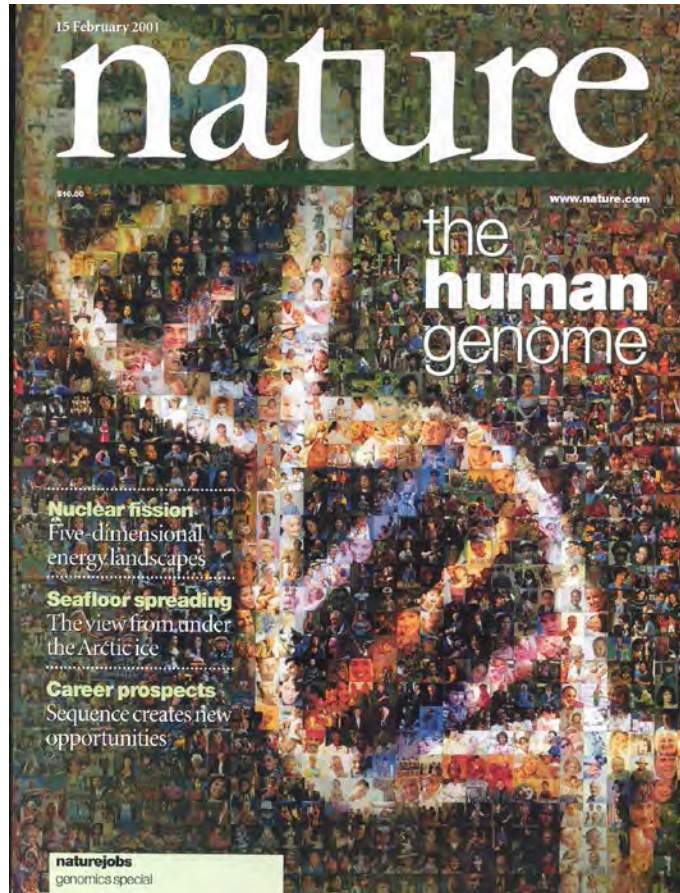
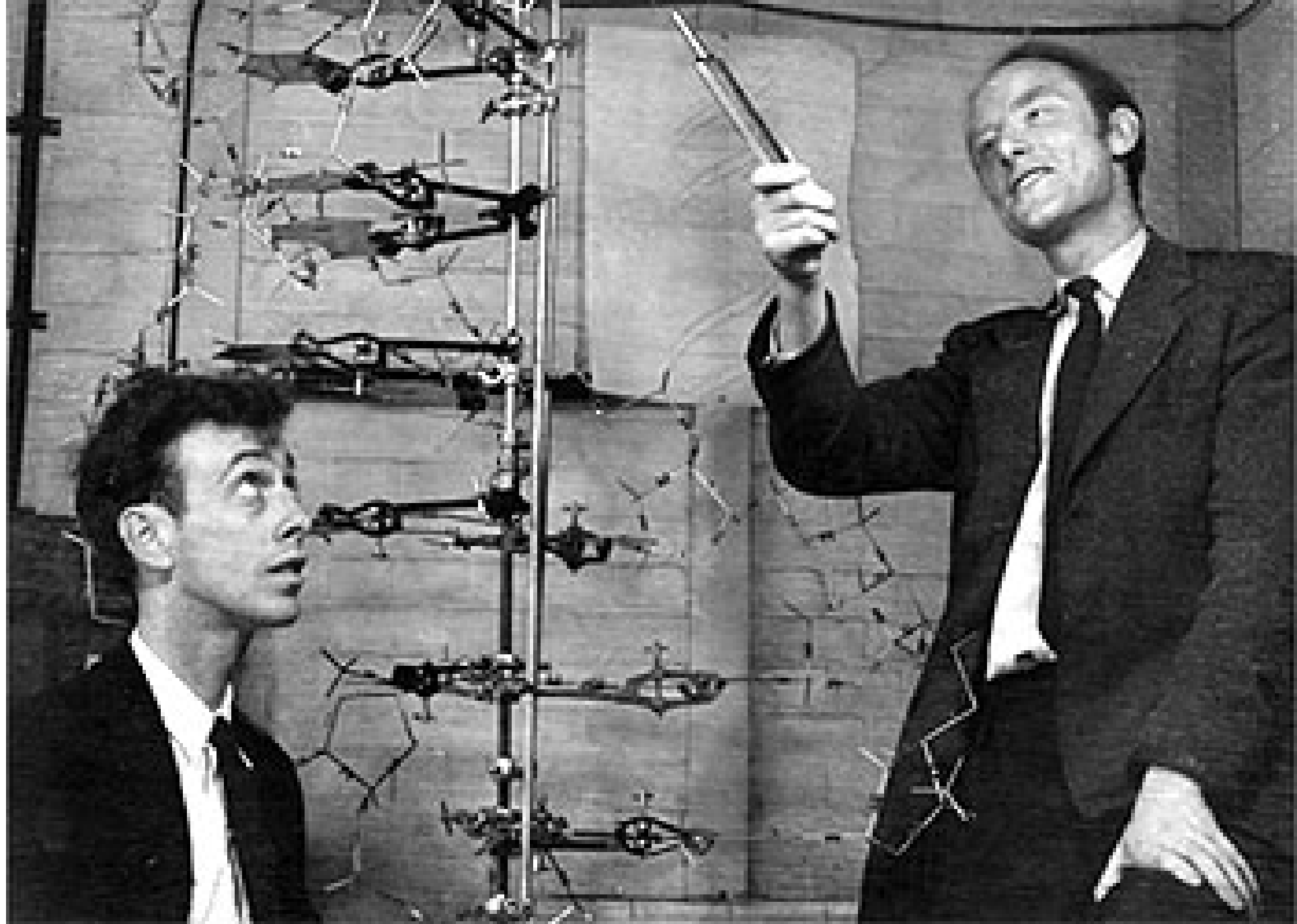


