Orthopaedic Trauma Institute

Bones & Joints:

Keeping Them Healthy & Healing Them When Injured

UCSF Osher Mini Medical School for the Public
Department of Orthopaedic Surgery, Orthopaedic Trauma Institute
Course Chair: Theodore Miclau III, M.D.

Orthopaedic Trauma Institute

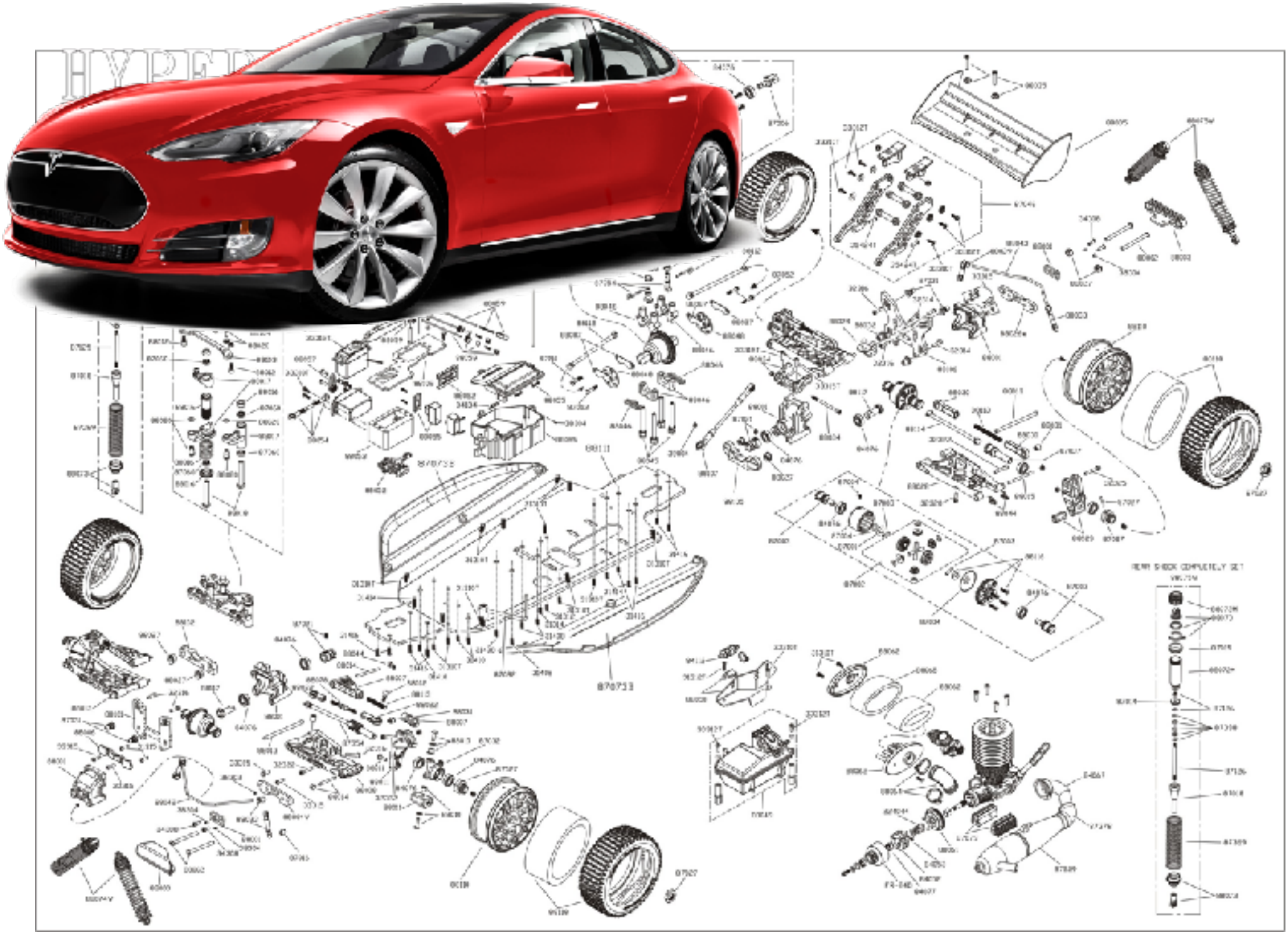
"Our mission: to mend the injured, inspire innovators, and empower leaders to restore lives."

