

# Ethics in Biomedical Engineering

BIOM1010

21<sup>st</sup> August 2018

Professor John Whitelock

# What is ethics?



# What ethics is not

- Your religious beliefs
- A science
- Your personal feelings
- Adhering to the law of the land
- Following your cultural training

# Ethics is

- Set of standards of human behaviour
- Code of professional conduct
- Values of right and wrong
- Set of moral principles

# Why are Ethics Important in Biomedical Engineering?

- Medical field - serious and personal issues.
  - Integrity and confidentiality - research with patients that provide for safe and efficacious treatments
- Technology advances push capabilities in engineering and medical fields.
  - Increased capabilities may seem to some as science interfering with nature or religious beliefs.

# How are Codes of Ethics Created in Biomedical Engineering?

- Combines ethics from medical and engineering fields.
  - Examples:
    - Medical: Hippocratic Oath
    - Engineering: IEEE, EA & others

# “Types” of Ethics in Biomedical Engineering

- Professional Ethics
  - Honest and impartial
  - Not publishing false reports
- Patient Ethics
  - Confidentiality
  - Full disclosure
- Natural & Human ethics
  - Not “playing God”
  - Not interfering with natural life and/or nature.
  - Not crossing the line between improving quality of life and changing life.

# Codes of biomedical engineering ethics

- Blend of codes from the medical and engineering disciplines
- Hippocratic oath – medical ethics
- ABET & IEEE codes – engineering ethics
- Biomedical engineers - indirect practitioners.
  - Work closely with clinical practitioners.

# Associations with codes of ethics

- Accreditation Board for Engineering Technology (ABET – USA)
- Engineers Australia
- IEEE
- Biomedical Engineering Society (BMES)
- American Society of Mechanical Engineers (ASME)

# Hippocratic oath

- At the time of being admitted as a member of the medical profession:
- I solemnly pledge myself to consecrate my life to the service of humanity;
- I will give to my teachers the respect and gratitude which is their due;
- I will practice my profession with conscience and dignity;
- The health of my patient will be my first consideration;
- I will respect the secrets which are confided in me, even after the patient has died;
- I will maintain by all the means in my power; the honor and the noble traditions of the medical profession;
- My colleagues will be my sisters and brothers;
- I will not permit considerations of age, disease or disability, creed, ethnic origin, gender, nationality, political affiliation,
- race, sexual orientation, or social standing to intervene between my duty and my patient;
- I will maintain the utmost respect for human life from its beginning even under threat and I will not use my medical knowledge contrary to the laws of humanity;
- I make these promises solemnly, freely and upon my honor.

Taken from Monzon 1999 Int.J.Engng 15;276-281. Fig. 2. The Hippocratic Oath, adopted by the 2nd General Assembly of the World Medical Association (Geneva, 1948) and amended by the 46th WMA General Assembly (Stockholm, 1994).

# Inst Electrical & Electronics Engineers – Code of Ethics

- We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout
- the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby
- commit ourselves to the highest ethical and professional conduct and agree:
- to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public;
- and to disclose promptly factors that might endanger the public or the environment;
- to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
- to be honest and realistic in stating claims or estimates based on available data;
- to reject bribery in all its forms;
- to improve the understanding of technology, its appropriate application, and potential consequences;
- to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
- to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
- to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
- to avoid injuring others, their property, reputation, or employment by false or malicious action;
- to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

Taken from Monzon 1999 Int.J.Engng 15;276-281. Fig. 1. Fig. 1. The Institute of Electrical and Electronics Engineers Code of Ethics. Approved by the Board of Directors, August 1990

# Consequences of Breaking the Codes of Ethics

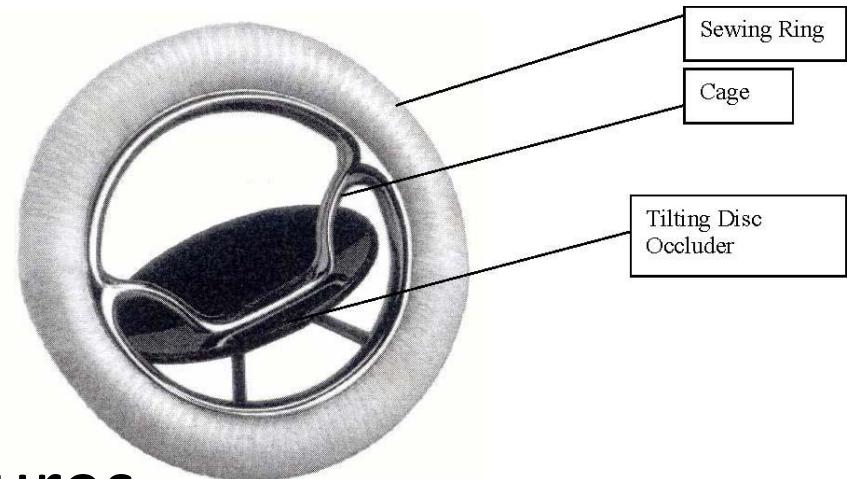
- Ethical standards are not the law – legal prosecution focused on outcomes of the behavior eg personal injury and class action lawsuits
- A loss of reputation, credibility, employment and research funding
  - peers, elite organizations, Govt and funding agencies

