

# BIOMEDICAL ENGINEERING DESIGN

WB2308

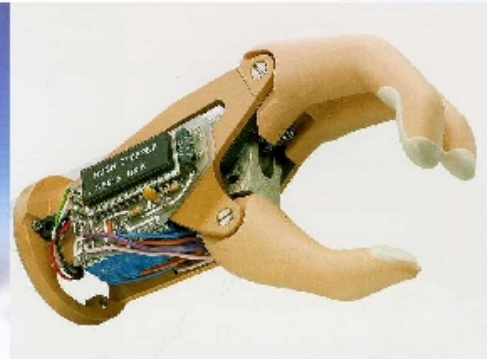
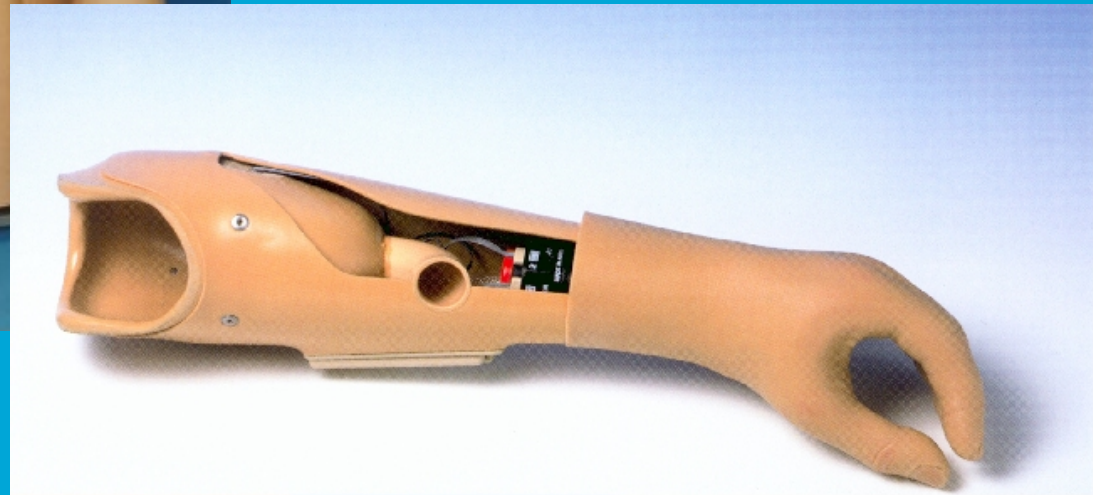


# LECTURE STRUCTURE

1. INTRODUCTION  
CLINICALLY DRIVEN PROBLEM ANALYSIS  
ASSIGNMENT
2. **BASIC REQUIREMENTS: REHABILITATION**
3. BASIC REQUIREMENTS: ORTHOPAEDICS
4. PROBLEM ANALYSIS: STUDENT PRESENTATIONS
5. DESIGN ENGINEERING: THE CREATIVE PROCESS
6. DESIGN ENGINEERING PRINCIPLES
7. EXAMPLES: REHABILITATION  
ORTHOPAEDICS