Orthopaedic Trauma Institute

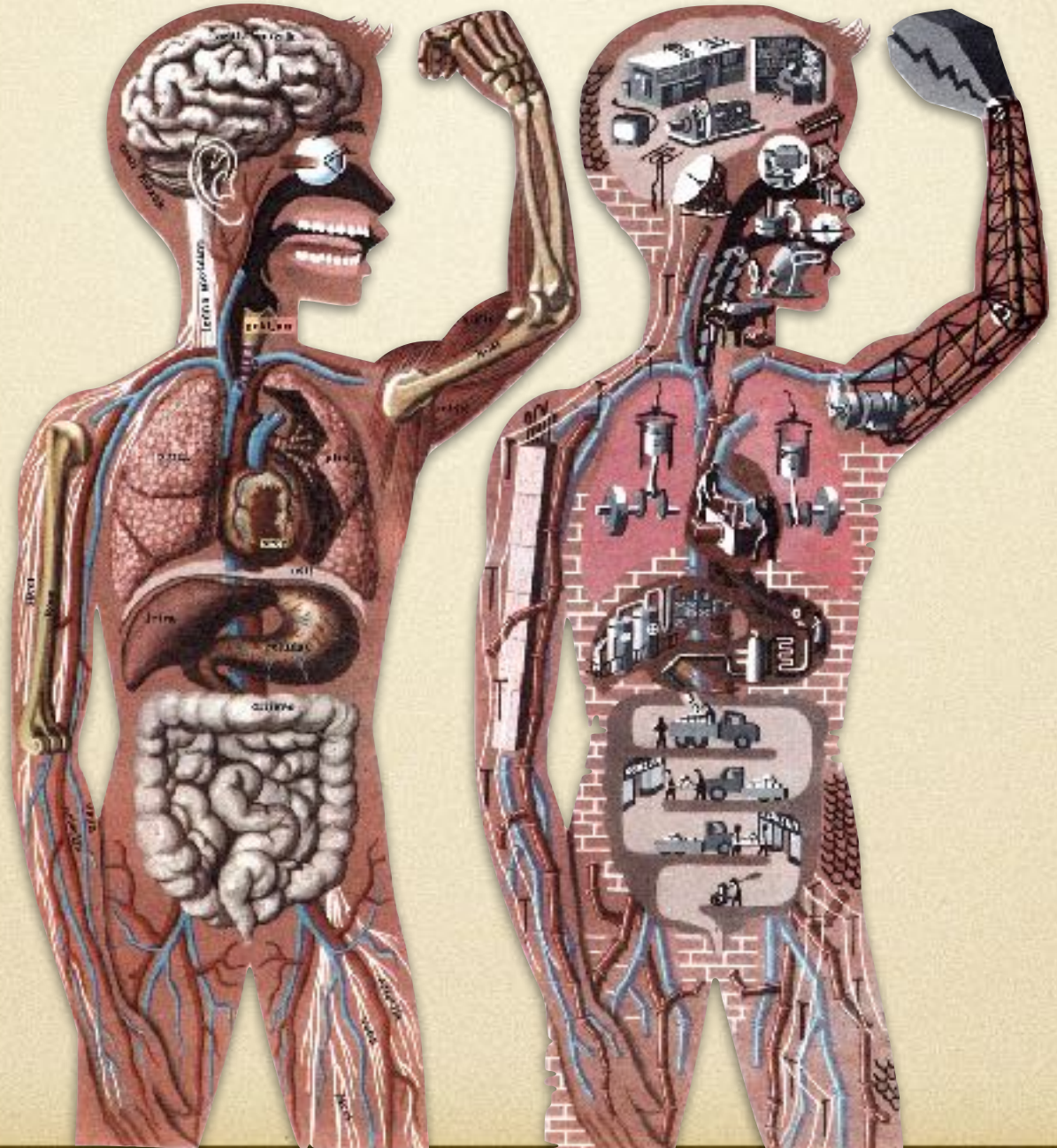
Engineering the Skeleton

Dr. Nathan Young, Ph.D.
Assistant Professor
UCSF Orthopaedic Surgery
Orthopaedic Trauma Institute