# Ethics in design

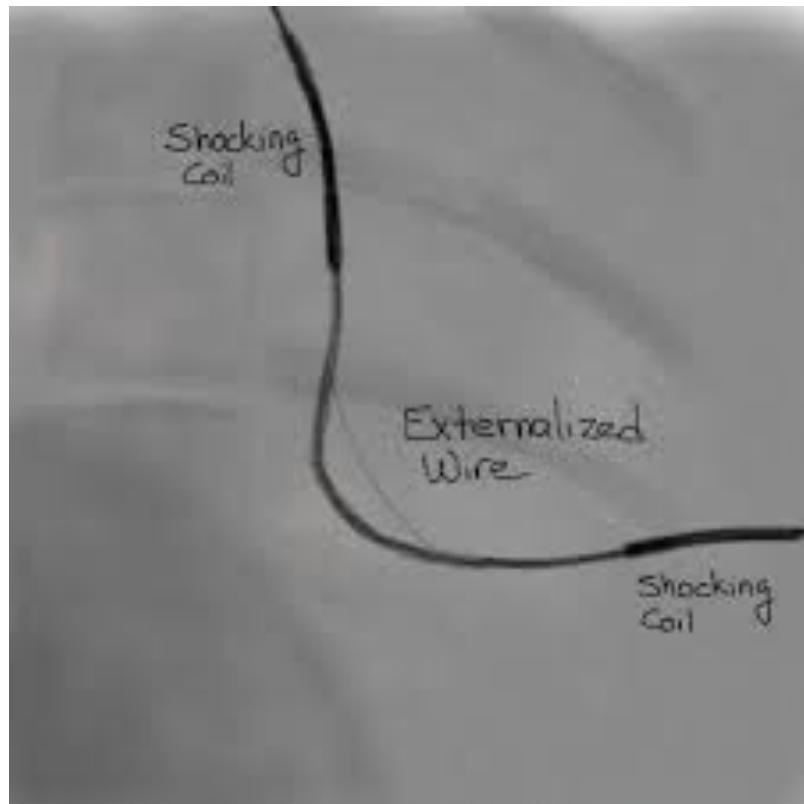
- Challenger disaster
- Solid rocket booster O-ring and temperature issues
- Timing to launch
- Political pressure
- Communication to launch controllers and R&D team lead engineers- decision not to launch
- Safety and public welfare is paramount

# Design in Biomedical Engineering

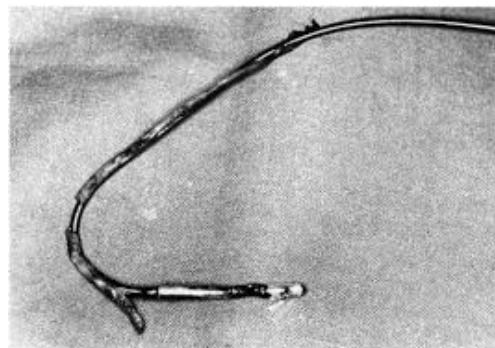
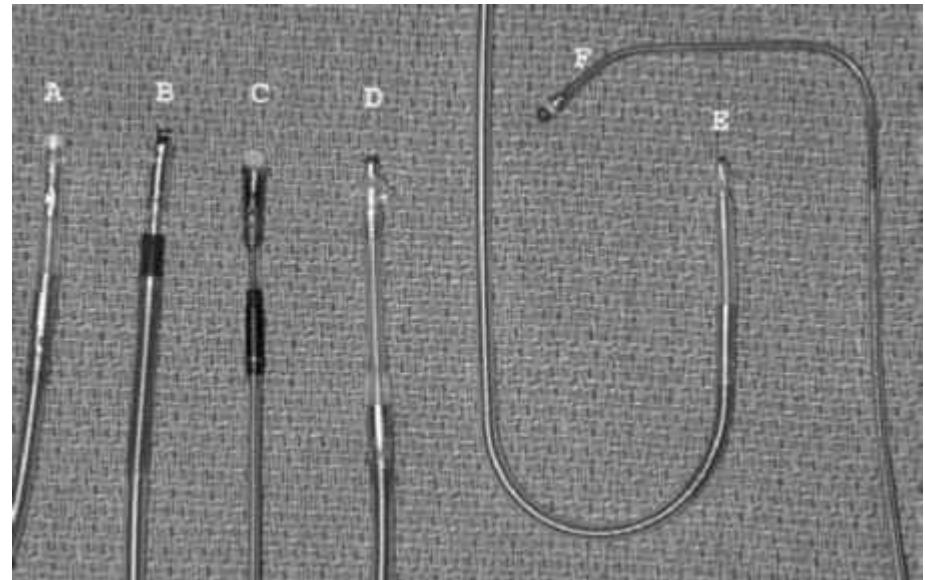
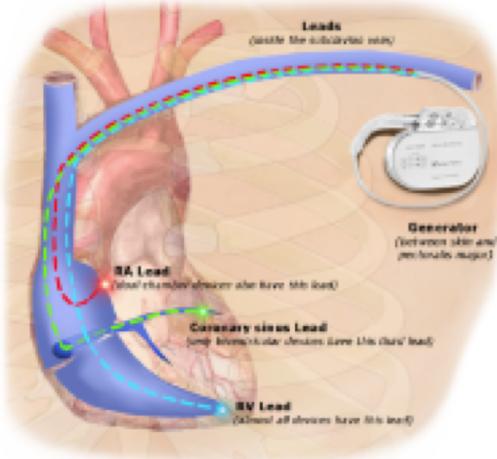
- Bjork-Shiley heart valve
- Introduced in 1976
- Clinical trials – weld fractures
- Modified welding and design but did not withdraw from market
- Patients not notified
- FDA also failed to enforce notification