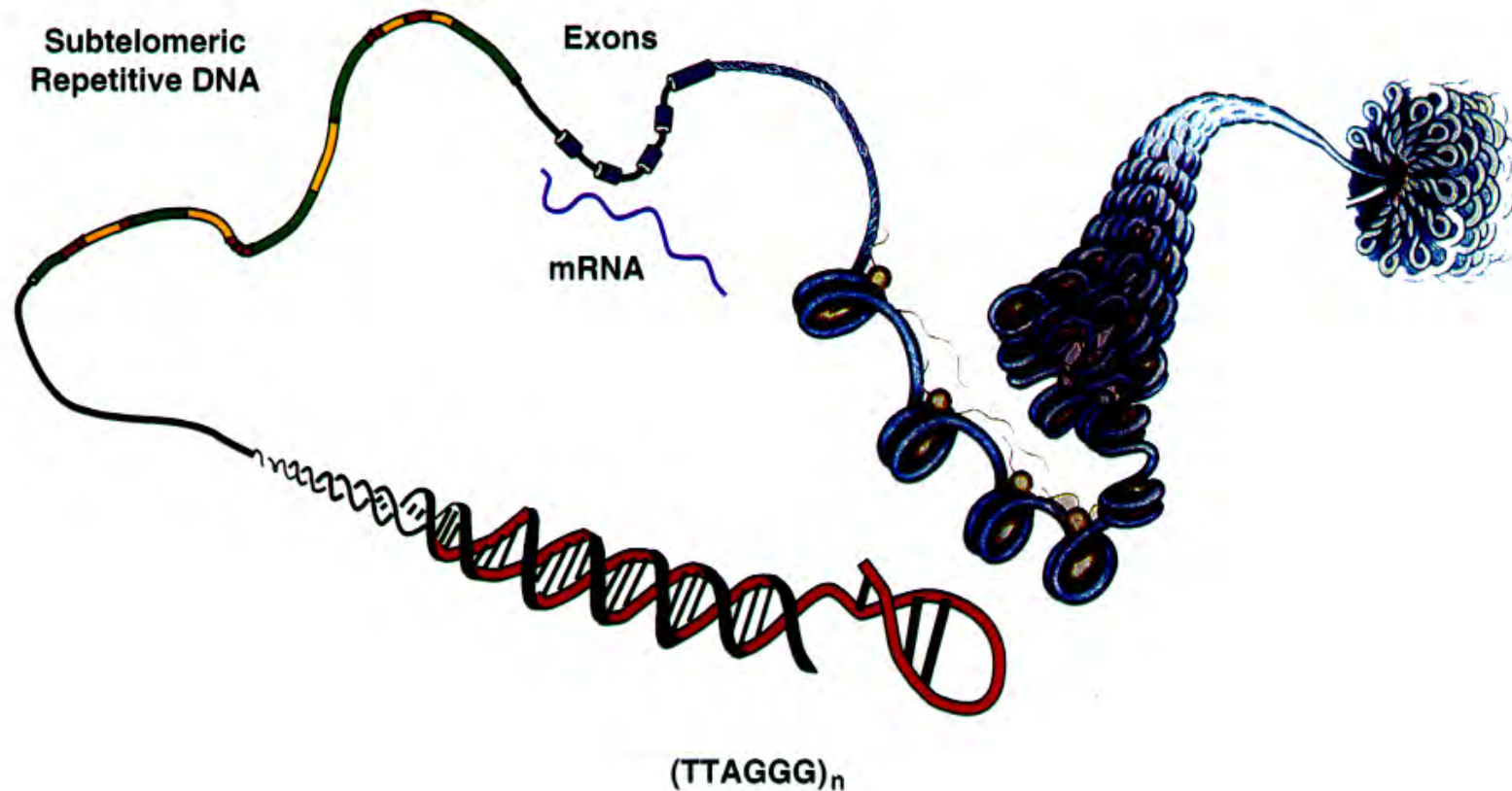
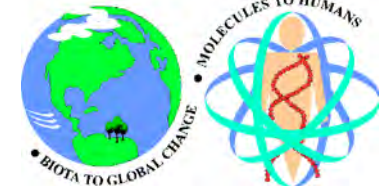
# *The Promise and Challenges of the Human Genome Program*