Introduction / Moderator

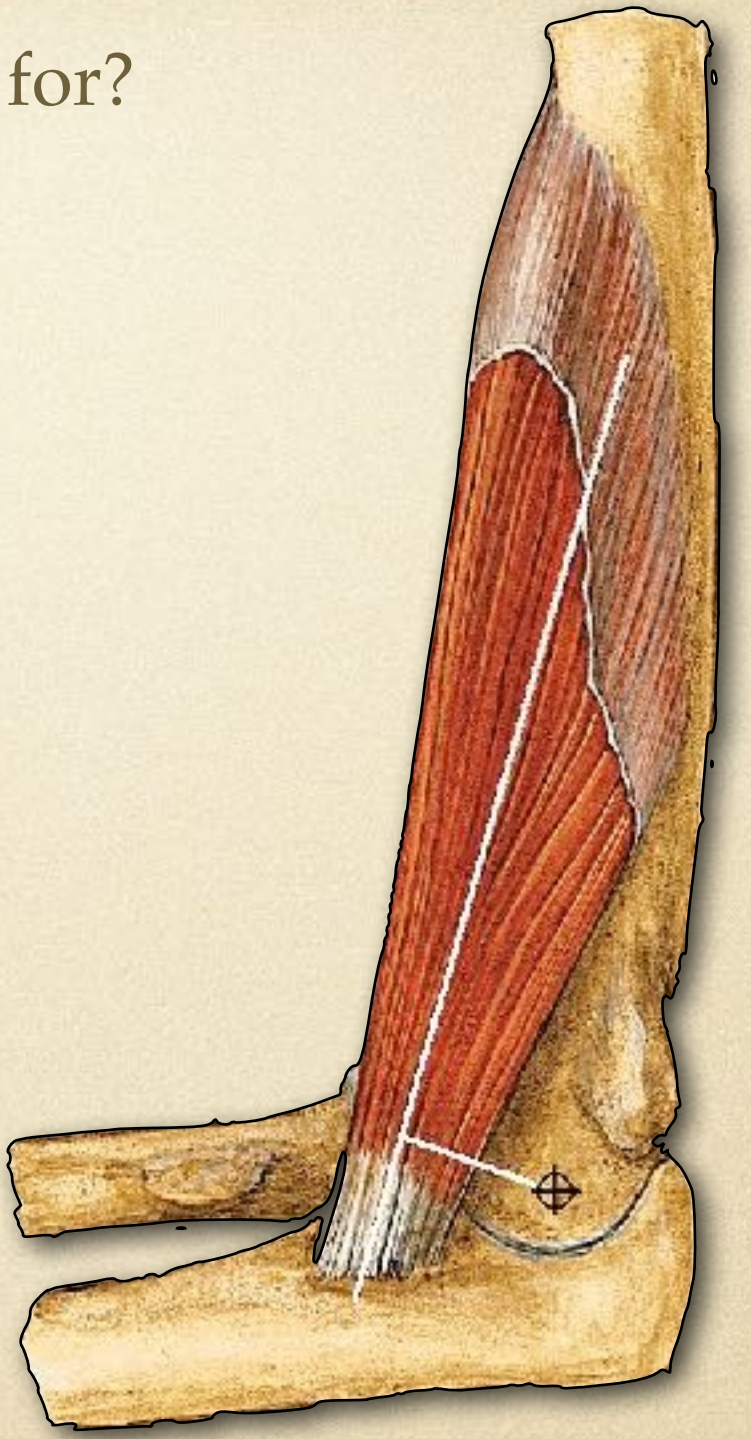

HYPER
REAR SHOCK COMPLETELY SET

The Body as Machine



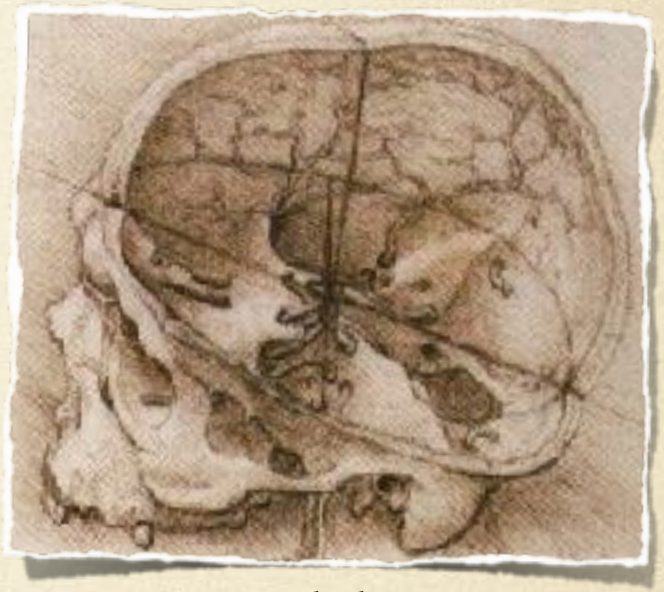
The Skeleton: What is it good for?

1. Structural Support
    A. Framework for the body
    B. Attachment point for muscles



The Skeleton: What is it good for?

1. Structural Support
    A. Framework for the body
    B. Attachment point for muscles
2. Protection of vital structures
    A. Brain
    B. Spinal cord
    C. Thoracic organs
    D. Internal reproductive organs



Leonardo de Vinci

Mike Tyson

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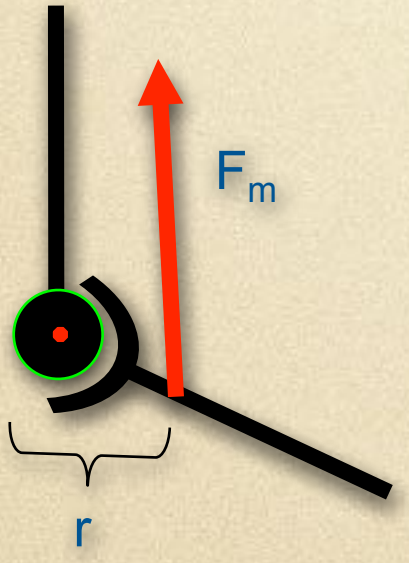
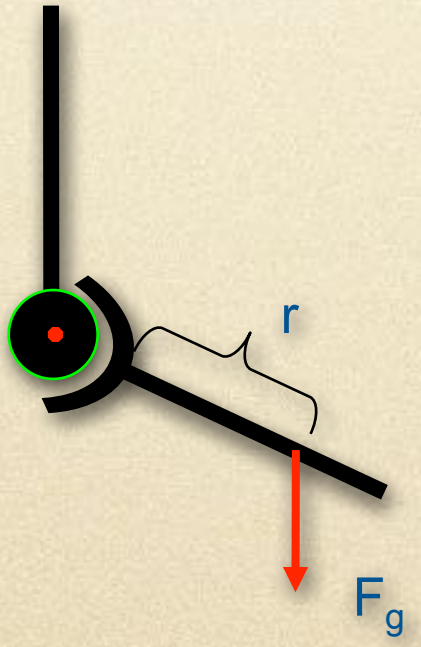
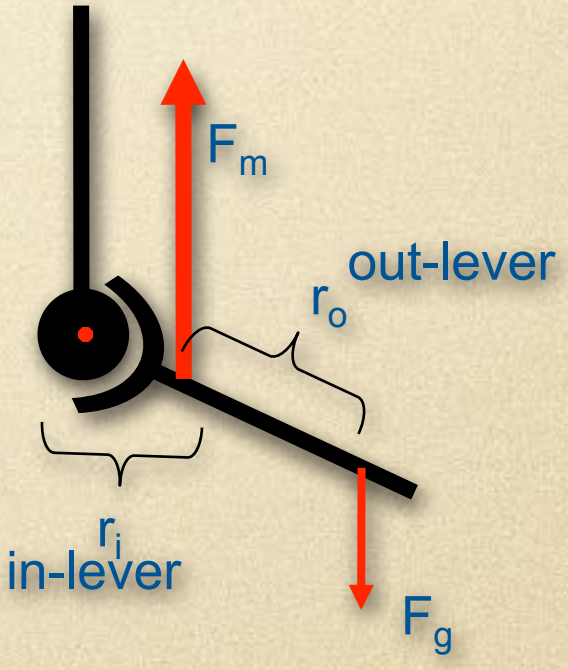
3. Facilitating Movement
    - A. Levers for muscles
    - B. Moveable joints act as fulcrums

