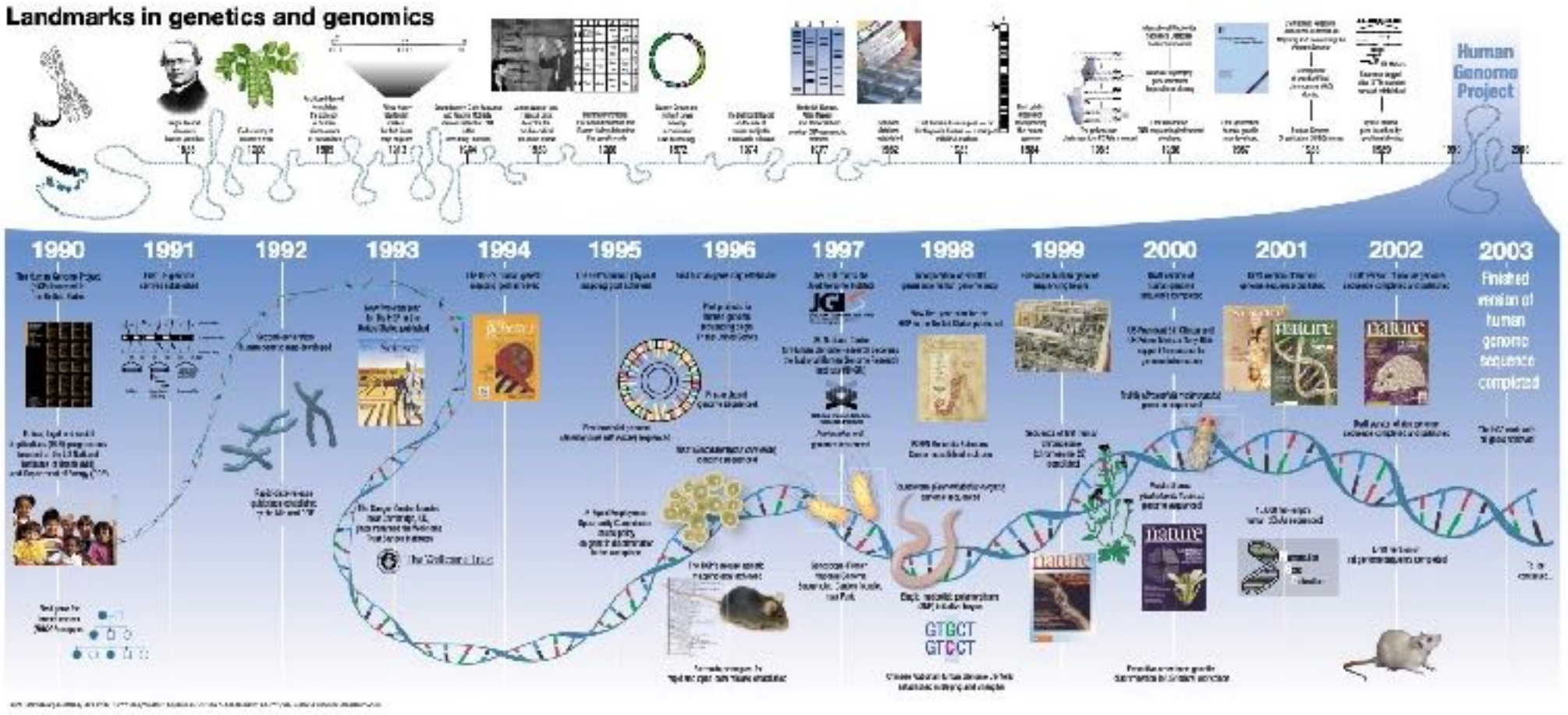
Science, **117** (3046): 528–9 (1953)

In the years that elapsed between the discovery of the double helix structure of DNA and the elucidation of the genetic code, molecular biology is established and affirmed; a path that walks away from theoretical arguments coming from physics and mathematics is followed.

A final sprint is represented by the race for sequencing the human genome and the consequent development of sequencing technology.

Former proposals for developing a theoretical biology informed in the hard sciences fail, including the monumental work of Waddington that extends for many decades and continues until the 1970's.

Historical Introduction, 80, 70, 20, -20



Historical Introduction, 80, 70, 20, -20

Where we are?