# Electrical lead failures



# The J pacing lead



# Chromium release and blood levels

## Metal-on-Metal Hip Implant Systems

Total Hip Replacement



Hip Resurfacing



# How can ethical dilemmas commonly arise?

## Conflicts of interest

- Personal benefit from employer associated activities – promotion and remuneration - research and teaching
- Refereeing and peer review
- Confidentiality

# What should you do to try and avoid conflicts of interest?

- Always keep the potential of conflicts in mind as you go through your professional career.
- Disclosure of a “perceived” conflict of interest
- Communication of any safety issues to patients

# Data acquisition

- Fabrication, falsification & plagiarism
- Publication and data ownership
- Research integrity
- Record keeping – missing data
- Intellectual property

# Professional Ethics

- Stem Cell Case (2005-2006)
  - *Dr. Hwang Woo-Suk, a professor at Seoul National University, published two papers in Science claiming his team had created human ES cells via cloning.*
  - *Co-worker made allegations about fabricated data.*
  - *As a result:*
    - *papers retracted.*
    - *Dr. Hwang lost his job and all Govt funding, reputation.*



# Health & Safety

- Obligation of safe behaviour
- Hazardous materials

# Research with human subjects

- Privacy of patient details and results
- Ethics committees

# Organ transplants patient consent



**"It's unethical to remove a healthy kidney,  
but I have a pending lawsuit and need  
the money."**

# Patient Ethics

- James Wilson (1999)
  - Gene therapy researcher at the University of Pennsylvania in Philadelphia.
  - Working with gene therapy to correct genetic disorder of ornithine transcarbamylase deficiency
  - Directed a clinical trial - death of 18-year-old Jesse Gelsinger
  - Did not fully disclose the extent of adverse events



# Conscious bias

- Hiring of staff
- Contractors
- Pricing of quotes
- Reviewing student applications

# Mentoring

- Mentor / mentee expectations
- Supervisor or mentor?
- Teacher or mentor?
- Advisor or mentor?

# Authorship and Collaboration

- What determines the list of authors
- What determines the order?
- How are disputes over interpretation sorted out?
- Collaborating and authorships – what determines senior positions
- Scale of collaboration
- Journal and society guidelines

# Dual submission of data

- Some journals have shorter turnaround time
- Why not submit data to multiple journals and withdraw from the journals that don't accept it first?

# Errata

- Research can't be repeated with an explanation
- Technical error that does not change the interpretation of the data or take home message
- Which example needs an errata to be published?

# Conflict of interest in refereeing

- Referees often working on the same problem
- Gets a heads up and hastens their own publication
- The author under review complains to the journal who contacts the referee and may contact the referee's employer
- How could have the referee avoided this situation all together?

# Credit for work

- Junior students not listed as an author on a paper even though they did some of the work
- PhD student not given credit for results used as preliminary data in a grant application
- Is this ethical behaviour?
- What should you do?
- Universities have guidelines on professional conduct focused on authorship and appropriate acknowledgement for work used in a publication

# Fabrication, falsification and plagiarism

- A co-author changes the data in a previously rejected paper at the suggestion of a reviewer and states that they made a mistake and missed the data but you suspect it has just been changed
- What should you do?

# Conflict of interest – peer review

- Your HoS tells you that he is reviewing a paper from a competitive group to yours and is going to give a bad review to support you. He then asks you for your comments on the paper
- Is this unethical?
- What should you do?

# Publication and data ownership

- Student can't wait for a slow supervisor and writes up a paper, includes his supervisor and other students as authors
- Due to the writing style, the editor is suspicious and contacts the supervisor to find out she had no idea of the submission
- What should have happened here to prevent what might be perceived as unethical behaviour?

# Finance and research travel

- Using research funds for the purchase of your holiday flights
- Is this unethical? Also fraud?
- Travel and using cheaper hotels and charging the fixed per diem
- Eating cheap and taking the fixed per diem

# Animal testing of devices

- Ethical to reduce numbers and harm minimisation to animals
- Non-experienced surgeons on implant team
- Animal Ethics review committee

# Patents & cancer diagnosis

- Cancer genes patented - “owned”?
- How can you invent something that exists naturally?
- Are mutated genes naturally occurring?
- Myriad Genetics patented the BRCA1/2 gene sequence mutations
- PCR licence fee for every test
- Other tests

# Ethics, DNA analysis & diagnostics

- <https://www.23andme.com/>
- Personalised medicine



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G "engineers australia" AND ... x G https://www...Fer8h4umSFw x G https://www...422649,d,dGo x X Health and Traits - Health ... x Implantable Cardioverter-... x +

https://www.23andme.com/you/health/risk/ Search

23andMe HOME MY RESULTS FAMILY & FRIENDS RESEARCH & COMMUNITY CONNECT HELP RATE

HEALTH RISKS

23andMe Research Discoveries were made possible by 23andMe members who took surveys.

