

The Joyful Complementarity of Science and Faith

But...How Should Believers View Advances in Biotechnology?

Francis S. Collins, M.D., Ph.D.

American Scientific Affiliation

July 28, 2018



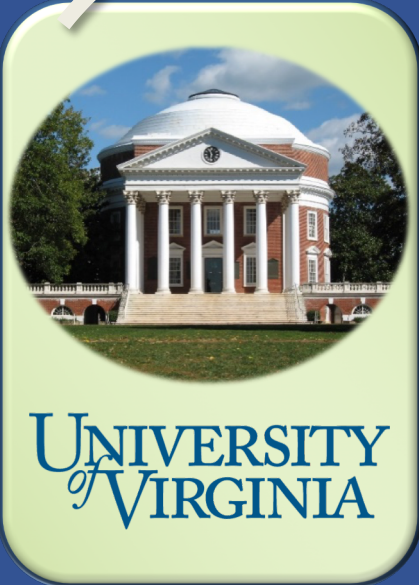


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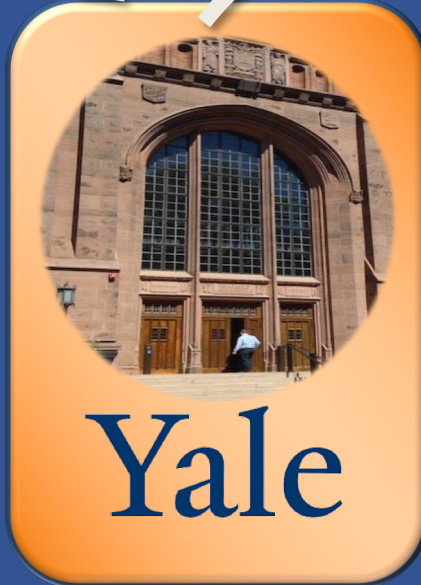


Yale





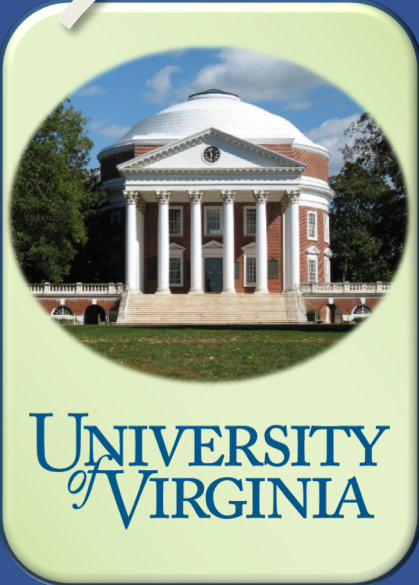
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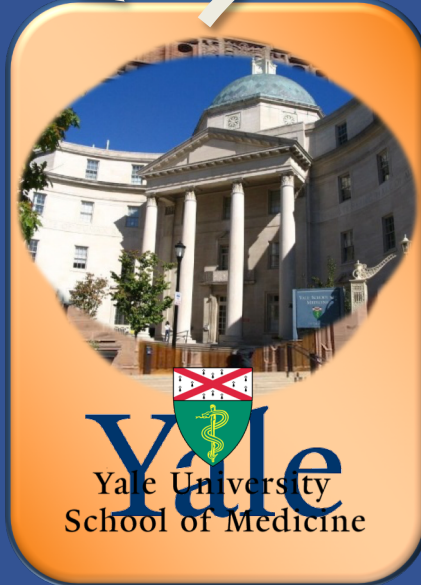
Yale




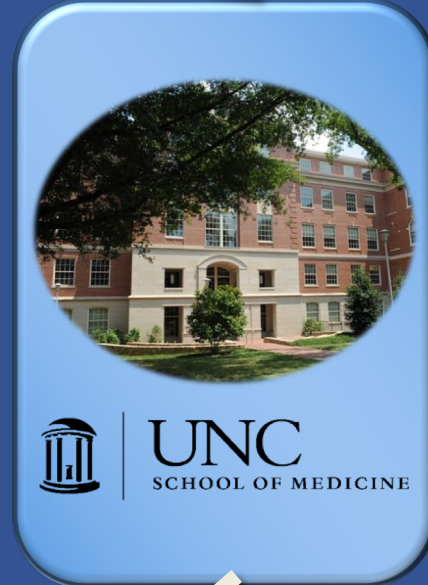
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SCHOOL OF MEDICINE