NEWTON'S THREE LAWS

1. Inertia: a body stays at rest unless acted upon by a force
2. Acceleration: F/ mass (or F=ma)
3. **Reaction: For every action there is an equal and opposite reaction**







Part 1: Bone Biomechanics

Dr. Safa Herfat, Ph.D.
Orthopaedic Trauma Institute
Director, Biomechanics Laboratory

What is this guy doing?
How is he moving his arm?
How are the forces affecting his bones?

Something to think about…

?

Form = Function?

Part 1: Bone Biomechanics

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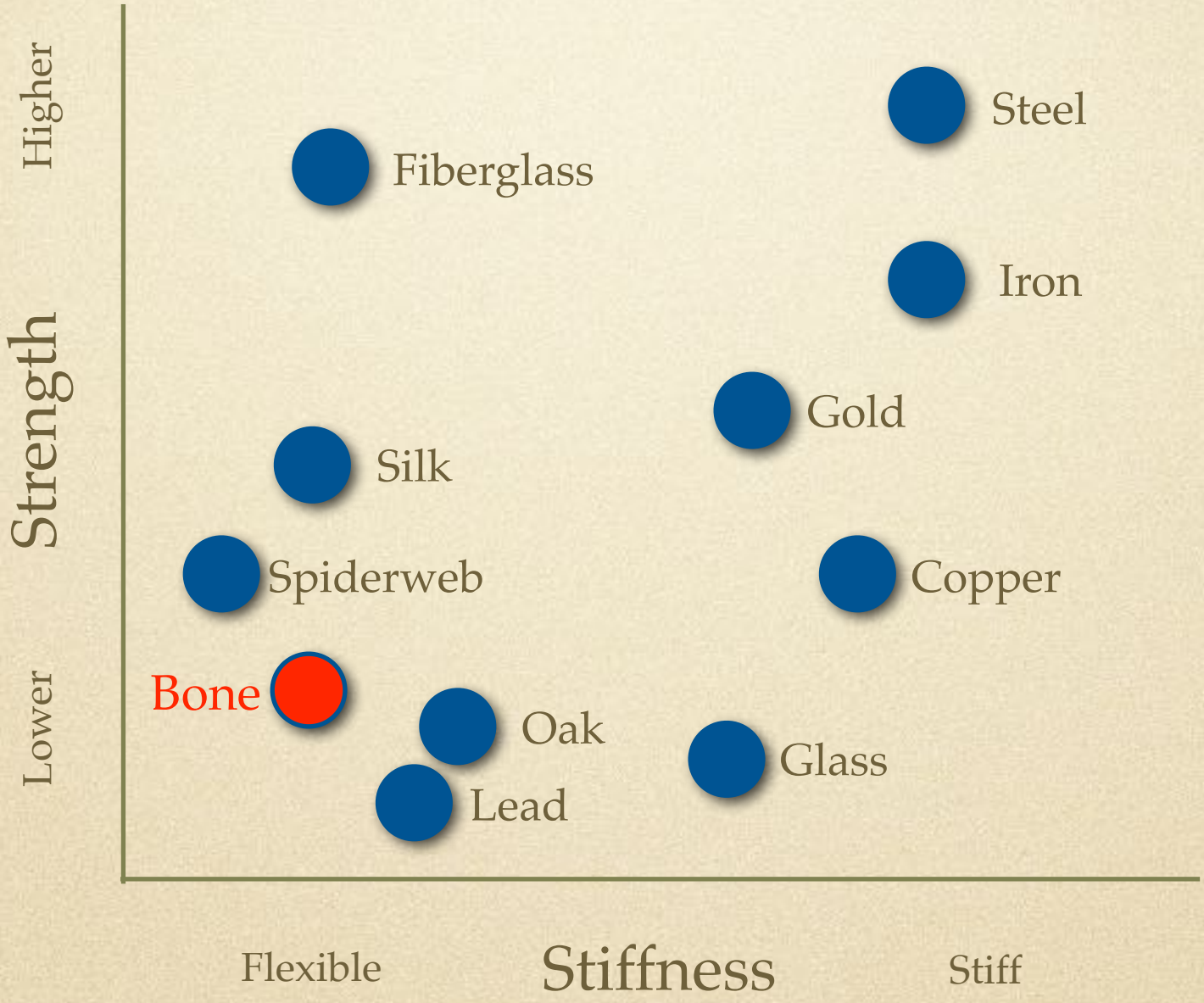
What happened to this guy?
How did the forces affect his bones?
How can we repair them?