SHOW RESULTS FOR SEE NEW AND RECENTLY UPDATED REPORTS »

These reports provide information about your possible risk for developing certain health conditions based on genetics. Environmental and lifestyle factors also often play a large role in your risk for developing these conditions.

Locked Reports ?

NAME	CONFIDENCE	YOUR RISK	AVG. RISK	COMPARED TO AVERAGE
Alzheimer's Disease	★★★★	🔒	🔒	🔒

Elevated Risk ?

NAME	CONFIDENCE	YOUR RISK	AVG. RISK	COMPARED TO AVERAGE
Coronary Heart Disease	★★★★	58.0%	46.8%	1.24x 🔴
Atrial Fibrillation	★★★★	33.9%	27.2%	1.25x 🔴
Type 1 Diabetes	★★★★	9.5%	1.0%	9.34x 🔴

https://www.23andme.com/you/journal/alzheimers/overview/

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17/08/2016

# Is there an ethical boundary in knowing about future disease?

The screenshot shows a web browser window with multiple tabs open. The active tab is for 23andMe, specifically the 'Health Risks' section. The page header includes the 23andMe logo, navigation links for HOME, MY RESULTS, FAMILY & FRIENDS, RESEARCH & COMMUNITY, and buttons for CONNECT, HELP, and RATE. A sidebar on the right contains search and filter options.

**Health Risks**

23andMe Research Discoveries were made possible by 23andMe members who took surveys.

SHOW RESULTS FOR [REDACTED] SEE NEW AND RECENTLY UPDATED REPORTS »

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**Locked Reports**

NAME	CONFIDENCE	YOUR RISK	AVG. RISK	COMPARED TO AVERAGE
<a href="#">Alzheimer's Disease</a>	★★★★	🔒	🔒	🔒

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G "engineers australia" ... x | G https://w...r8h4umSFw x | G https://ww...649,d.dGo x | Browse Raw Data - 2... x | Implantable Cardiov... x +

https://www.23andme.com/you/explorer/gene/?gene\_name=HSPG2 | Search |

Your data includes 51 SNPs on gene HSPG2, which is on chromosome 1.

1 249m bases 3492 genes

Jump to a gene: HSPG2 Go a SNP:  Go or a chromosome: [1](#) [2](#) [3](#) [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#) [13](#) [14](#) [15](#) [16](#) [17](#) [18](#) [19](#) [20](#) [21](#) [22](#) [X](#) [Y](#) [MT](#)

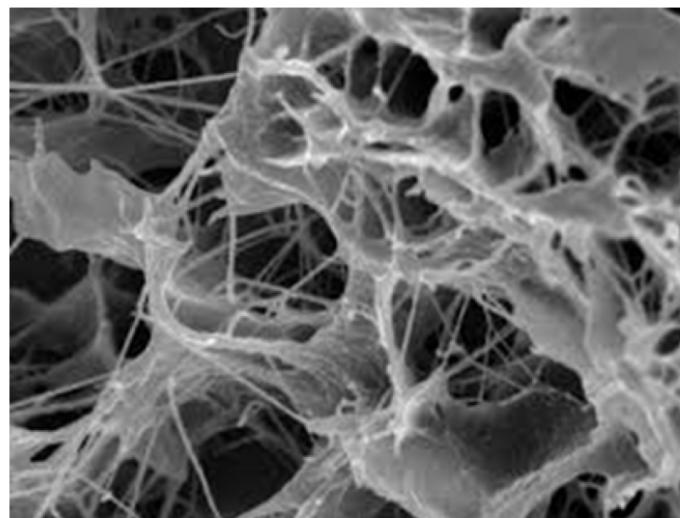
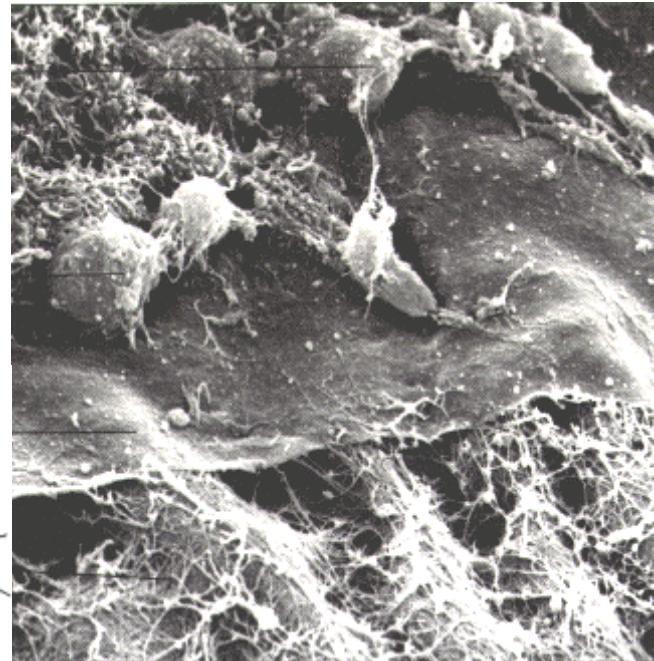
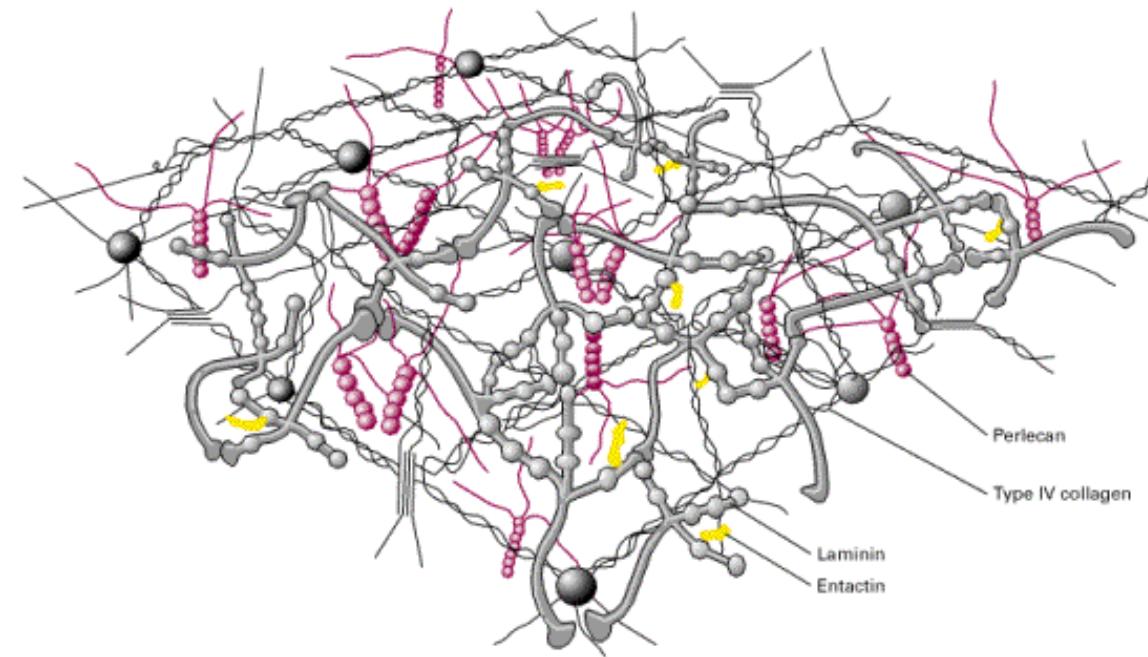
« Return to your whole genome.