# VIDEO

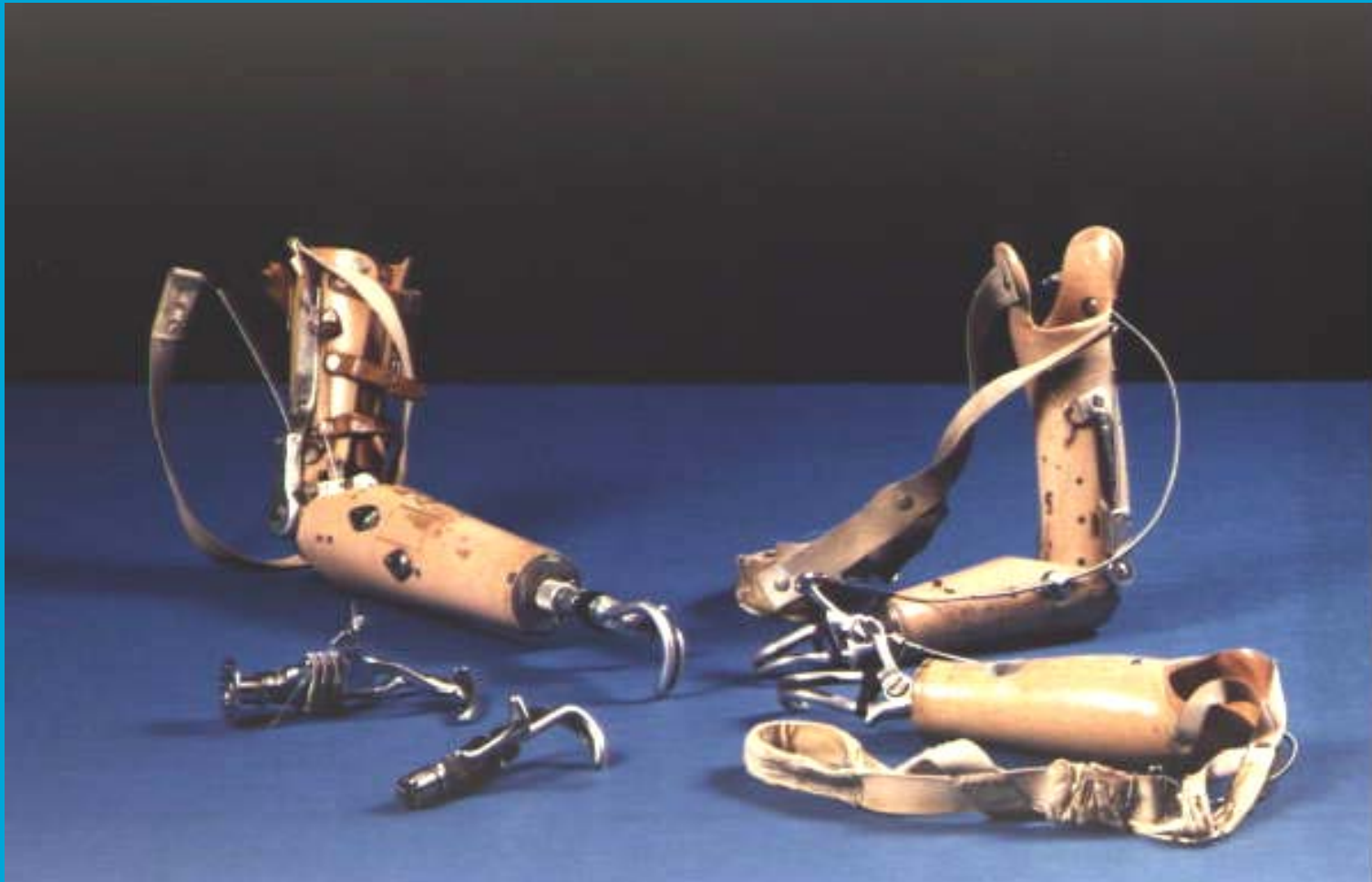
- INTRODUCTION INTO PROSTHETICS
- OLD, BUT STILL UP TO DATE
- PRO'S & CON'S
- AUDIO IN DUTCH
- 42 MINUTES



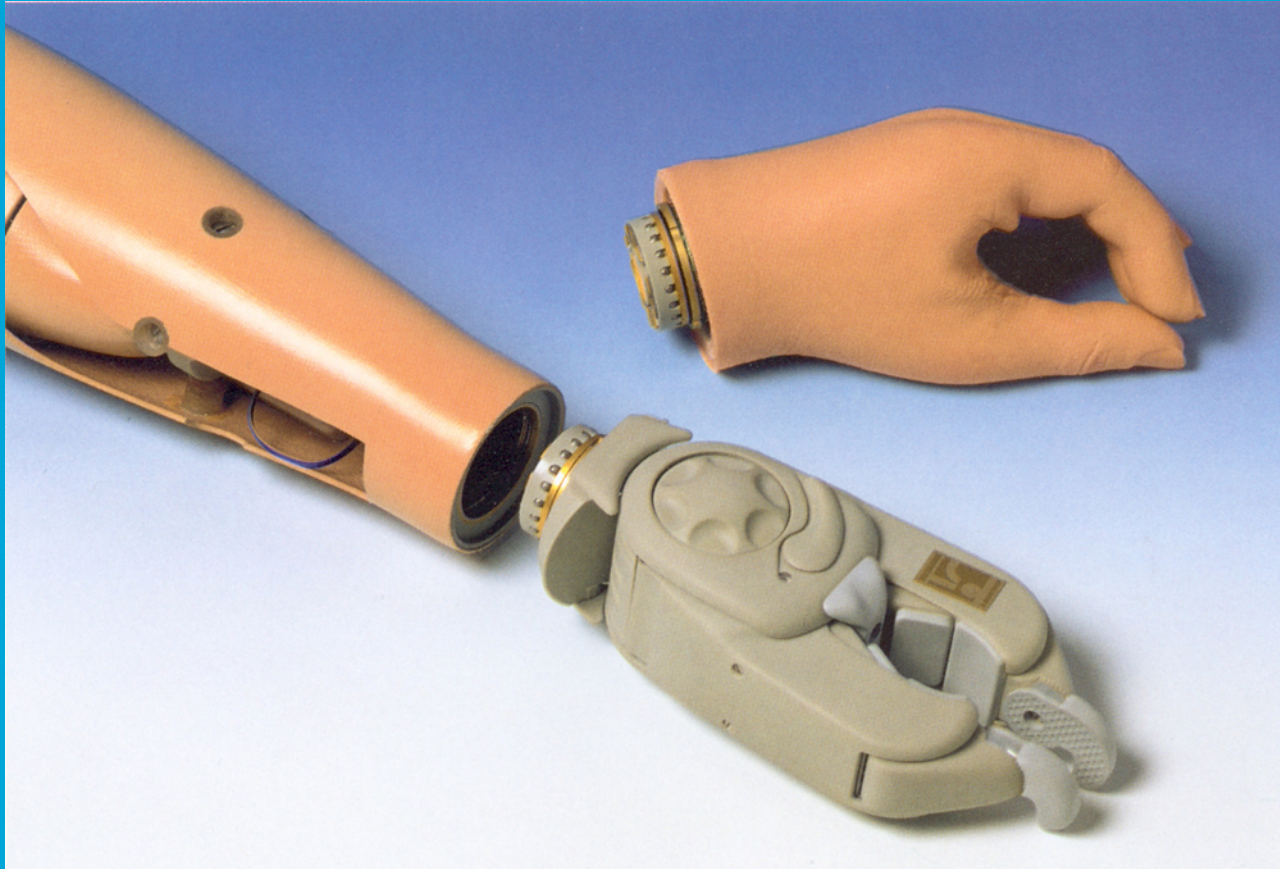
- MANY PROSTHESES NOT USED: 40 – 60 % <sup>1</sup>
- MANY PROSTHESES NOT WORN: 20 – 40 % <sup>1</sup>