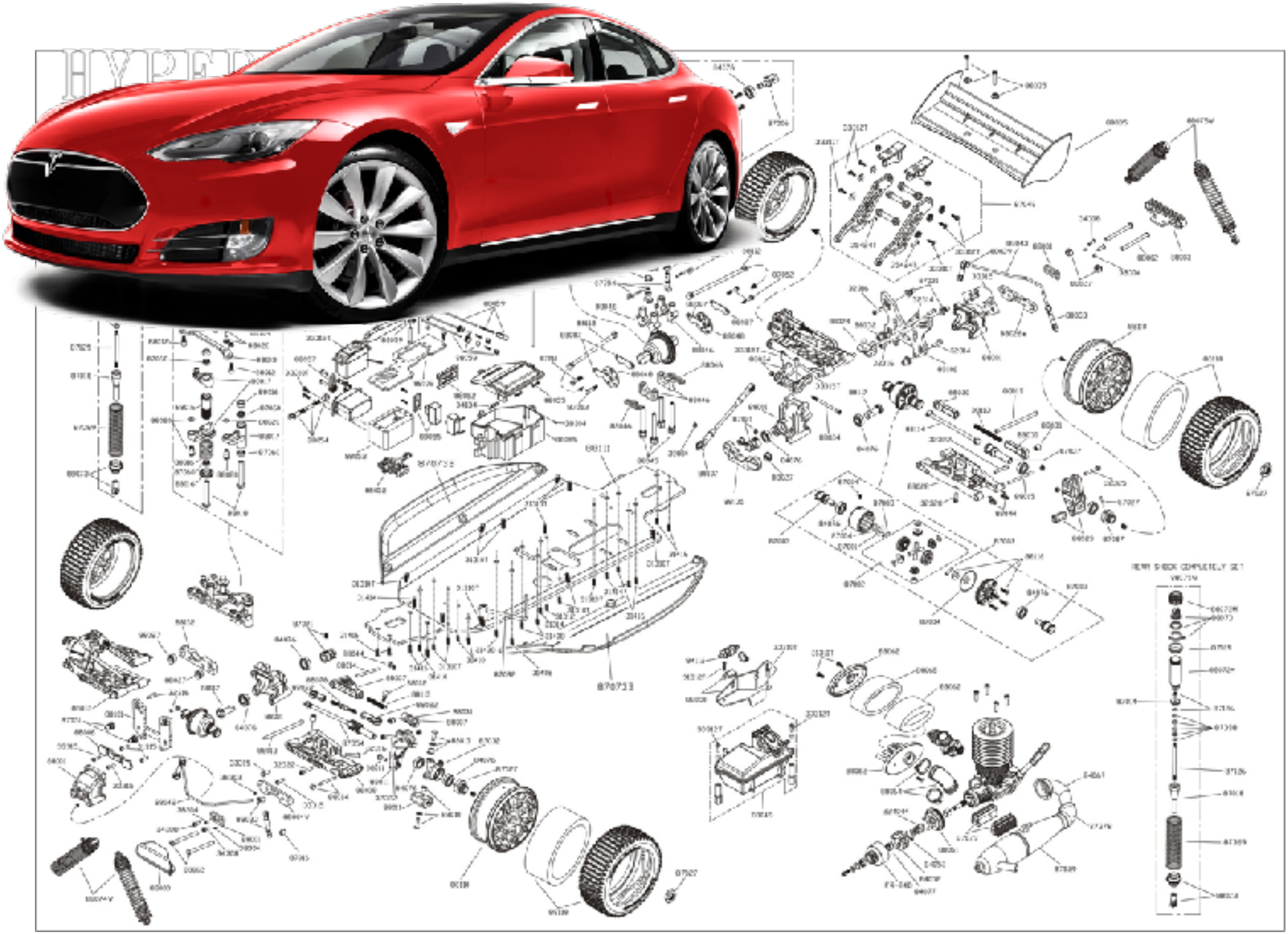
Bone: Material Properties



How can we leverage the properties of bone to better engineer skeletal repair?