Page 1 of 1

Gene	Position	SNP	Versions	Genotype
LDLRAD2, HSPG2	22150120	rs3736360	C or T	CC
HSPG2	22154987	rs10917052	A or G	AG
HSPG2	22158120	rs2270701	G or T	GG
HSPG2	22160020	rs17459097	C or T	CC
HSPG2	22160043	rs2229493	C or T	CT
HSPG2	22160148	rs7547731	C or T	CT
HSPG2	22160723	rs3767137	A or G	AG
HSPG2	22161304	rs2270699	A or G	GG
HSPG2	22165987	rs2291827	A or G	GG
HSPG2	22168216	rs7556412	C or T	CT

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# Basement membranes



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https://www.23andme.com/you/explorer/gene/?gene\_name=HSPC Search

Your data includes 51 SNPs on gene HSPG2, which is on chromosome 1.

1 249m bases 3492 genes

Jump to a gene: HSPG2 Go a SNP: Go

or a chromosome: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X Y MT

« Return to your whole genome.

Page 1 of 1

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HSPG2	22154987	rs10917052	A or G	AG
Reference Links: Entrez Gene Google Scholar (Gene) dbSNP Lookup Google Scholar (SNP)				
HSPG2	22158120	rs2270701	G or T	GG
Reference Links: Entrez Gene				

Rewards Club

Design and Encrypt Privacy

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# HSPG2 mutations

- Scwhartz-Jampel syndrome
- Develop a PCR based test to identify the mutations
- Screen embryos
- Is it ethical to develop this test, which may lead people to terminate their pregnancy?

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G "engineer..." G "schwartz..." Schwartz... Schwartz Jam... http://dGo Browse R... HSPG2 h... Impl... X

https://rarediseases.info.nih.gov/diseases/250/schwartz-jampel-syndrome

National Center for Advancing Translational Sciences | GARD Genetic and Rare Diseases Information Center

1-888-205-2311

HOME > DISEASES > SCHWARTZ JAMPEL SYNDROME

## Schwartz Jampel syndrome

Información en español

Other Names: Aberfeld syndrome; Burton skeletal dysplasia; Burton syndrome; See More

Categories: Congenital and Genetic Diseases; Eye diseases; Musculoskeletal Diseases; See More

Summary

Symptoms

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# Symptoms and prognosis

- The main signs and symptoms of SJS include the following:<sup>[3][4][5]</sup>  
Short stature and other bone abnormalities, such as a short neck, outward-bowed chest ([pectus carinatum](#)), curved spine ([kyphosis](#)), a hip deformity (coxa valga), and fragile bones ([osteoporosis](#))
- Joint contractures
- Muscle abnormalities, such as an inability to relax muscles (myotonia), increased muscle size (hypertrophy), and muscle weakness
- Characteristic facial features, including a “fixed” expression; a small, puckered mouth; a small lower jaw ([micrognathia](#)); and eye abnormalities, such as narrow eye openings (blepharophimosis), involuntary blinking or eyelid spasms ([blepharospasm](#)), and skin that covers the inner corner of the eyes ([epicanthal folds](#))
- Prognosis of normal life span and intelligence