Strong hyping of the human genome project

2000: US President **Bill Clinton**
echoing opinions such as that of Francis Collins, head of the National Human Genome Research Institute:

the Genome Project would revolutionize the diagnosis, prevention, and treatment of most, if not all, human diseases

2003 First version of the "complete" human genome

2010: **Stephen S. Hall**
(Revolution Postponed, Scientific American, Oct. 2010, 60-67)

"the human genome project has failed so far to produce the medical miracles that scientists promised. Biologists are now divided over what, if anything, went wrong - and what needs to happen next."

Present Situation (1)

Big data and the necessity of a new Theoretical Biology

Sidney Brenner
Nobel Prize

Pioneer of Molecular Biology

Nobel Prize Lecture
2002

“We are all conscious today that we are drowning in a sea of data and starving for knowledge.

The biological sciences have exploded, largely through our unprecedented power to accumulate descriptive facts. How to understanding genomes and how to use them is going to be a central task of our research for the future.

We need to turn data into knowledge and we need a framework to do it.”

DYNALIFE VENICE 2023

80, 70, 20 Conference: (Historical Introduction)
Towards Excellence and Convergence Research in Theoretical Biology (Strategy to face difficulties taking profit of the opportunities)

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Present Situation (2)
Bottlenecks and opportunities

The situation is very similar to that of the physical sciences at the end of the 19th and beginning of the 20th century, many experimental results needed to be placed in a theoretical framework. The enormous theoretical effort produced in the physical sciences in these years led to the development of quantum mechanics and the theory of relativity; these theories produced a revolution in our understanding of the material world.

But we have seen that analogous proposals for the biological sciences failed, why our proposal should be successful?

1.Because there are recent successful examples; recently, Giorgio Parisi obtained the Nobel Prize for the application of the paradigm of statistical mechanics to complex systems, including biological ones.

2.Because the rapid evolution of different disciplines that are bringing new elements for the interpretation of life processes. A few examples are:

- **INFORMATION THEORY** (Starting in the 40's **Physical meaning of information, quantum information**)
- **THEORY OF DYNAMICAL SYSTEMS** (Starting (practically) in the 70's **Deterministic complexity**)

3.Because the bottleneck of big data urgently call for alternative approaches in the interpretation and management of biological data

Bottlenecks and Opportunities

Key practical problems and strategy for coping with them

Problem 1: molecular biologists don't read theoretical papers!
theoretical articles find publication opportunities almost exclusively in journals of secondary interest for molecular biologists.

Strategy 1: to create interest in theoretical publications on the scientific community of molecular biology. DYNALIFE can promote this aspect thanks to the creation of a pan-European net which can, in the best sense of the word, implement also lobbying actions with this scope (examples: position papers, thematic issues, special sessions, etc.) Also **excellence** of theoretical contributions need to be enhanced and publication in high impact biological journals encouraged.

Problem 2: theoretical models are often published for theorists, not for biologists; biological interpretations are often weak and the presentation does not favour the dialogue between disciplines.

Strategy 2: **interdisciplinary dialogue**, **biological interpretation** of results through the use of existing biological data, and/or computational models, and/or new experiments, needs to be strongly encouraged. **Testing** of models together with the development of **holistic** views, will need to be also highly encouraged, together with **strong outreach actions.**

EXPECTATIONS

Within DYNALIFE there are individual researchers and groups working across Europe that have produced and are producing **excellent theoretical models and non-deterministic models** including AI and Machine learning. Moreover a relevant **expertise in biological data management and exploitation**, **interdisciplinary research** at the borders of different disciplines together with expertise in **outreach and scientific communication** are also widely present in the Action.

The potential impact of the Action goes well beyond scientific matters, and should produce true revolutions in areas with **strong social repercussions**, not only medicine and biotechnology. For this reason DYNALIFE needs to cope from the beginning with a **trans-disciplinary** dialogue that ends with society, a subject that is now being called **convergence research**.

The Action needs also to be affirmed and reinforced in the next future by creating a scientific humus that necessary will offer the **opportunity to young researchers of being formed in this promising field.**

CONCLUSION

key words that represent a starting point for Dynalife

CONVERGENCE RESEARCH

EXCELLENCE

BIG DATA AND COMPUTER SCIENCE FOR IMPROVING CONCEPTUAL ADVANCE

KNOWLEDGE EXCHANGE AND INTEGRATION

OPPORTUNITIES FOR THE FORMATION OF YOUNG RESEARCHERS

CONSTANT INTERDISCIPLINARY DIALOGUE AND STRONG DISSEMINATION OF RESULTS

Please join us in Dynalife!

for details see COST Action CA21169 DYNALIFE

https://www.cost.eu/actions/CA21169/