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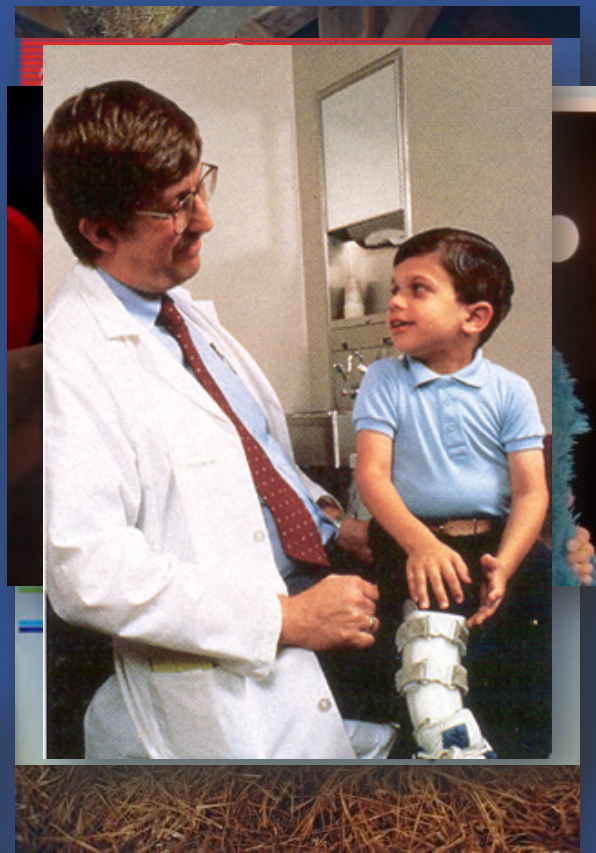
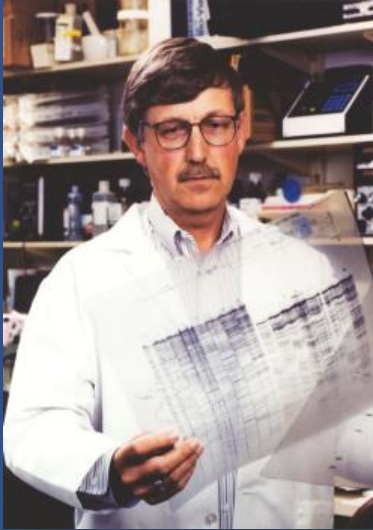

Yale University
School of Medicine



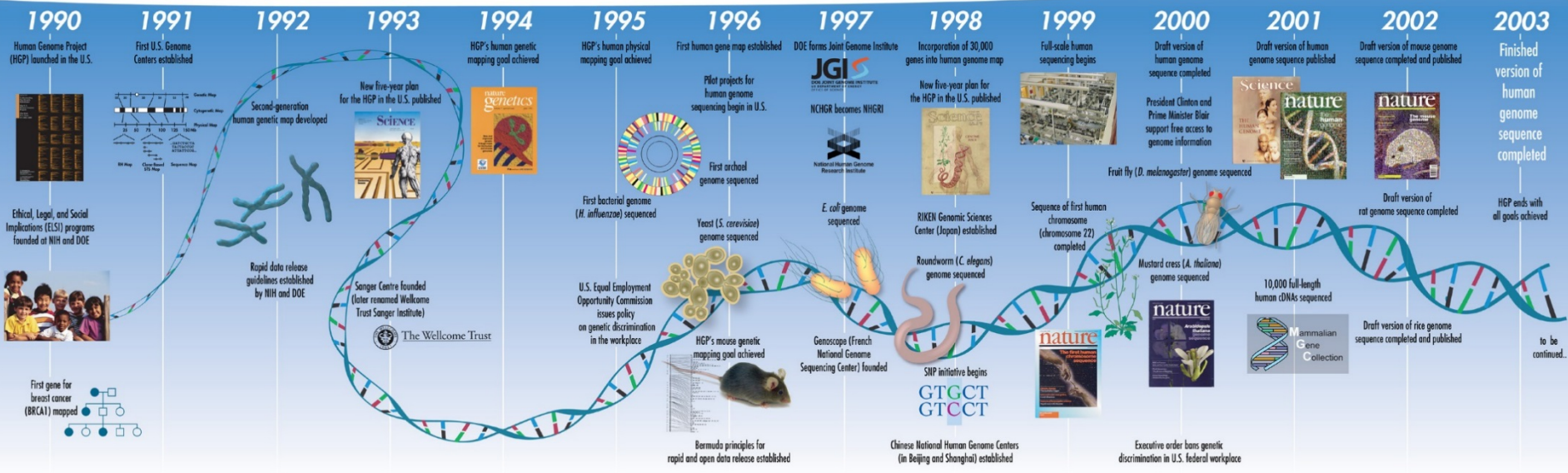
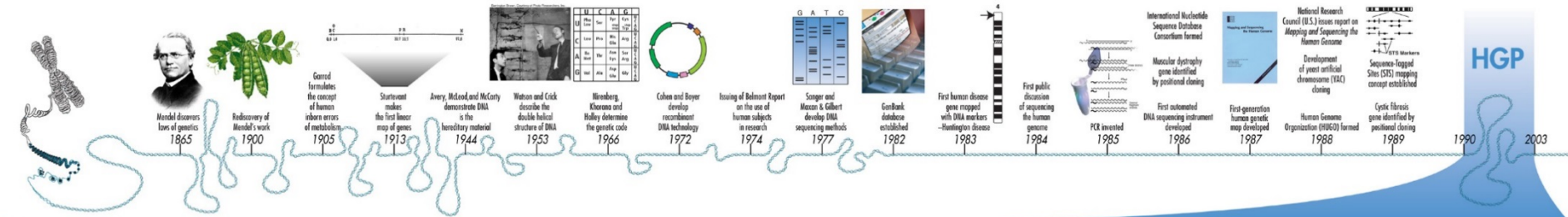
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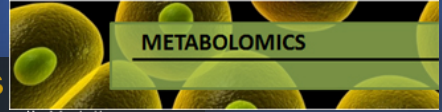
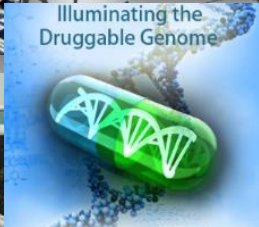
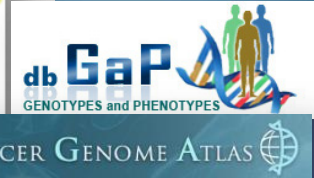
“Gene Hunter”