## RESEARCH ARTICLE

# Spectrum of *HSPG2* (Perlecan) Mutations in Patients With Schwartz-Jampel Syndrome

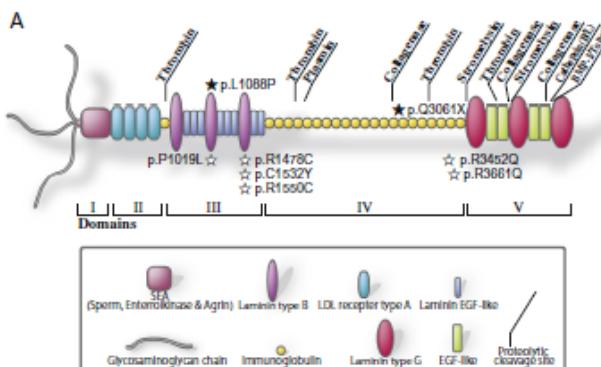
Morgane Stum,<sup>1,2</sup> Claire-Sophie Davoine,<sup>1,2</sup> Savine Vicart,<sup>1,2,10</sup> Léna Guillot-Noël,<sup>1,2</sup> Haluk Topaloglu,<sup>3</sup> Francisco Javier Carod-Artal,<sup>4</sup> Hülya Kayserili,<sup>5</sup> Fayçal Hentati,<sup>6</sup> Luciano Merlini,<sup>7</sup> Jon Andoni Urtizberea,<sup>8</sup> EL-Hadi Hammouda,<sup>9</sup> Phuc Canh Quan,<sup>1,2</sup> Bertrand Fontaine,<sup>1,2,10</sup> and Sophie Nicole<sup>1,2,10\*</sup>

<sup>1</sup>Insem, U546, Paris, France; <sup>2</sup>Université Pierre et Marie Curie-Paris6, UMR S546, Paris, France; <sup>3</sup>Hacettepe University, Faculty of Medicine, Ankara, Turkey; <sup>4</sup>Neurology Department, Sarah Hospital, Brasília, Brazil; <sup>5</sup>Medical Genetics Department, Istanbul Medical Faculty, Istanbul University, Istanbul, Turkey; <sup>6</sup>National Institute of Neurology, Tunis, Tunisia; <sup>7</sup>Muscle Unit, Division of Medical Genetics, Department of Experimental and Diagnostic Medicine, University of Ferrara, Ferrara, Italy; <sup>8</sup>Assistance Publique-Hôpitaux de Paris, Hôpital Marin d'Hendaye, Consultation Neuromusculaire, European Neuromuscular Center (ENMC), Hendaye, France; <sup>9</sup>Généthon, AFM, Evry, France; <sup>10</sup>Assistance Publique-Hôpitaux de Paris, Groupe Hospitalier de la Pitié-Salpêtrière, Fédération des Maladies du Système Nerveux et Centre de Référence "Canalopathies Musculaires," Paris, France

Communicated by Christine Van Broeckhoven

668

S. Iwata et al. / Neuromuscular Disorders 25 (2015) 667–671



Patient	P
Human	LLMALAGIDTLLIRASYAQQQPAE
Chimpanzee	LLMALAGIDTLLIRASYAQQQPAE
Orangutan	LLMALAGIDTLLIRASYTQQPAE
Macaque	LLMALAGIDTLLVRASYAQQPTE
Elephant	LLMALAGIDTLLIQASYTQRPAE
Horse	LLMALAGLDTLLIQASYTQRPAE
Mouse	LLMALAGIDALLIQASYTQQPAE
Rat	LLMALAGIDALLIQASHTQQPAE
Opossum	LLMALADIDVIMIRASYAESQVE
Zebrafish	LLMALADINVFMIRATVADNMAE
Medaka	LLMALADVDFVMIRATYADNLAE

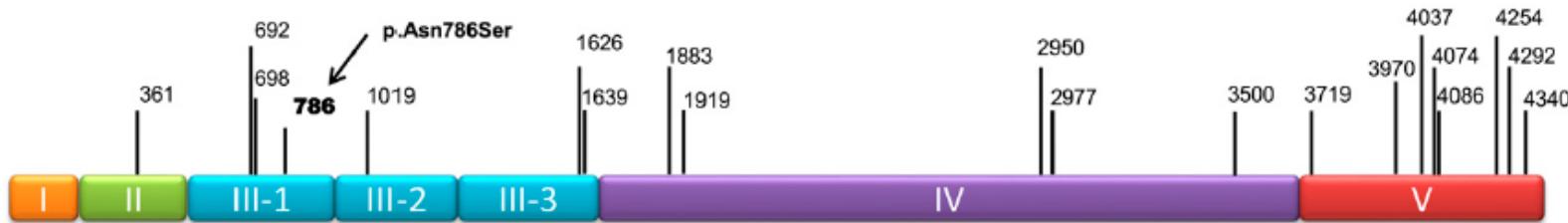
Fig. 1. (A) Domain structure of perlecan. Previously reported missense mutations are indicated by open stars. Currently identified missense and nonsense mutations are indicated by closed stars. Note that five of the seven missense mutations are located in domain III. (B) Alignment of codons 1077–1099 of perlecan in various species. Domain III-2 is comprised of codons 985–1112. Leu1088 is conserved across mammals except for opossum.