**Aristides Patrinos**



# Human Genome Project: A Scientific Revolution



Sequence the 3.1647 billion base pairs of human DNA and identify the ~26,000 genes contained in the human genome

# First Genome Sequenced 1995

25 thousand sequences

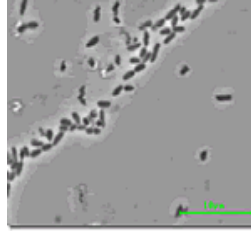
$6.25 \times 10^8$  pair wise comparisons



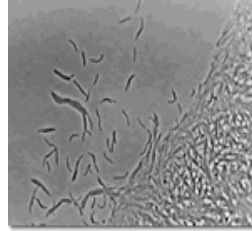
*“so we should venture on the study of every kind of animal without distaste; for each and all will reveal to us something natural and something beautiful.”*

Aristotle’s “On the Parts of Animals”

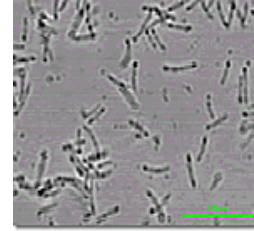
# Microbial Genomes



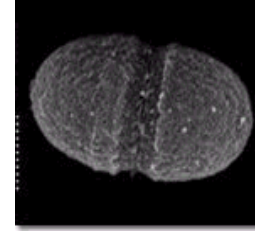
*Burkholderia cepacia*



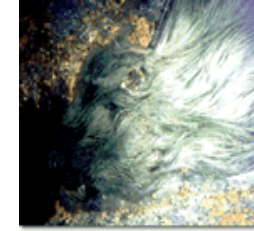
*Cytophaga hutchinsonii*



*Desulfitobacterium halfniense*