Plate

Intra-
medullary
rod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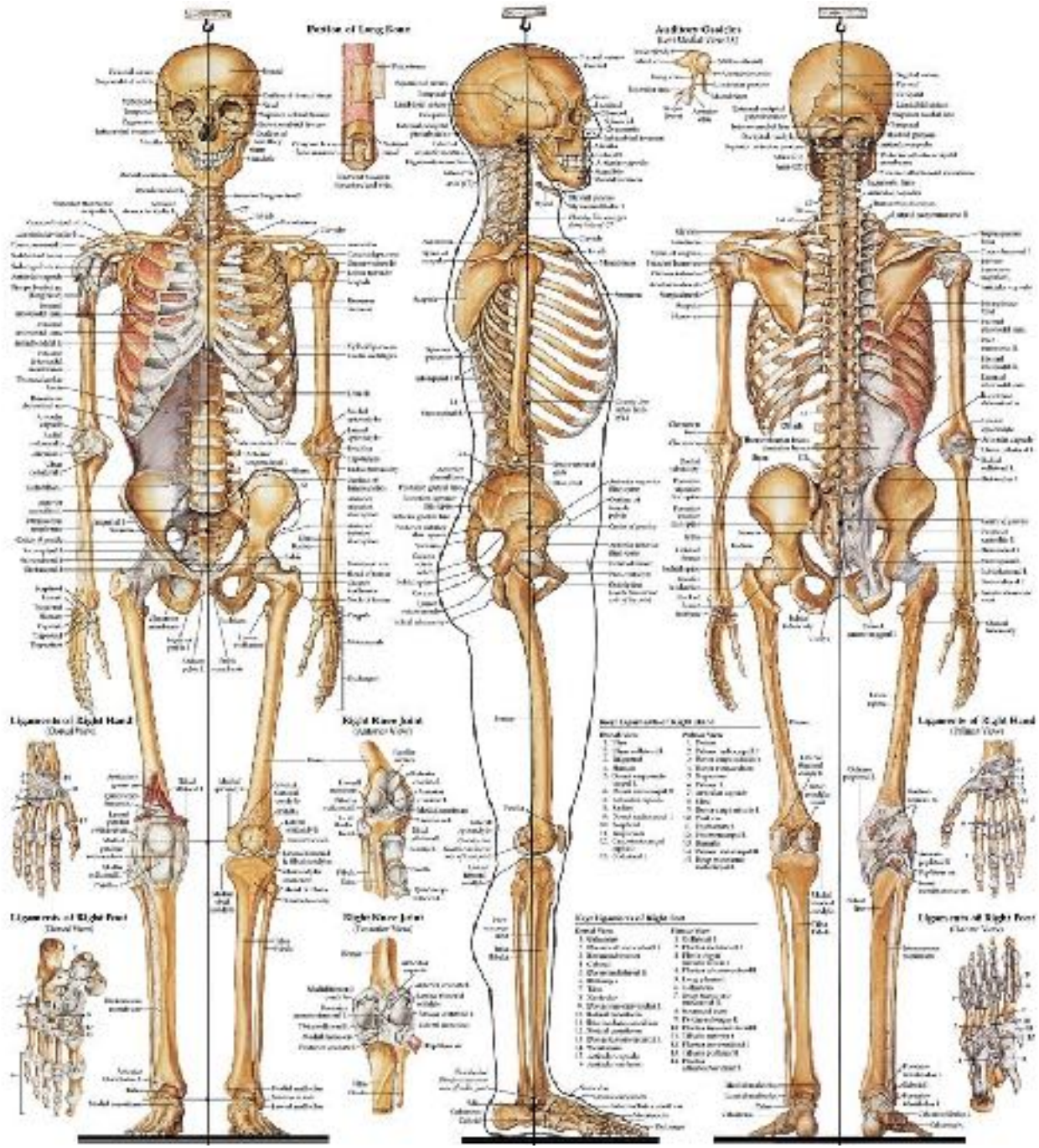