# HSPG2 mutations and idiopathic scoliosis

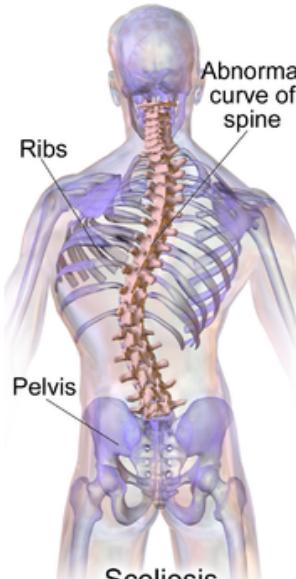
## Exome Sequencing Identifies a Rare HSPG2 Variant Associated with Familial Idiopathic Scoliosis

Erin E. Baschal,\* Cambria I. Wethey,\* Kandice Swindle,\* Robin M. Baschal,\* Katherine Gowan,\*  
Nelson L.S. Tang,\* David M. Alvarado,\*\* Gabe E. Haller,\*\* Matthew B. Dobbs,\*\*  
Matthew R.G. Taylor,†† Christina A. Gurnett,††,§§ Kenneth L. Jones,‡ and Nancy H. Miller\*,†,‡

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†Musculoskeletal Research Center, Children's Hospital Colorado, Aurora, Colorado 80045, ‡Department of Biochemistry,  
University of Colorado Denver Anschutz Medical Campus, Aurora, Colorado 80045, §Department of Chemical Pathology  
and Li Ka Shing Institute of Health Sciences, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong SAR,  
\*\*Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, Missouri 63130, ††Saint  
Louis Shriners Hospital for Children, St. Louis, Missouri 63131, ‡‡Department of Cardiology, University of Colorado  
Denver Anschutz Medical Campus, Aurora, Colorado 80045, and §§Department of Neurology, Washington University  
School of Medicine, St. Louis, Missouri 63130



**Figure 2** Rare HSPG2 variants identified in IS patients. Structure of the HSPG2 protein showing the amino acid positions of the rare coding variants identified in the combined IS cohort of 241 individuals. Amino acid positions are based on transcript NM\_005529.5. Variant p.Asn786Ser is the original variant identified in this study (combined Denver–St. Louis dataset,  $P = 0.024$ , odds ratio 2.4). Also note that variant 22186669 (c.5014+1G > A) is not shown on the diagram because it is a splicing variant and does not have an amino acid position. IS, idiopathic scoliosis.



Before Surgery

After Surgery

WILL YOU BE  
TRUTHFUL WITH  
ME, PLEASE?

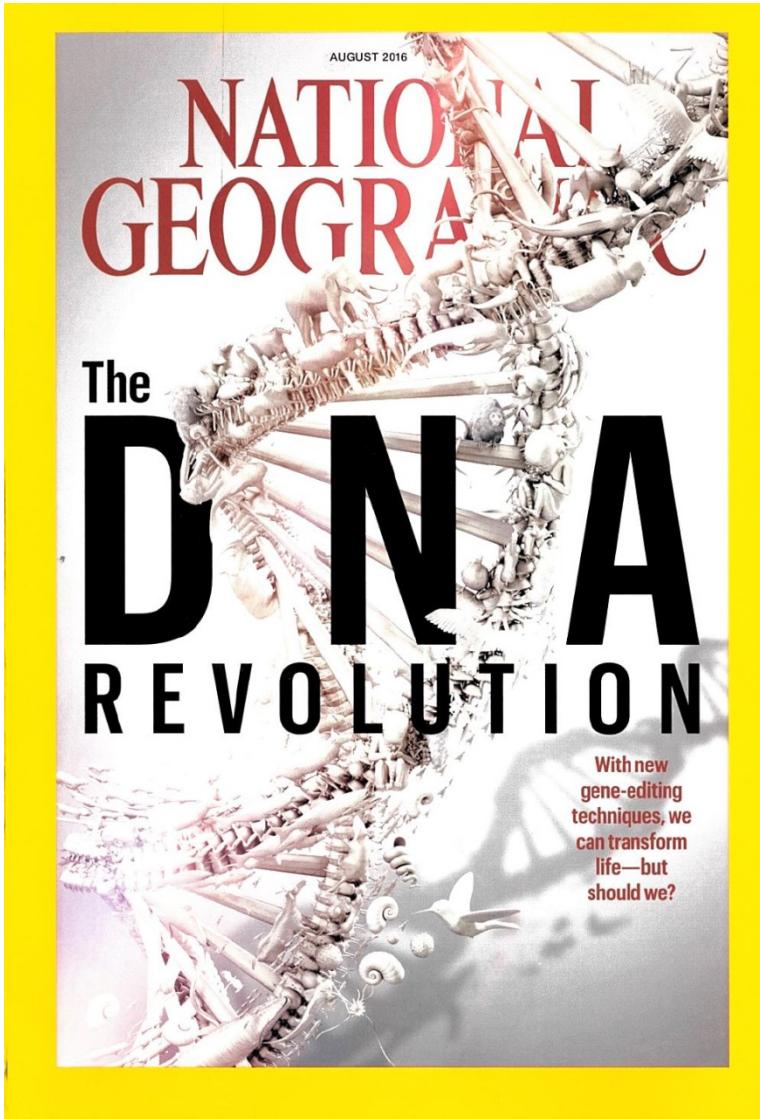
SORRY, THAT'S  
AGAINST MEDICAL  
ETHICS!