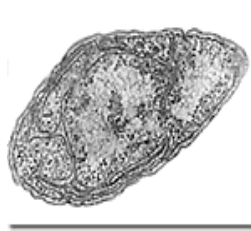
*Enterococcus faecium*



*Ferroplasma acidarmanus*



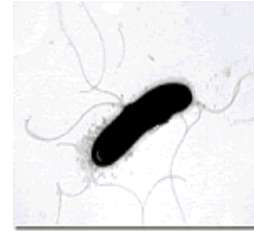
*Magnetospirillum magnetotacticum*



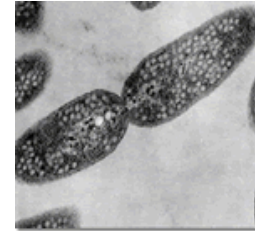
*Nitrosomonas europaea*



*Prochlorococcus marinus*



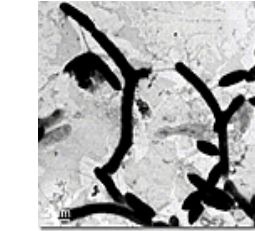
*Pseudomonas fluorescens*



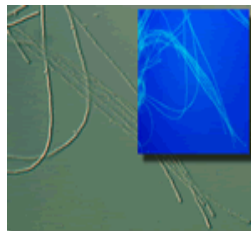
*Rhodobacter sphaeroides*



*Rhodospseudomonas palustris*



*Shingomonas aromaticivorans*



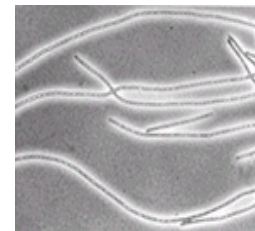
*Thermomonospora fusca*



*Trichodesmium erythraeum*



*Xylella fastidiosa*



*Nostoc punctiforme*



*Marine synechococcusβ*



*Magnetococcus MC-1*

# White House Announcement



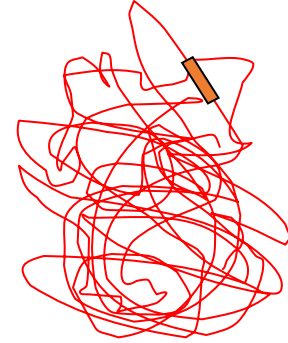
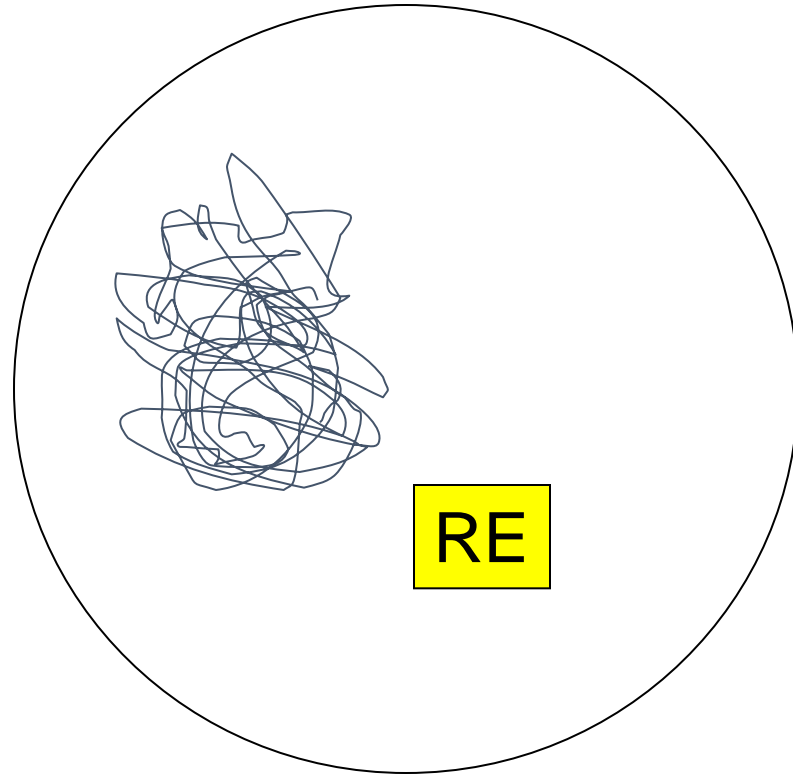
# *Important Dates in Genomics*