BECAUSE:  
CURRENT PROSTHESES DO NOT MATCH EXPECTATIONS

# TOO UGLY



# TOO HEAVY



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# TOO CLUMSY



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COSMESIS

COMFORT

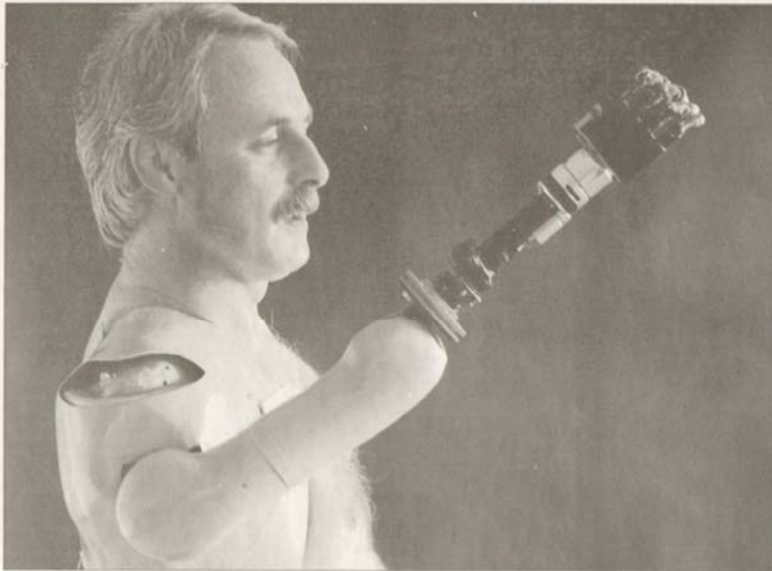
CONTROL

## WHAT TO DO?

- PROPER EDUCATION
- PROSTHESIS ACCORDING STATE OF THE ART
- NEW PROSTHETIC DESIGNS

## Science fiction becomes a reality with first bionic arm

It was the stuff of science fiction. As Mr Campbell Aird lifted his right arm for the first time in more than 16 years last week the faint whirr of electric motors could be heard from underneath his



Schot krijgt bionische arm

Campbell Aird (47) toont vol trots de bionische arm die artsen gisteren in een ziekenhuis in Edinburgh bij hem aanbrachten. Airds rechterarm was zestien jaar geleden geamputeerd wegens spierkanker. Hij is nu de eerste man ter wereld met een bionische schouder en arm.