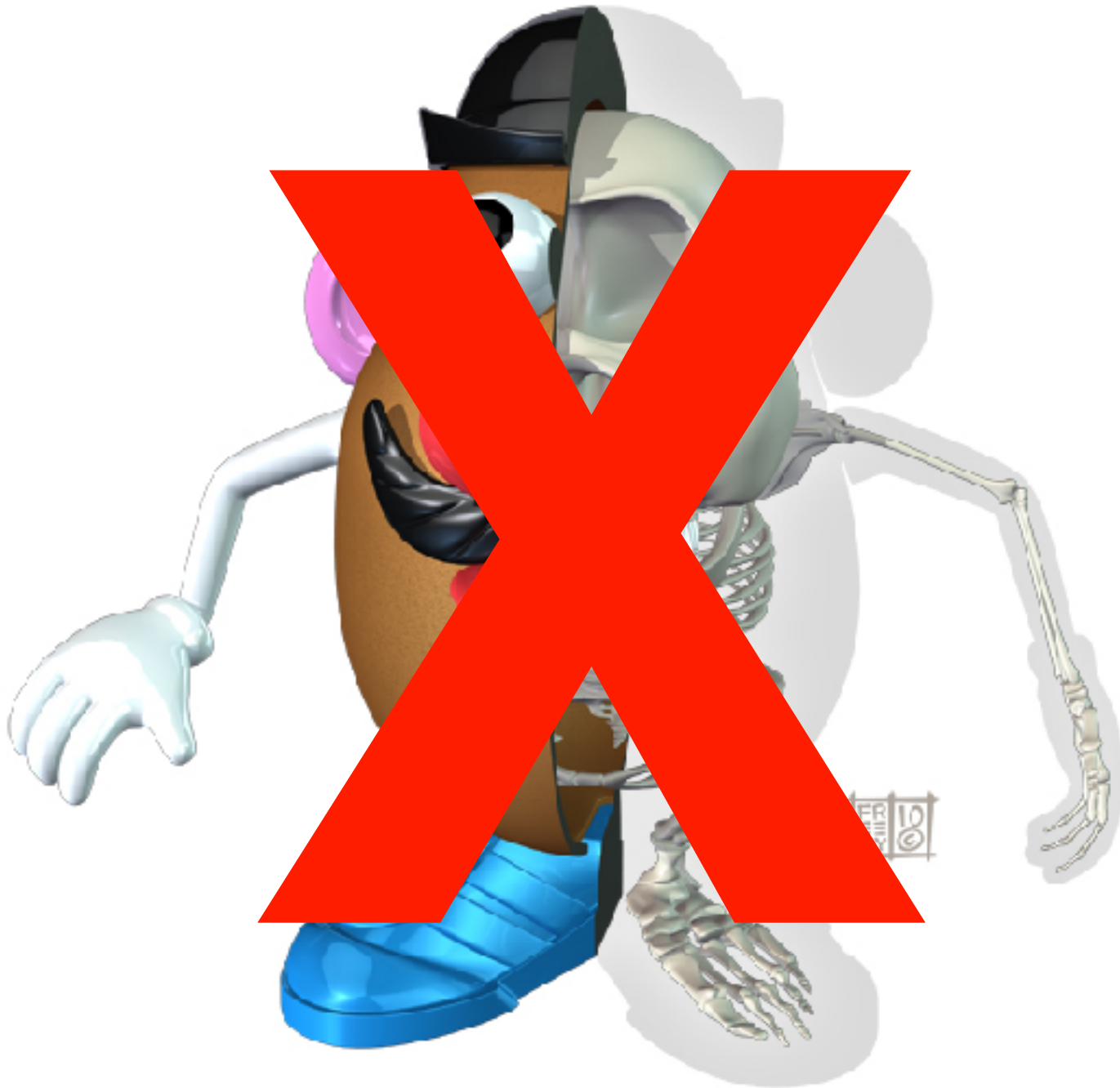
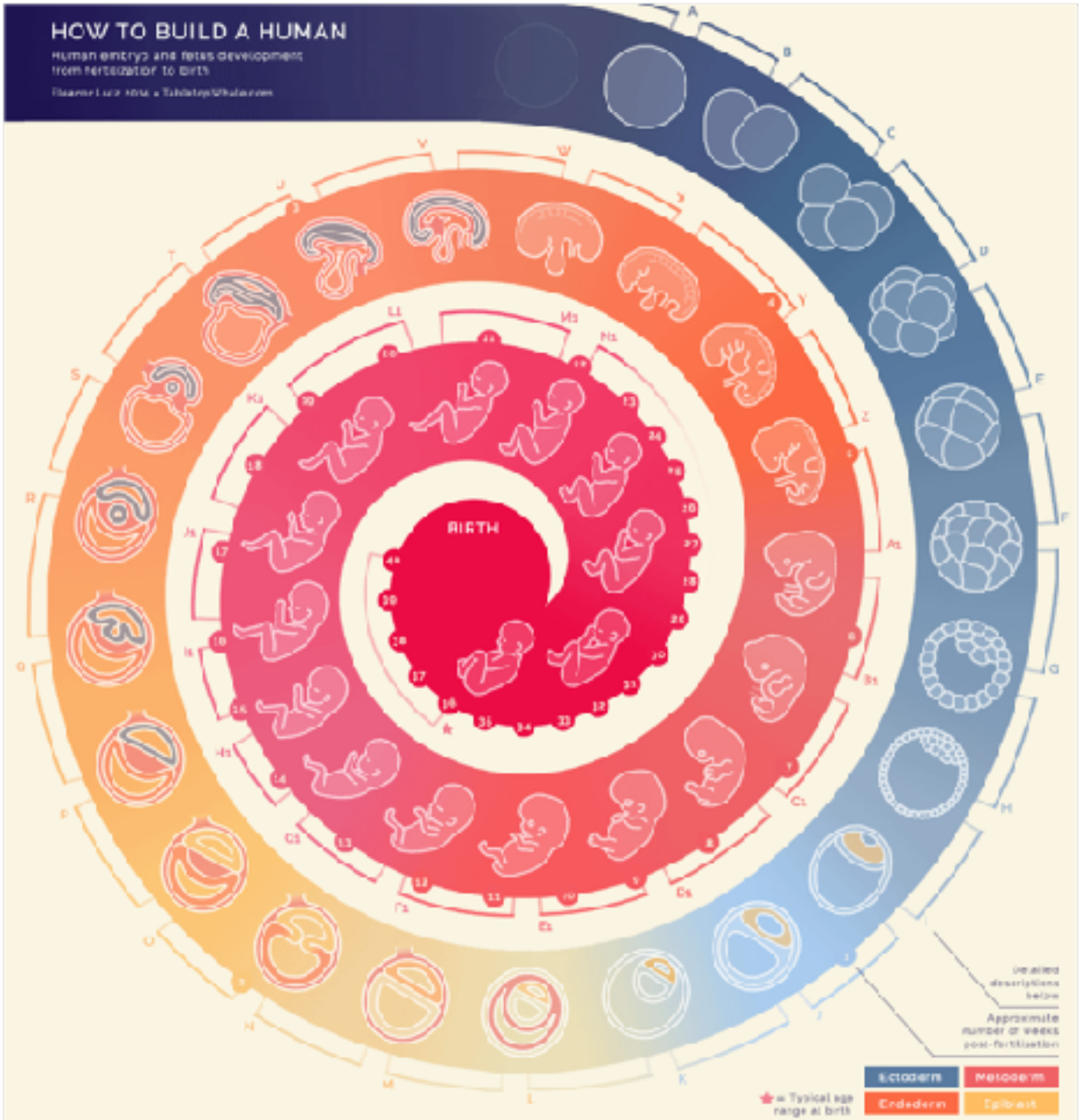