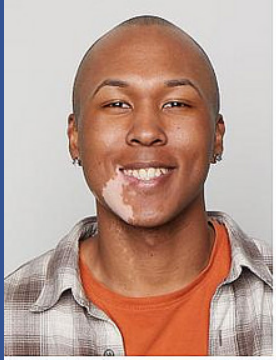
- Cystic fibrosis
- Huntington’s disease
- Neurofibromatosis
- Hutchinson-Gilford Progeria Syndrome



Reading the human DNA instruction book







The future of health
begins with you

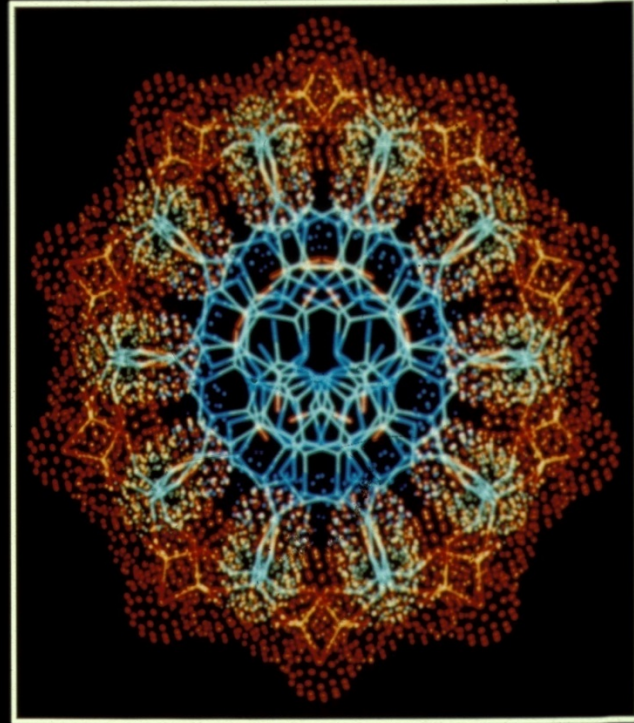
All of Us
RESEARCH PROGRAM



www.joinallofus.org



Rose Window, York Minster
(Photograph by C.J. Bassham)



**View Along the Axis
of the β DNA Double Helix**
(Courtesy of Dr. R. Langridge)

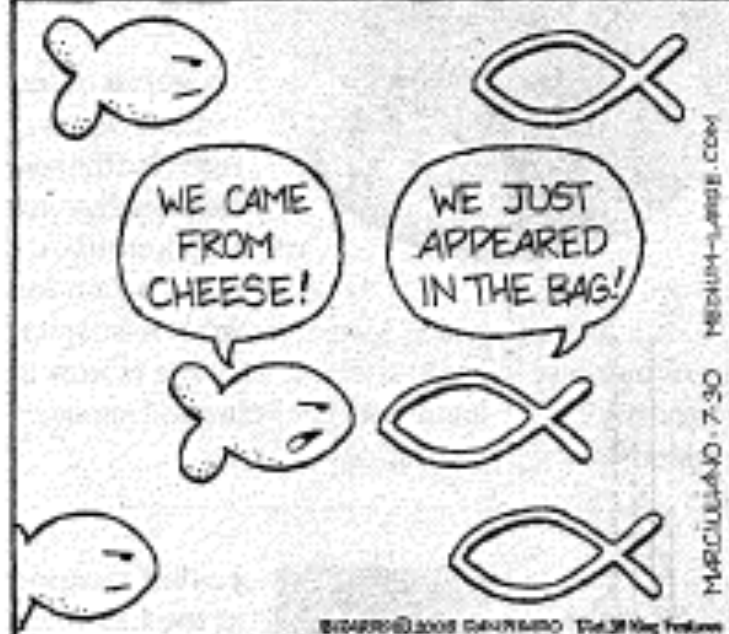
Nature provides some interesting pointers to God

- There is something instead of nothing
- “The unreasonable effectiveness of mathematics”
- The Big Bang
- The precise tuning of physical constants in the universe
- The Moral Law

Faith and Science

- Two ways of knowing
- Science answers how, faith answers why
- Reading both of the books God gave us (Bacon)
 - The book of God's words – Scripture
 - The book of God's works -- Nature
- *No problem, right?*

This week's guest artist: Francesco Marciuliano



THE NEVER-ENDING DEBATE
BETWEEN CHEDDAR AND
EVANGELICAL GOLDFISH CRACKERS.



A SCIENTIST PRESENTS
EVIDENCE FOR BELIEF

THE
LANGUAGE
OF GOD

FRANCIS S. COLLINS

A simple synthesis of science and faith

Almighty God, who is not limited in space or time, created a universe 13.8 billion years ago with its parameters precisely tuned to allow the development of complexity and beauty over long periods of time.

God's original plan included the mechanism of evolution to create the marvelous diversity of living things on our planet. Most especially, that creative plan included human beings.

After God's plan for evolution, in the fullness of time, had prepared a sufficiently advanced brain, humanity was gifted with free will, consciousness, and a moral sense. Thus humans were granted special status, "made in God's image".

We humans used our free will to disobey God, leading to our realization of being in violation of the Moral Law. Thus we were estranged from God our Creator, who embodies all that is good, loving, and holy. For Christians, Jesus Christ is the solution to that estrangement.