# SCHEPPER VAN NIEUW LEVEN



*De bionische mens wordt werkelijkheid!*

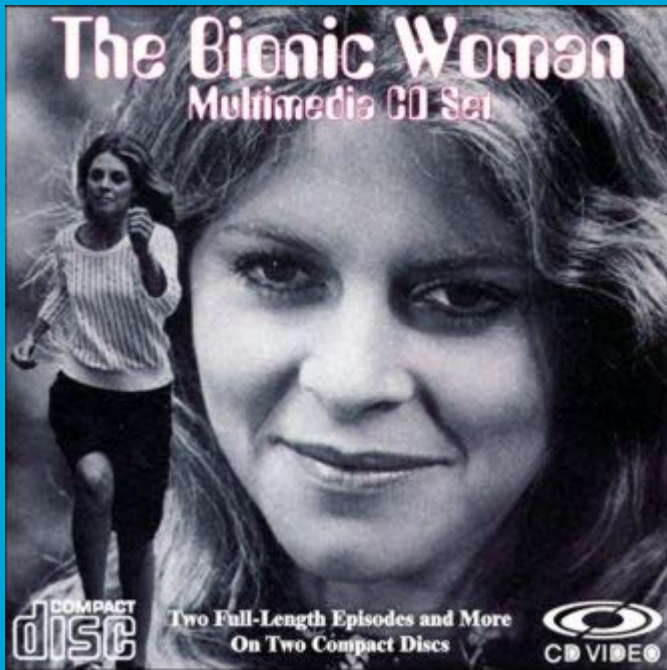




Terminator 3: The Redemption developer Paradigm Entertainment publisher Atari

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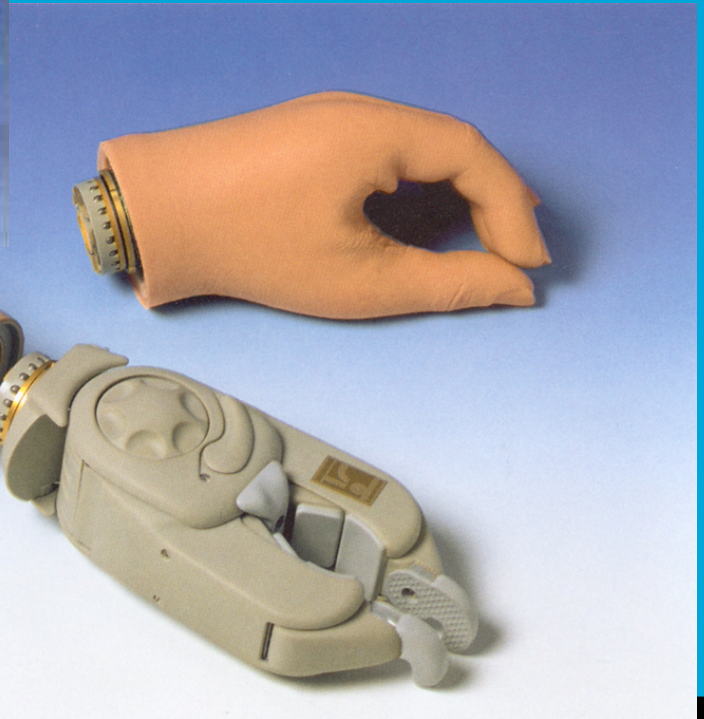
# Remember Lindsey Wagner as the "Bionic Woman"?



Well, we have the new version...  
Claudia Mitchell ...and this one's  
for real.



".... controlled by thoughts alone ...."



Otto Bock Healthcare GmbH



*Human  
Limbs  
and Their  
Substitutes*

KLOPSTEG  
and WILSON  
ET AL.

McGRAW-HILL

## HUMAN LIMBS AND THEIR SUBSTITUTES

*Presenting Results of Engineering and Medical Studies of the  
Human Extremities and Application of the Data to the Design and  
Fitting of Artificial Limbs and to the Care and Training of Amputees*

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*Prepared under the sponsorship of the  
Advisory Committee on Artificial Limbs  
National Academy of Sciences  
National Research Council*

*In summary and correlation of a research  
program for the Department of Medicine and  
Surgery, U.S. Veterans Administration, and for  
the Office of the Surgeon General, Department  
of the Army*