HOW TO BUILD A HUMAN

Human embryo and fetus development from fertilization to birth

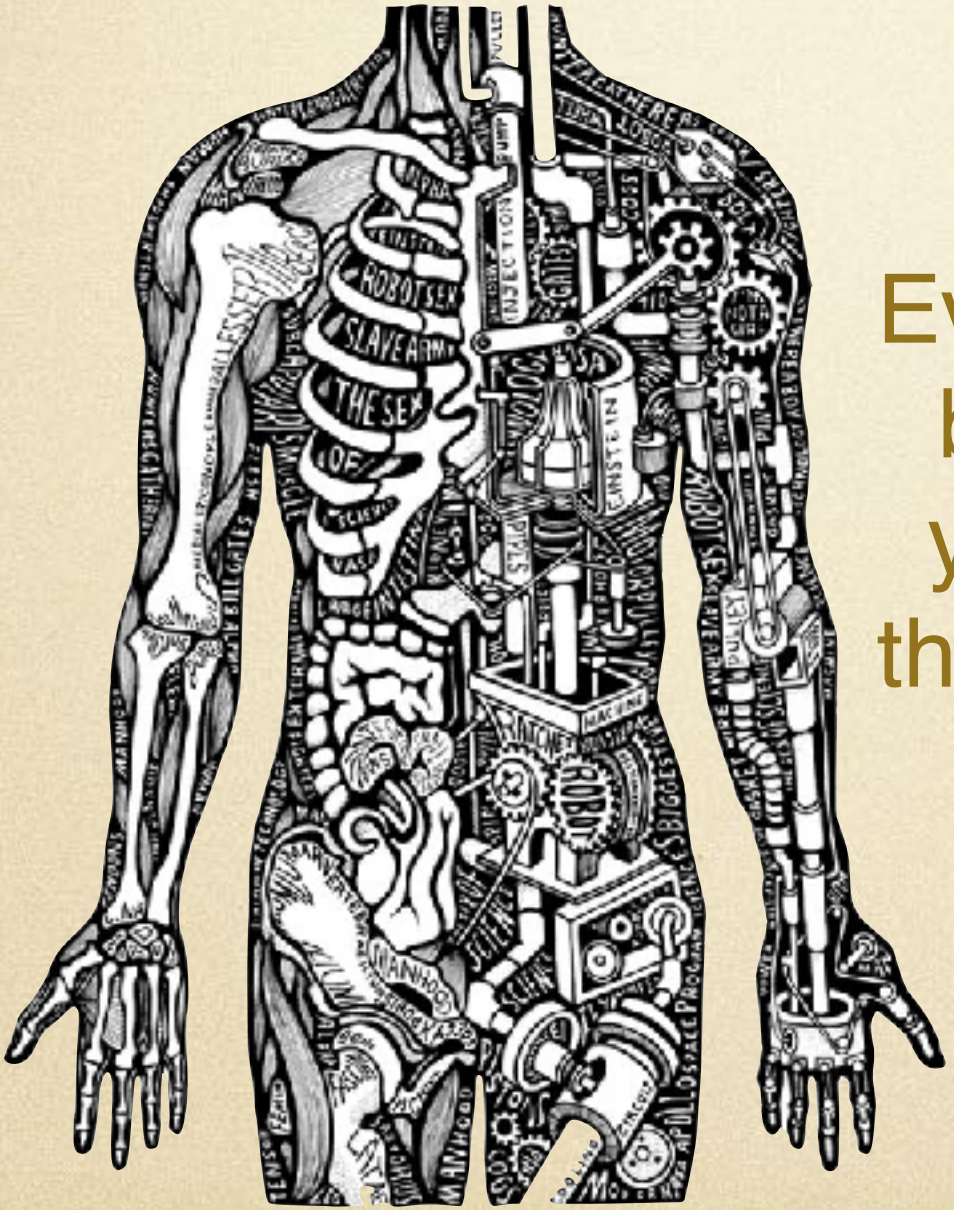


A. Fertilized egg
B. 2-cell stage
C. 4-cell stage
D. 8-cell stage
E. Compacted 8-cell
F. Morula
G. Blastocyst
H. ICM growth
I. Bilaminar germ disk
J. Amniotic cavity/yolk sac
K. Implantation complete
L. Extraembryonic mesoderm
M. (Zoom)
N. Hypoblast cells replaced
O. Mesoderm immigration
P. Ectoderm formation
Q. Primary neurulation
R. Secondary neurulation
S. Neurulation complete
T. (Ballate view)
U. Embryonic folding
V. Primitive gut tube forms
W. Oxidate to outside view)
X. Major blood vessels form
Y. Upper limb bud forms
Z. Lower limb bud forms
A1. Hand plate forms
B1. Webbed fingers and toes
C1. Fingers/toes separate
D1. Gonads differentiate by sex
E1. Eyelids fuse
F1. Iris develops
G1. Second trimester
H1. Taste pores develop
I1. Fetus weighs about 100g
J1. Vernix caseosa covers skin
K1. Lanugo replaced by villus
L1. HPA axis established
M1. Fetus weighs about 500g
N1. >50% survival if born

Amazing system!

Permits function during growth

BioEngineering Challenges



Every bone in your body took many years to achieve their current shape and size!

BioEngineering Challenges

We’re not quite here yet (thankfully?)

FOLLOWED BY…Part 2: Regrowing the Skeleton

Dr. Chelsea Bahney, Ph.D.
Orthopaedic Trauma Institute
Co-Director, Laboratory for
Skeletal Regeneration

Developmental Engineering:
How can we make bones?
How can we heal them
quicker?

Instructive Cues in the Microenvironment

Chemical	Biochemical	Physical
• hypoxia • pH	• growth factors • cytokines • hormones	• topography • flow • stiffness

Development

Same developmental signals are disrupted in disease

Chemical	Biochemical	Physical
• hypoxia	• growth factors	• topography
• pH	• cytokines	• flow
	• hormones	• stiffness

Development

Disease Progression

Understanding the instructive cues
in skeletal development provides insight
into skeletal disease and therapies to treat it

These signals are recapitulated during skeletal repair

How can we leverage & augment the bodies innate capacity to heal?