- 1986** DOE announces Human Genome Initiative
- 1990** DOE & NIH join forces and launch the Human Genome Project (HGP)
- 2000** Completion of the working draft by the HGP and Celera
- 2003** Finished human genome delivered on the 50<sup>th</sup> anniversary of the Watson-Crick paper





# Genome Transplantation



# **Ethical, Legal, and Social Implications**

**An integral component of the  
Human Genome Project**

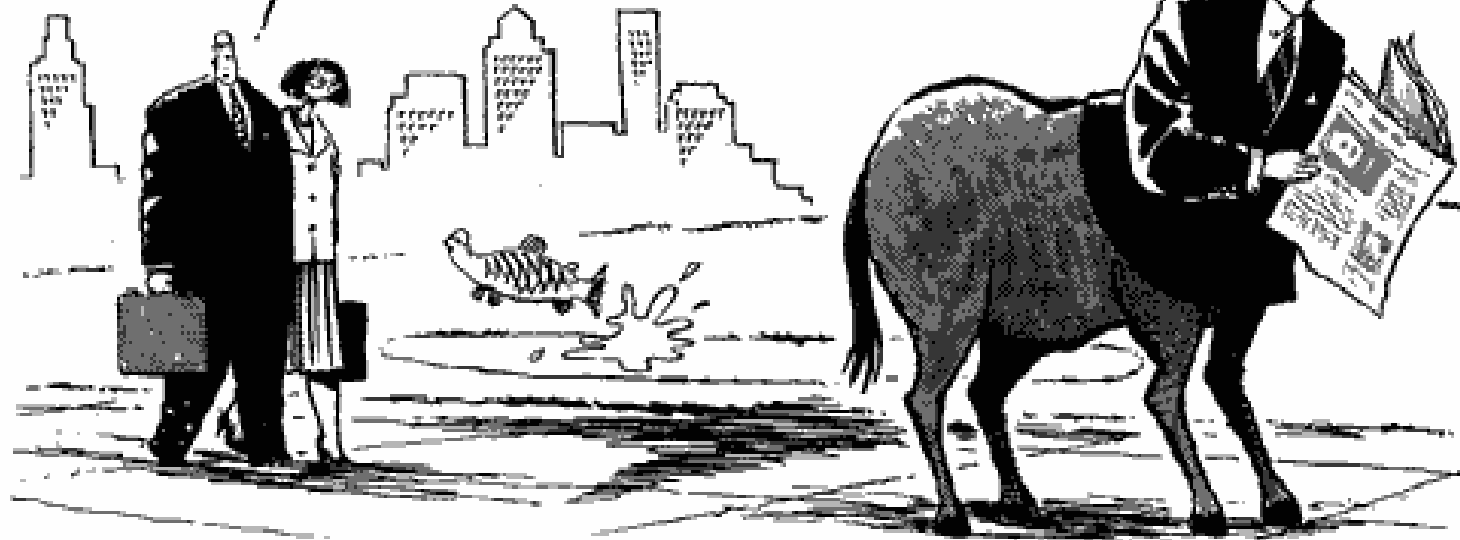
# **Ethical, Legal, and Social Issues Raised by Advances in Genetics**

- **Genetics and race**
- **Genomics, stem cells, and cloning**
- **Germline gene therapy**
- **Use of genetic technology for  
“enhancement”**
- **Gene patenting**
- **Education of the public and health  
providers**