PAUL E. KLOPSTEG, Ph.D., Sc.D

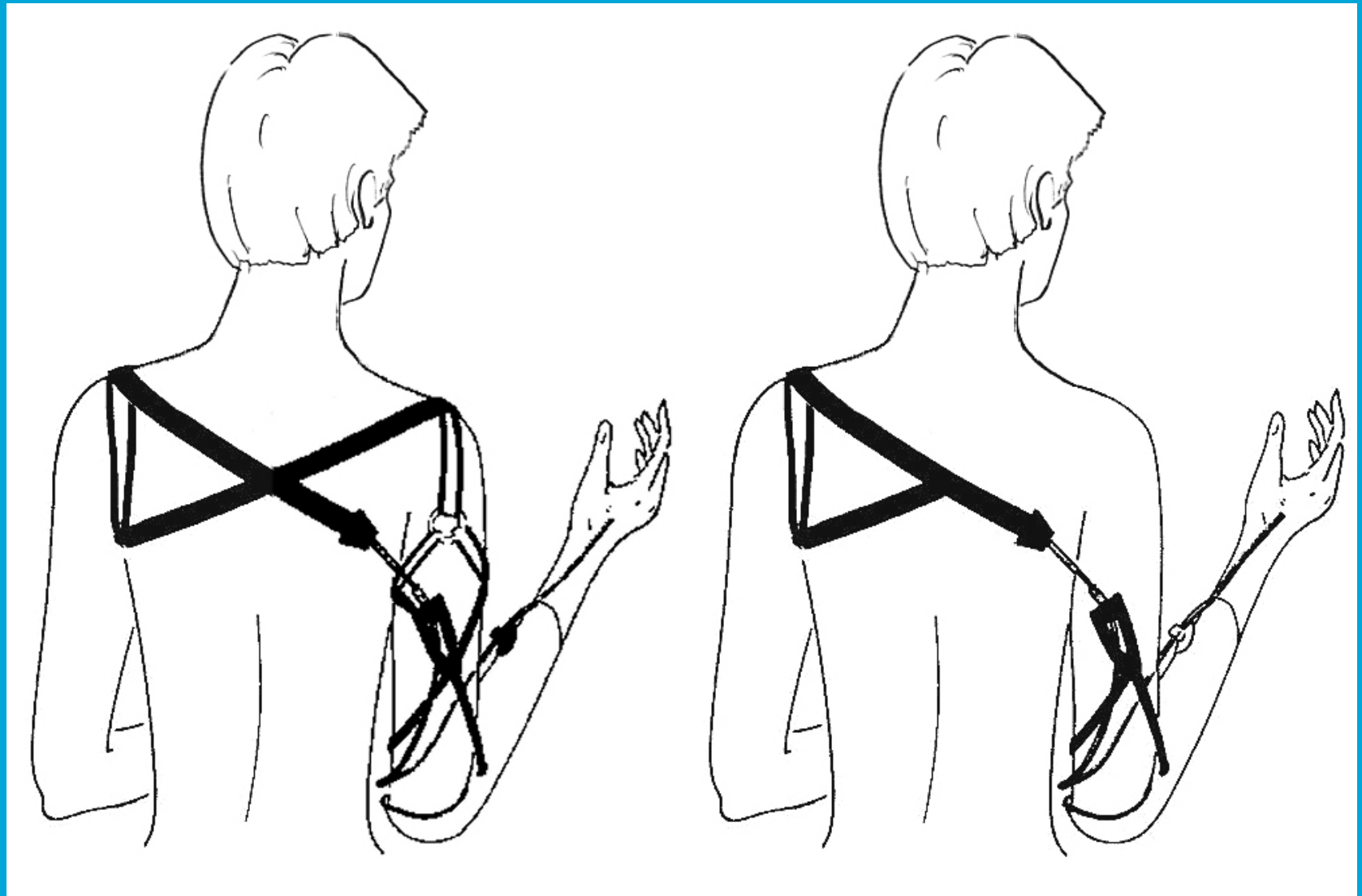
PHILIP D. WILSON, M.D., *et al.*

1954 · McGraw-Hill Book Company, Inc.