What could this synthesis be called?

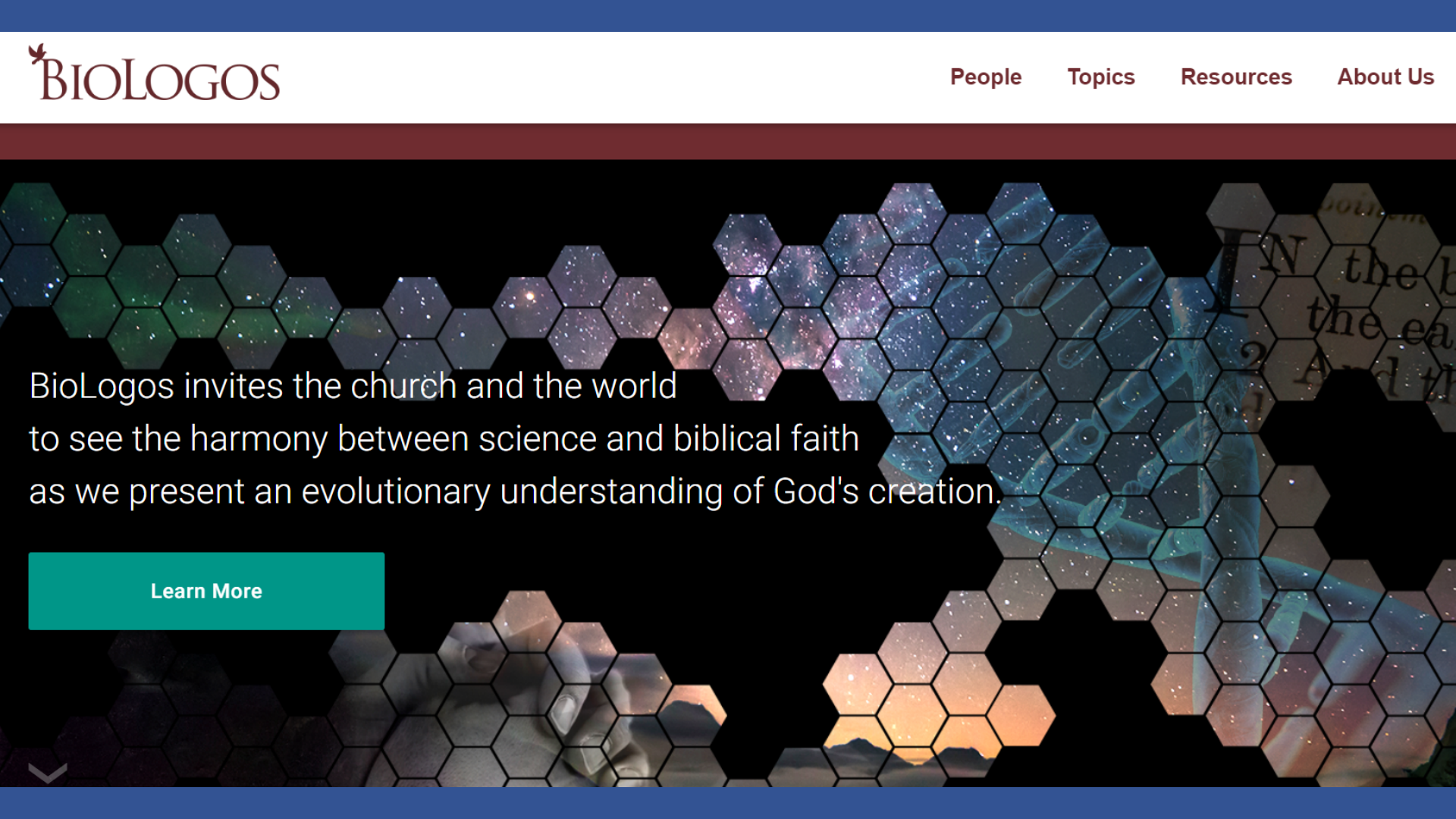
Bios = Life

through

Logos = The Word

Or more simply, “BioLogos”

God speaking life into being



BioLogos invites the church and the world
to see the harmony between science and biblical faith
as we present an evolutionary understanding of God's creation.

[Learn More](#)



**GORDON
COLLEGE**

In Honor of R. Judson and Janice Carlberg

The trustees, faculty, staff, students and friends of Gordon College designate this hall of worship and community engagement in honor of Gordon's seventh president, Jud Carlberg, and his wife, Jan, in recognition of their dedication to fostering a welcoming and vibrant community marked by leadership, devotion, creativity and passion for excellence.