# *There is no Shortage of Concerns*

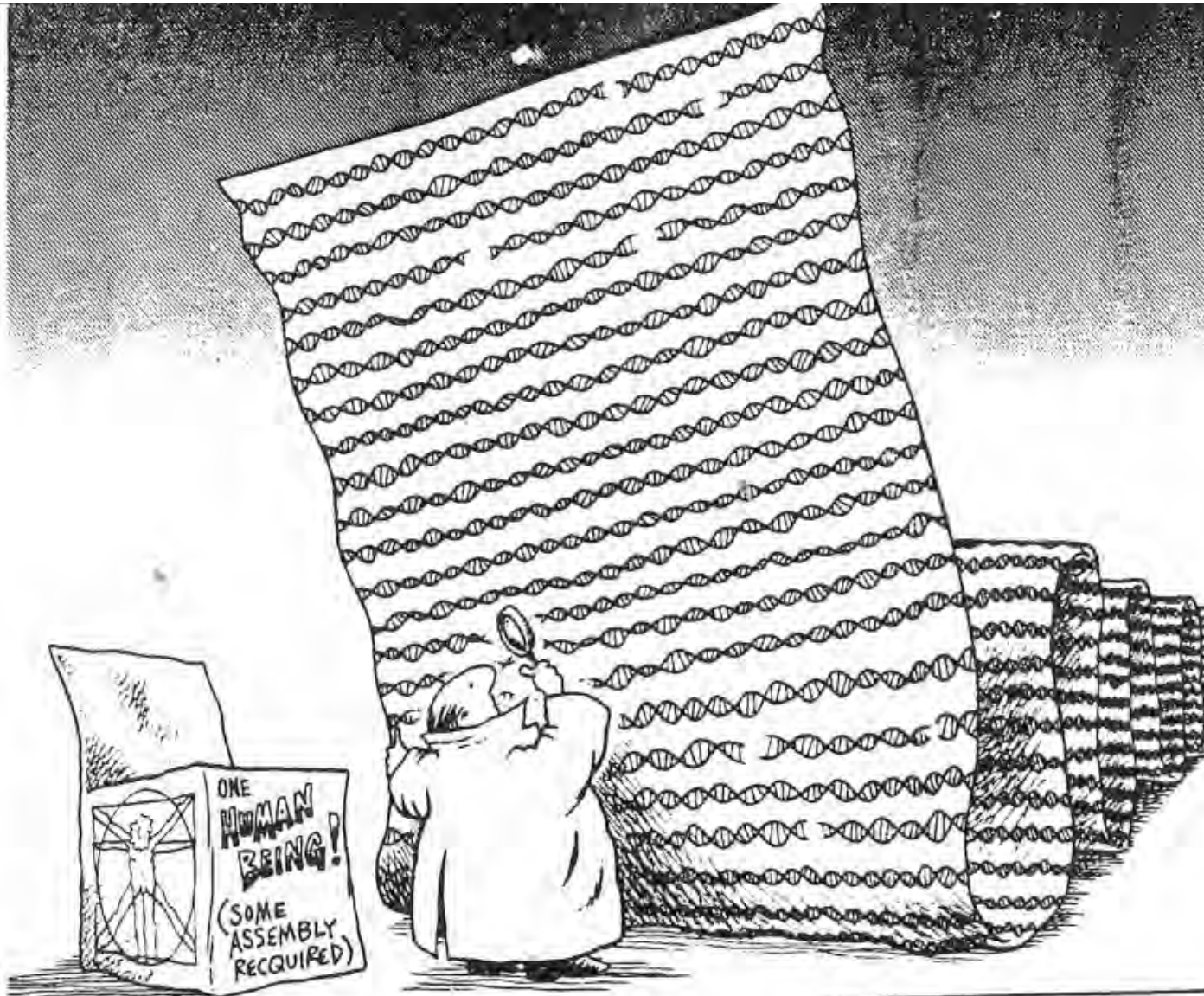
OWMAN THE ORIGINAL © 2000

SOMETIMES, I WISH  
THEY HAD NEVER  
MAPPED THE  
HUMAN GENOME...