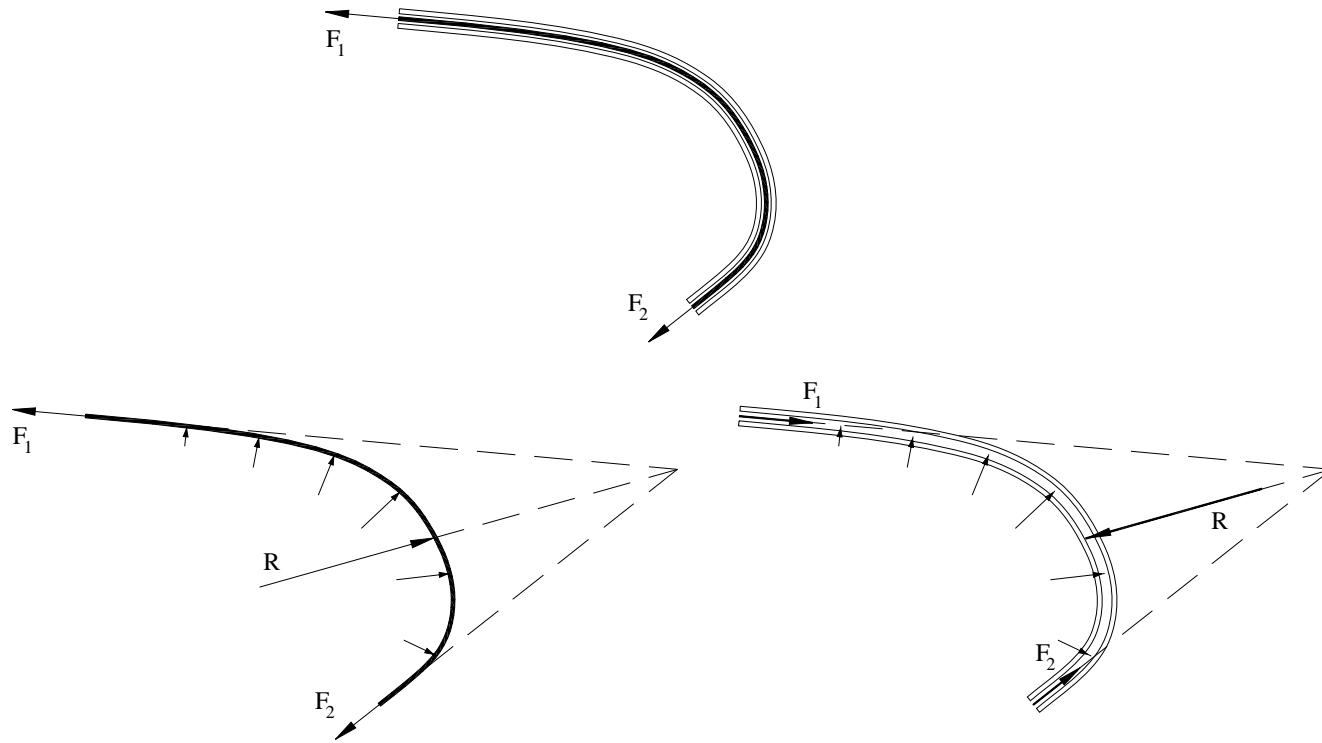
New York Toronto London

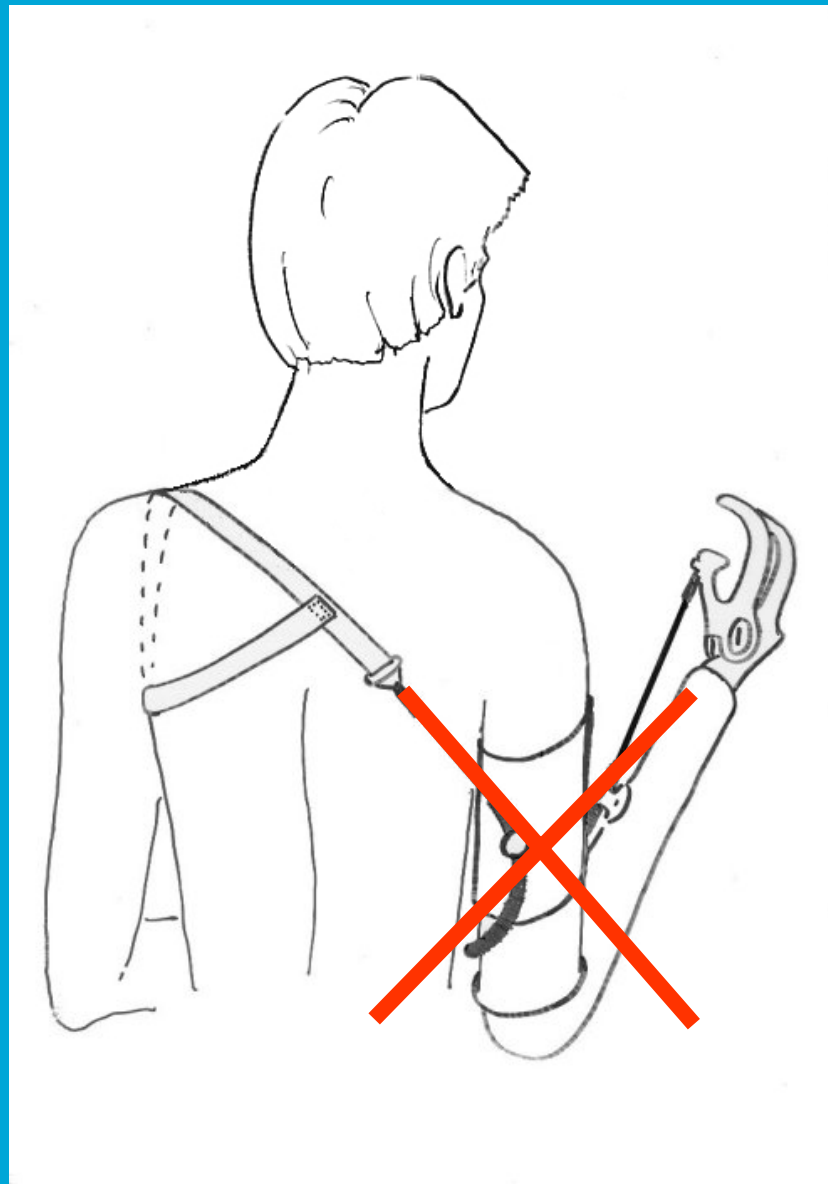


# STATE of the ART