JUNE 2011

In essential things -- unity
In non-essential things -- liberty
In all things -- charity

Augustine

The Joyful Complementarity of Science and Faith

**But...How Should Believers View
Advances in Biotechnology?**

**Francis S. Collins, M.D., Ph.D.
American Scientific Affiliation
July 28, 2018**

Some ethical challenges in biotechnology

- Privacy of human DNA databases
- Animal research – especially non-human primates
- Neuroethics – the BRAIN initiative
- Human embryonic stem cell research
- Human-animal chimeras
- Dramatic life extension
- **Gene editing**

CRISPR-Cas9 and Gene Editing

- Basic science advance: from studies of yogurt, bacterial viruses
- Achieves precisely targeted editing of genomes – “search and replace”
- Has revolutionized basic molecular biology
- Applications to human genetic disease now being actively explored



Francis S. Collins @NIHDirector · 8:03 AM - 25 Jan 2018

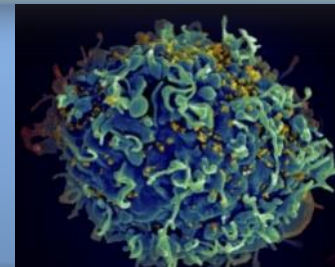
I just announced this at #wef18: #NIH's Somatic Cell Genome Editing research program will focus on accelerating dramatically the translation of technologies like CRISPR/Cas9 for treatment of as many genetic diseases as possible. bit.ly/2F78HBI #CFGGenomeEditing



NIH to launch genome editing research program

Somatic Cell Genome Editing aims to develop tools for safe and effective genome editing in humans.

nih.gov



The Promise...

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

MARCH 6, 2014

VOL. 370 NO. 10

Gene Editing of CCR5 in Autologous CD4+ T Cells of Persons Infected with HIV

Pablo Tebas, M.D., David Stein, M.D., Winson W. Tang, M.D., Ian Frank, M.D., Shelley S. Kaye Spratt, Ph.D., Richard T. Surosky, Ph.D., Martin A. Giedlin, Ph.D., Michael C. Holmes, Ph.D., Philip D. Gregory, Ph.D., Dale G. Ando, M.D., Ronald G. Collman, M.D., Gwendalyn Binder-Schell, Ph.D., Gabriela

24 NOVEMBER 2016 | VOL 539 | NATURE

CRISPR gene editing tested in a person

Trial could spark biomedical duel between China and US.

Science



FDA U.S. FOOD & DRUG
ADMINISTRATION

FDA approval brings first gene therapy to the United States

CAR T-cell therapy approved to treat certain children and young adults with B-cell acute lymphoblastic leukemia

For Immediate
Release

November 22, 2017

Release

The U.S. Food and Drug Administration issued a historic action today making the first gene therapy available in the United States, ushering in a new approach to the treatment of cancer and other serious and life-threatening diseases.

...me of his liver

...tools to
...ed to

The Peril...

“We must not allow our technology to exceed our humanity.”

- Albert Schweitzer

The Guardian



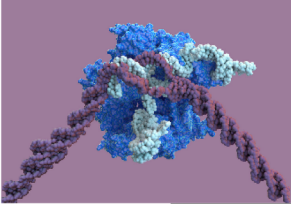
Philip Ball
Sun 8 Jan 2017

Designer babies: an ethical horror waiting to happen?

Alakssei Lisevich / Alamy Stock

New Scientist
DAILY NEWS 14 February 2017

Human genome editing shouldn't be used for enhancement - yet



CRISPR, gene editing made easy
TheMacDaily191

By Jessica Hamzelou

Daily **Mail**.com

Controversial 'gene drive' research sparking ethical debate

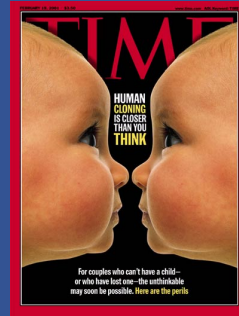
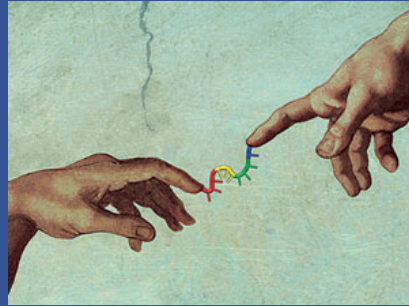
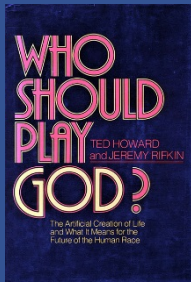
By AFP
PUBLISHED: 06:08 EDT, 6 September 2016

Science

CRISPR—a weapon of mass destruction?

By Kelly Servick | Feb. 11, 2016, 4:45 PM

Concern About “Playing God” Is Not New to Biotechnology



Recombinant DNA

Genetic Engineering

Cloning

Human Genome Project

Synthetic Biology

Genome Editing

DIY

70s

80s

90s

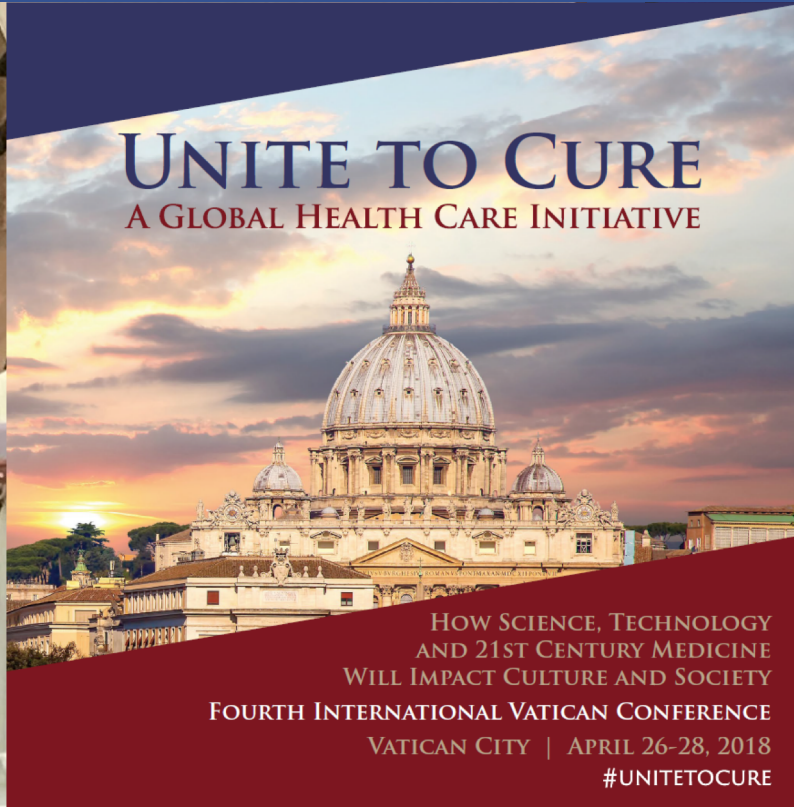
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Present