- Insurance
- Employment
- Criminal justice
- Patenting
- Medical diagnosis & therapy

# *The Sequence is Only the Beginning*



BY AUTH FOR THE PHILADELPHIA INQUIRER

- **The rest of biology**
- **Medicine**
- **Data issues**
- **Informatics**
- **Intellectual property**
- **Ethical, legal, and societal concerns**

**2010**



- **Predictive genetic tests available for a dozen conditions**
- **Interventions to reduce risk available for several of these**
- **Gene therapy successful for several conditions**
- **Many primary care providers begin to practice genetic medicine**
- **Reasonably effective federal legislative solutions to genetic discrimination and privacy in place in U.S.**
- **Access remains inequitable, especially in developing world**

**2020**



- **Gene-based designer drugs for diabetes, hypertension, etc., available and highly effective**
- **Cancer therapy is precisely targeted to molecular fingerprint of tumor**
- **Dx/Rx pharmacogenomic approach is standard practice for many drugs**
- **Mental illness diagnosis transformed, new therapies under study, societal views shifting**

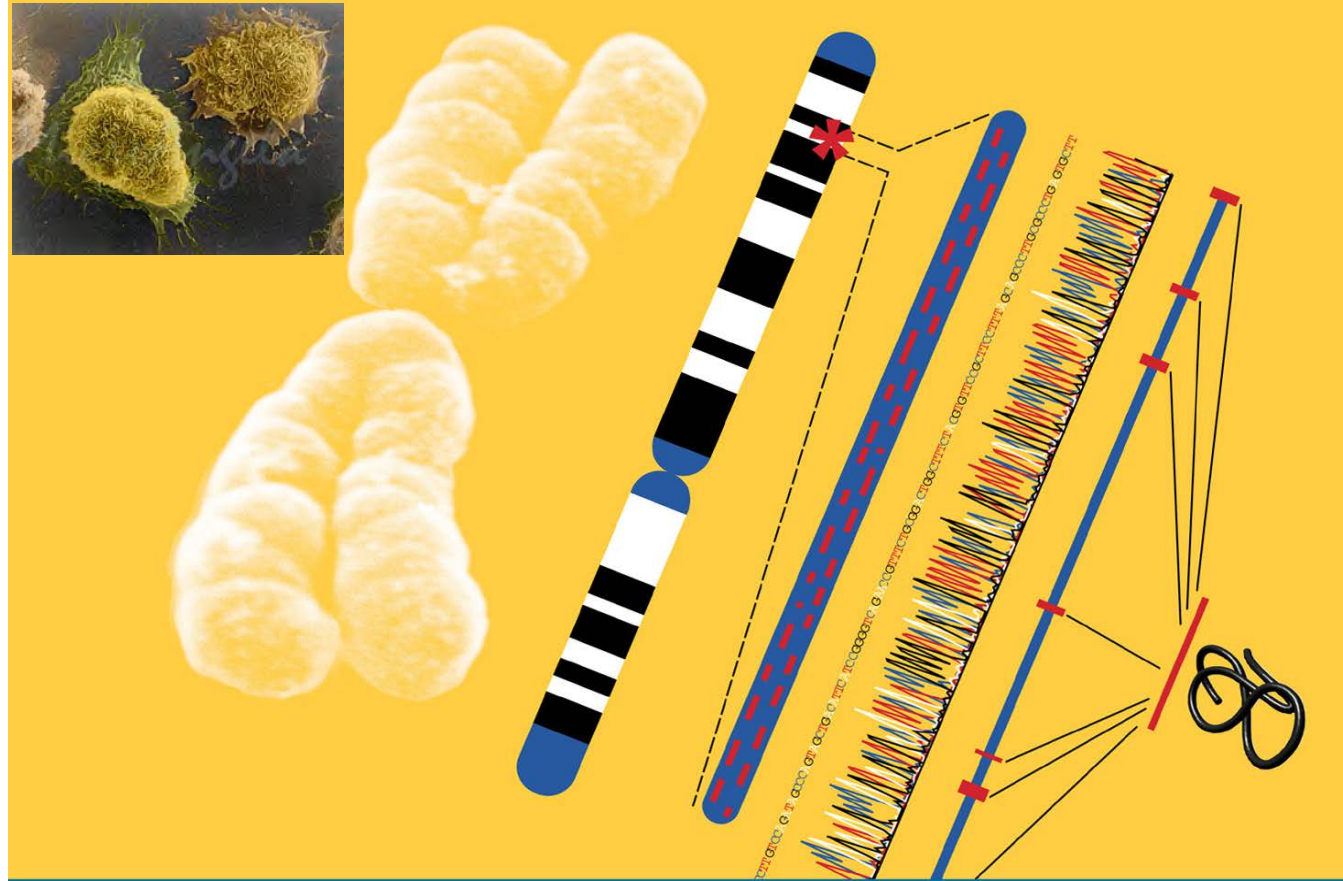
**2030**



- **Comprehensive genomics-based health care is the norm**
  - **Individualized preventive medicine available**
  - **Environmental factors and their interaction with genotype, pinpointed for many diseases**
  - **Illnesses are detected early by molecular surveillance**
  - **Gene therapy and gene-based drug therapy available for many diseases**
- **Full computer model of human cell replaces many laboratory experiments**
- **Average life span reaches 90 years, stressing prior socioeconomic norms**
- **Major anti-technology movements active in U.S., elsewhere**



# *Proteins: The Workhorses of a Cell*



## HUMAN GENOME ROW

Lyrics paraphrased by Ari Patrinos  
from Bob Dylan's "Desolation Row" 1965)



**Ari and Marista Patrinos at the HGP closure celebration, Smithsonian Institution, April 14, 2003**

They're handing out postcards of the genome  
They're painting the sequence brown  
NIH is filled with groupies  
The circus is in town  
Here comes the great Jim Watson  