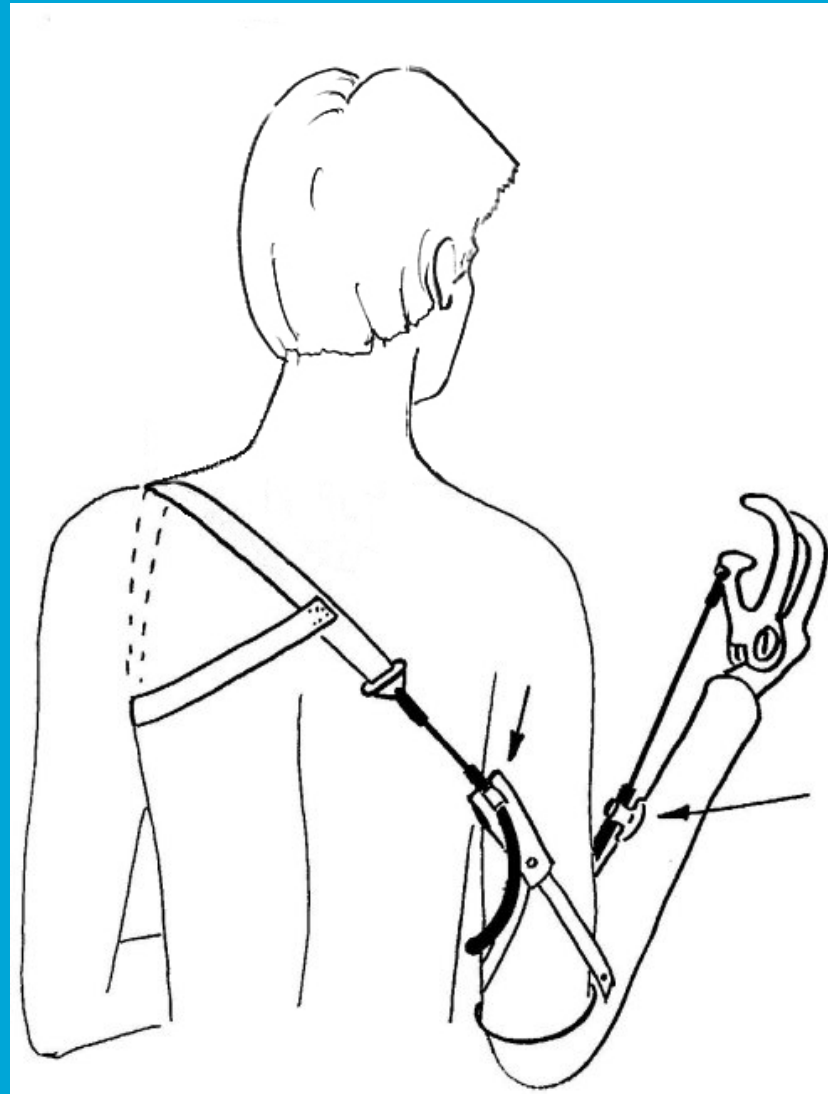


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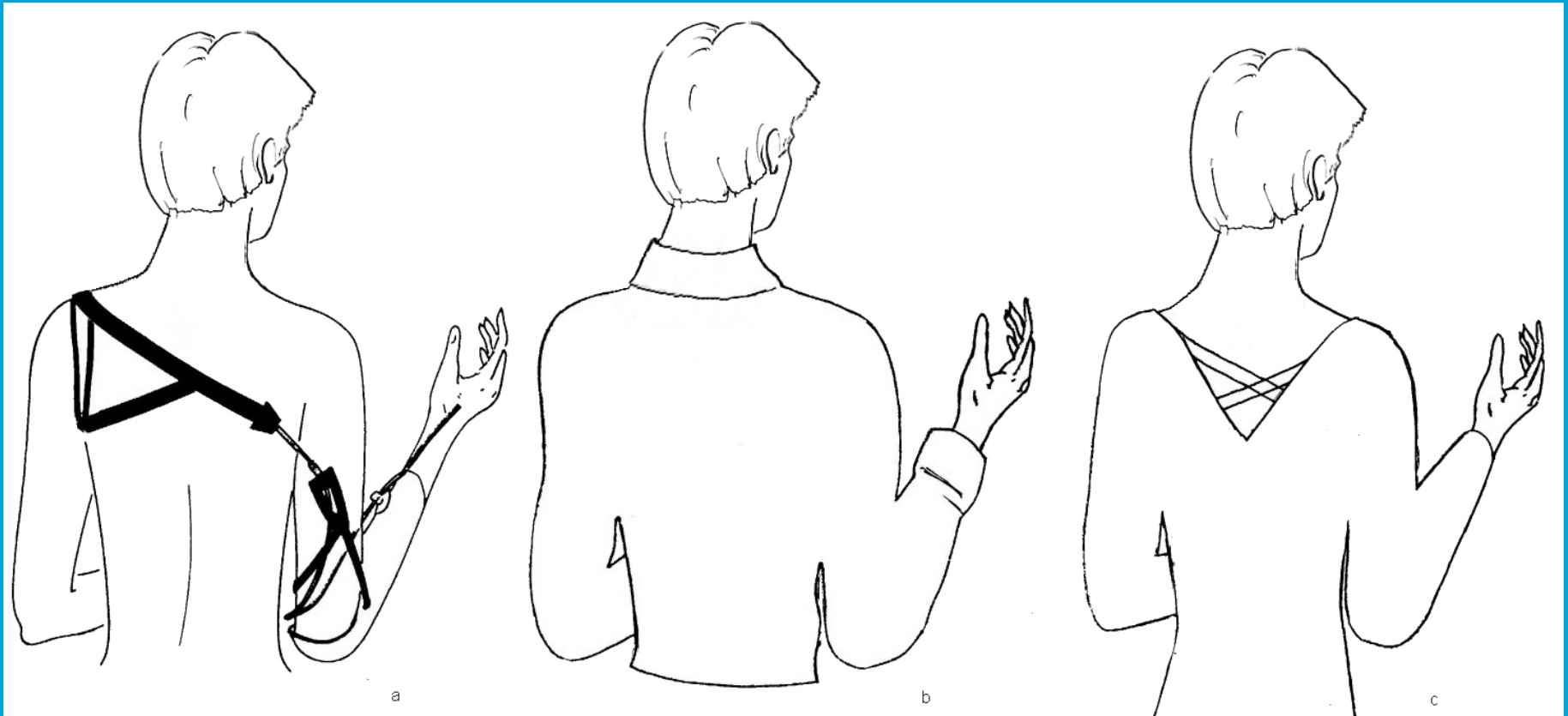