4th Annual Vatican Conference

April 26-28, 2018



Applications of Human Gene Editing

- Somatic cell gene editing
 - Focused on a particular organ
 - Does not affect the “germline”, so not passed on to children
 - Holds promise to cure many genetic diseases
 - Already being used for cancer immunotherapy
 - Clinical trials for sickle cell disease will begin this year

Fulfilling The Promise...

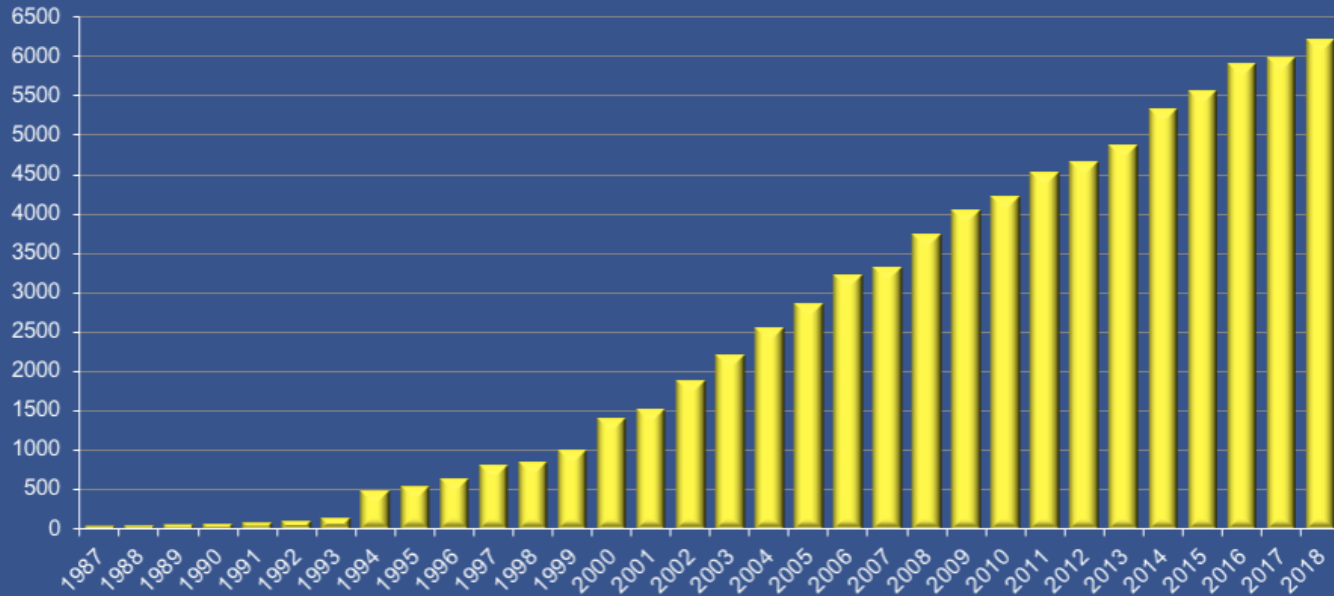
Toward the 1st Cure for the 1st Molecular Disease?

Sickle Cell Disease (SCD)

- 1910: Disease described
- 1949: Inheritance shown to be recessive
- 1957: Genetic basis determined
- 1980: Hemoglobin genes cloned
- 1998: Hydroxyurea, first approved SCD drug
- Recently: Bone marrow transplants, but few patients have match
- 2017: Gene transfer via viral vectors
- 2018: CRISPR/Cas gene editing



Disorders with Known Molecular Basis



Source: *Online Mendelian Inheritance in Man*, *Morbid Anatomy of the Human Genome*

Applications of Human Gene Editing

- Somatic cell gene editing
 - Focused on a particular organ
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 - Holds promise to cure many genetic diseases
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 - Clinical trials for sickle cell disease will begin this year
- Germline gene editing
 - Involves changing the DNA of a human embryo
 - Affects future offspring too
 - Medical applications harder to identify
 - Potential to go beyond treatment to enhancement?