They've got him in a trance  
One hand's tied to the double helix  
The other's in his pants  
And all the sequencers are restless  
They need somewhere to go  
As Francis Collins looks out tonight  
From Human Genome Row

Now, some of the gaps are stubborn  
Repeat regions are to blame  
Genbank's Prince Lipman  
Will treat them all just the same  
All except some on one and two and four  
Eight, seventeen and how  
Everybody will have to do  
With what's in there for now  
And the great Francis, he's dressing  
He's getting ready for the show  
He's going to the carnival tonight  
On Human Genome Row

So, at midnight imperial Guyer  
And all his superhuman crew  
Come out and round up everyone  
Who knows more than they do  
And they bring them to Bethesda  
Where the know-it-all machine  
Is strapped across their shoulder  
And then upon the screen  
Flash very tough instructions  
From program managers who go  
Check to see that nobody's escaping  
From Human Genome Row

Dr. Mike, he wants the world  
To fit inside Bermuda's cup  
While all the microbe lovers  
Are trying to blow it up  
Don and Barbara at Science are fretting  
They wanna have a serious role  
While Francis and disciples  
Chant "have mercy on their soul"  
They all play on penny whistles  
You can hear them blow  
If you lean your head out far enough  
From Human Genome Row

Now, DOE is looking out the window  
For her I feel so afraid  
On her twenty-fifth birthday  
She already is an old maid  
For her, nuclear waste is quite romantic  
She wears plutonium shrouds  
Her profession is nuclear weapons  
Her sins are her mushroom clouds  
And though her eyes are fixed upon  
Physics' great rainbow  
She spends her time peeking  
Into Human Genome Row

Across this town they nailed the curtains  
They're getting ready for the feast  
And the mighty Francis Collins  
A perfect image of a priest  
They're spoonfeeding Patrinos  
To get him to feel more assured  
Then they'll kill him with self-confidence  
After poisoning him with words  
And Branscomb's shouting to Rubin  
Get outa here if you don't know  
Ari's just been punished  
For strolling Human Genome Row