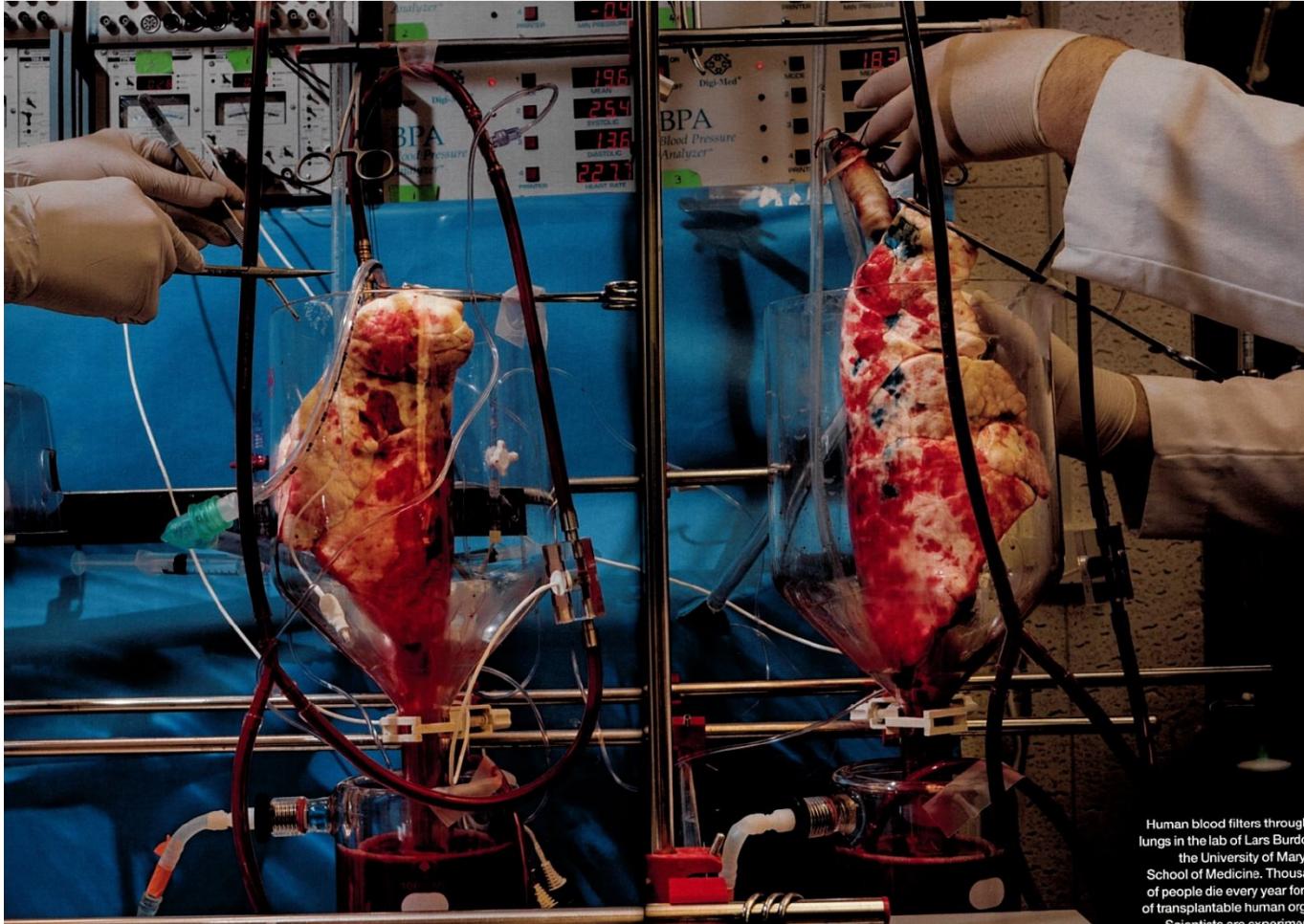
# Ethics - future human therapies

- Human enhancement:
  - Devices and techniques developed to support therapy or diagnosis may be used to enhance healthy human traits beyond a normal level.
  - Morally controversial because it moves traits beyond boundaries of the human species, and therefore has the potential to create super humans.
- Somatic Cell therapy:
  - genetic engineering of bodily cells other than sperm or egg cells in order to replace defective genes with functional ones.
  - Considerable agreement that somatic cell gene therapy to treat serious diseases is ethical.
- Germline cell engineering:
  - Not currently used therapeutically
  - Controversial practice in which genes in eggs, sperm or very early embryos are modified.
  - The long term side effects of such engineering are currently unpredictable.
  - Concerns it violates the rights of future generations or amounts to “playing God”.
  - Superhuman controversies.

# Gene editing



# Gene editing to assist transplanting of organs



# Acknowledgements

- Markkula Center for Applied Ethics  
(<https://www.scu.edu/ethics/ethics-resources>)
- Brey, P. (2009). ‘Biomedical Engineering Ethics.’ Eds. Berg-Olsen, J., Pedersen, S., Hendricks, V. (eds.), A Companion to Philosophy of Technology. Blackwell.
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- Monzon J.E. Teaching ethical issues in Biomedical Engineering Inst.J.Engng 15(4) 276-281, 1999