Advances in Gene Editing

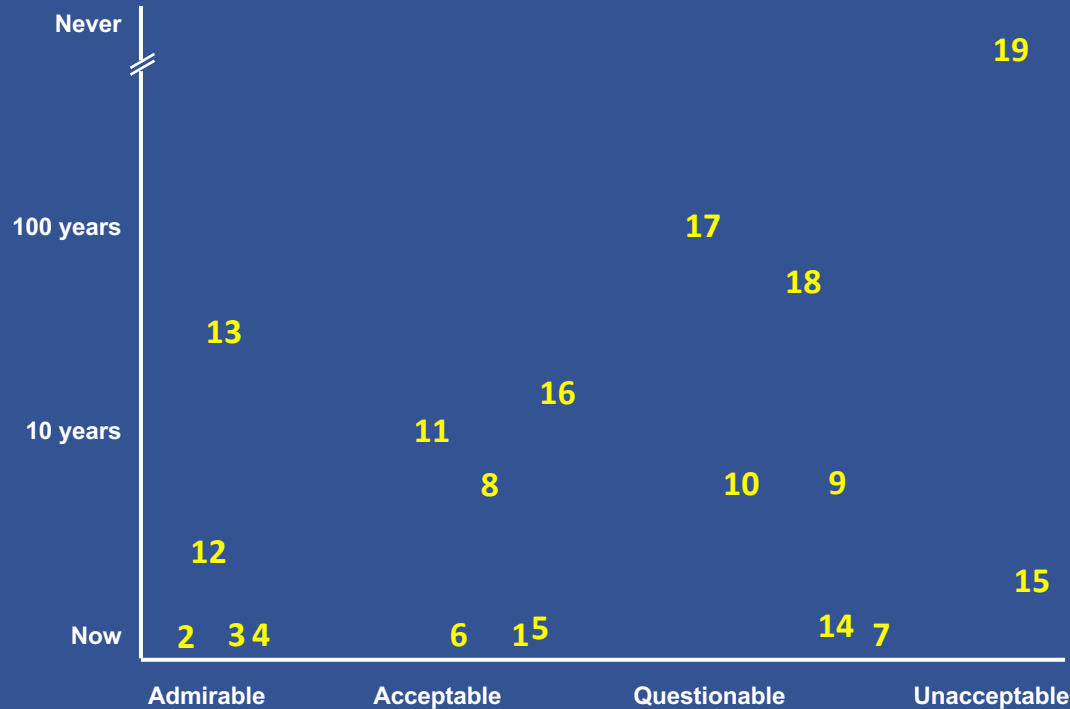
Moving From Abstract to Concrete...

- Once hypothetical concerns and academic discussions of bioethics made more real by advances in biotechnology
 - Area of greatest concern: Use of improved gene editing tools (CRISPR/Cas) for germline modification of humans
- Is there justification for prevention of disease?
 - Specific examples are not very compelling
- Is there justification for enhancement?
 - Scientific concerns
 - Safety concerns
 - Philosophical/theological concerns
 - Equity concerns
 - Boundaries not really clear



Is Enhancement Always Bad?

Timetable to Feasibility vs. Level of Concern



19. Designer babies with precisely predictable outcomes

Long-standing Widely-Shared Judeo-Christian Ethical Principles *Can* Guide Us

- **Respect for persons:** Recognition of the personal dignity and autonomy of individuals, with special protections for those with diminished autonomy
- **Beneficence:** Obligation to protect persons from harm by maximizing anticipated benefits and minimizing potential risks of harm
- **Justice and Equity:** Benefits and burdens of research should be justly distributed



But make no mistake: the implications of human germline gene editing are profound

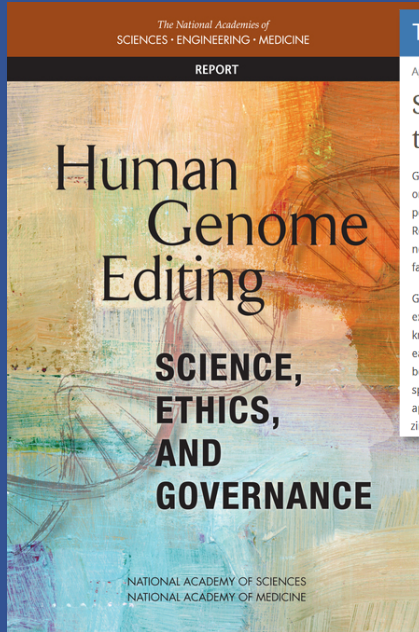
- Safety risks are currently unknown
- Future generations would be affected but don't have the chance to give consent
- Who decides what represents an "improvement"?
- If germline editing actually provides benefits, will that lead to further separation between the haves and the have nots?
- What does it mean to be human if that can be fundamentally altered by tinkering with our biological instruction book?
 - How would this affect our relationship with the Creator? The Imago Dei?
 - "Fearfully and wonderfully re-made"?

Psalm 139:13-16

For you created my inmost being;
you knit me together in my mother's womb.
I praise you because I am fearfully and wonderfully made;
your works are wonderful,
I know that full well.
My frame was not hidden from you
when I was made in the secret place,
when I was woven together in the depths of the earth.
Your eyes saw my unformed body;
all the days ordained for me were written in your book
before one of them came to be.

Concern About “Playing God”

Scientific Community is Paying Attention



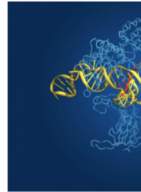
THE NIH DIRECTOR

April 28, 2015

Statement on NIH funding of research using gene-editing technologies in human embryos

Genomic editing is an area of research seeking to modify genes of living organisms to improve our understanding of gene function and advance potential therapeutic applications to correct genetic abnormalities. Researchers in China have recently described their experiments in a nonviable human embryo to modify the gene responsible for a potentially fatal blood disorder using a gene-editing technology called CRISPR/Cas9.

Genomic editing is already widely studied in a variety of organisms. For example, CRISPR/Cas9 has greatly shortened the time it takes to produce knockout mouse models of disease, enabling researchers to study more easily the underlying genetic causes of those diseases. This technology is also being used to develop the next generation of antimicrobials, which can specifically target harmful strains of bacteria and viruses. In the first clinical application of genomic editing, a related genome editing technique (using a zinc finger nuclease) was used to create HIV-1 resistance in human immune



Crystal structure of the Cas9 gene-editing enzyme (light blue) in complex with an RNA guide (red) and its target DNA (yellow). Wong, Broad Institute of Harvard and MIT, Cambridge, MA

Science

01 Dec 2017

Principles for gene drive research

Claudia Emerson¹, Stephanie James², Katherine Littler³, Filippo (Fil) Randazzo⁴

The New York Times

Scientists Seek Moratorium on Edits to Human Genome That Could Be Inherited

By NICHOLAS WADE DEC. 3, 2015

Concern about “Playing God”

In the Absence of Ethical Consensus, Science Moves Forward...

J Assist Reprod Genet (2016) 33:581–588

6 April 2016

Introducing precise genetic modifications into human 3PN embryos by CRISPR/Cas-mediated genome editing

Xiangjin Kang¹ · Wenyin He¹ · Yuling Huang¹ · Qian Yu¹ · Yaoyong Chen¹ · Xingcheng Gao¹ · Xiaofang Sun¹ · Yong Fan¹

Protein & Cell

RESEARCH ARTICLE

2015, 6(5)

CRISPR/Cas9-mediated gene editing in human tripronuclear zygotes

Puping Liang, Yanwen Xu, Xiya Zhang, Chenhui Ding, Rui Huang, Zhen Zhang, Jie Lv, Xiaowei Xie, Yuxi Chen, Yujing Li, Ying Sun, Yaofu Bai, Zhou Songyang, Wenbin Ma, Canquan Zhou[✉], Junjiu Huang[✉]



Exclusive: Inside The Lab Where Scientists Are Editing DNA In Human Embryos



ROB STEIN



August 18, 2017 · 5:00 AM ET
Heard on Morning Edition

ARTICLE

doi:10.1038/nature23305

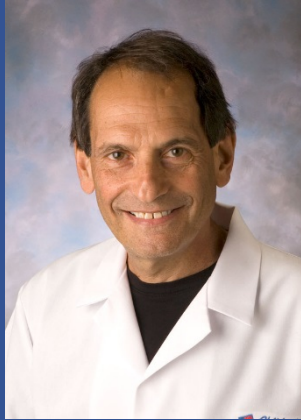
Correction of a pathogenic gene mutation in human embryos

Hong Ma^{1*}, Nuria Marti-Gutierrez^{1*}, Sang-Wook Park^{2*}, Jun Wu^{3*}, Yeonmi Lee¹, Keiichiro Suzuki³, Amy Koski¹, Dongmei Ji¹, Tomonari Hayama¹, Riffat Ahmed¹, Hayley Darby¹, Crystal Van Dyken¹, Ying Li¹, Eunju Kang¹, A.-Reum Park², Daesik Kim⁴, Sang-Tae Kim², Jianhui Gong^{5,6,7,8}, Ying Gu^{5,6,7}, Xun Xu^{5,6,7}, David Battaglia⁹, Sacha A. Krieg⁹, David M. Lee⁹, Diana H. Wu⁹, Don P. Wolf¹, Stephen B. Heitner¹⁰, Juan Carlos Izpisua Belmonte^{3§}, Paula Amato^{1,9§}, Jin-Soo Kim^{2,4§}, Sanjiv Kaul^{1,9§} & Shoukhrat Mitalipov^{1,10§}

24 AUGUST 2017 | VOL 548 | NATURE | 413

Mindful of the Perils ... but Focusing on the Promise

Gene Therapy for Spinal Muscular Atrophy



Jerry Mendell/Nationwide
Children's Hospital,
Columbus, OH



Toward the Future

Striking the Balance for Responsible Innovation

- Bringing hope to those who are suffering is an ethical imperative
- Doing nothing is the most unethical of the options
- So we must proceed, but proceed responsibly
- Longstanding ethical principles can form the cornerstone
- International consensus is desirable, but will be difficult to achieve
- People of faith have an important role to play – but need to be well-grounded in the science





“If any one age really attains, by eugenics and scientific education, the power to make its descendants what it pleases, all men who live after it are the patients of that power. They are weaker, not stronger: for though we may have put wonderful machines in their hands we have pre-ordained how they are to use them.”

C.S. Lewis

The Abolition of Man

“Praise the Source of Faith and Learning”

Words: Thomas Troeger

Music: Hyfrydol

Praise the source of faith and learning that
has sparked and stoked the mind

With a passion for discerning how the world
has been designed.

Let the sense of wonder flowing from the
wonders we survey

Keep our faith forever growing and renew
our need to pray.

God of wisdom, we acknowledge that our
science and our art

And the breadth of human knowledge only
partial truth impart.

Far beyond our calculation lies a depth we
cannot sound

Where Your purpose for creation and the
pulse of life are found.

**As two currents in a river fight each other's
undertow**

**Till converging they deliver one coherent
steady flow;**

**Blend, O God, our faith and learning till they
carve a single course,**

**Till they join as one, returning praise and
thanks to You, their source.**