# STATE of the ART



# STATE of the ART

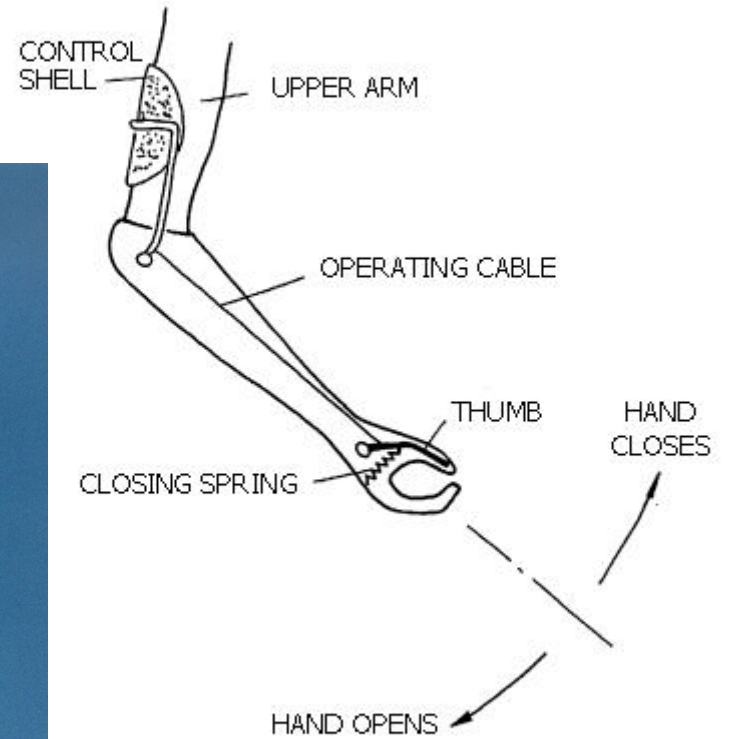
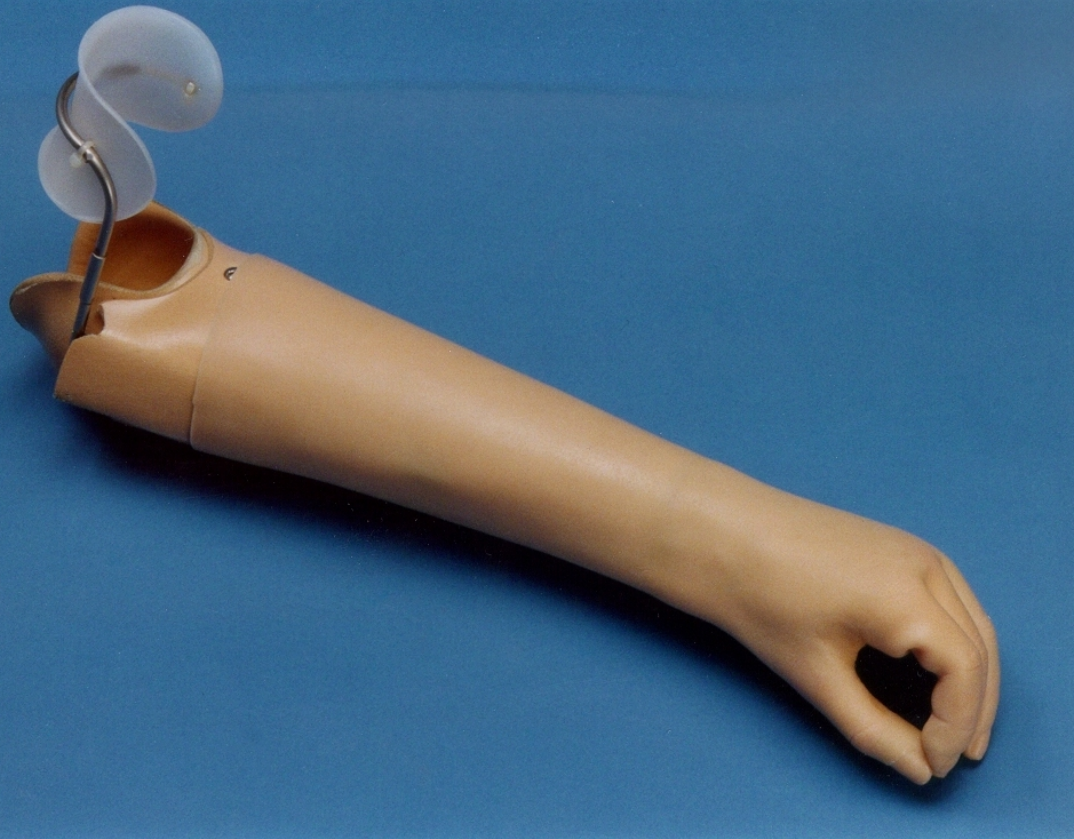


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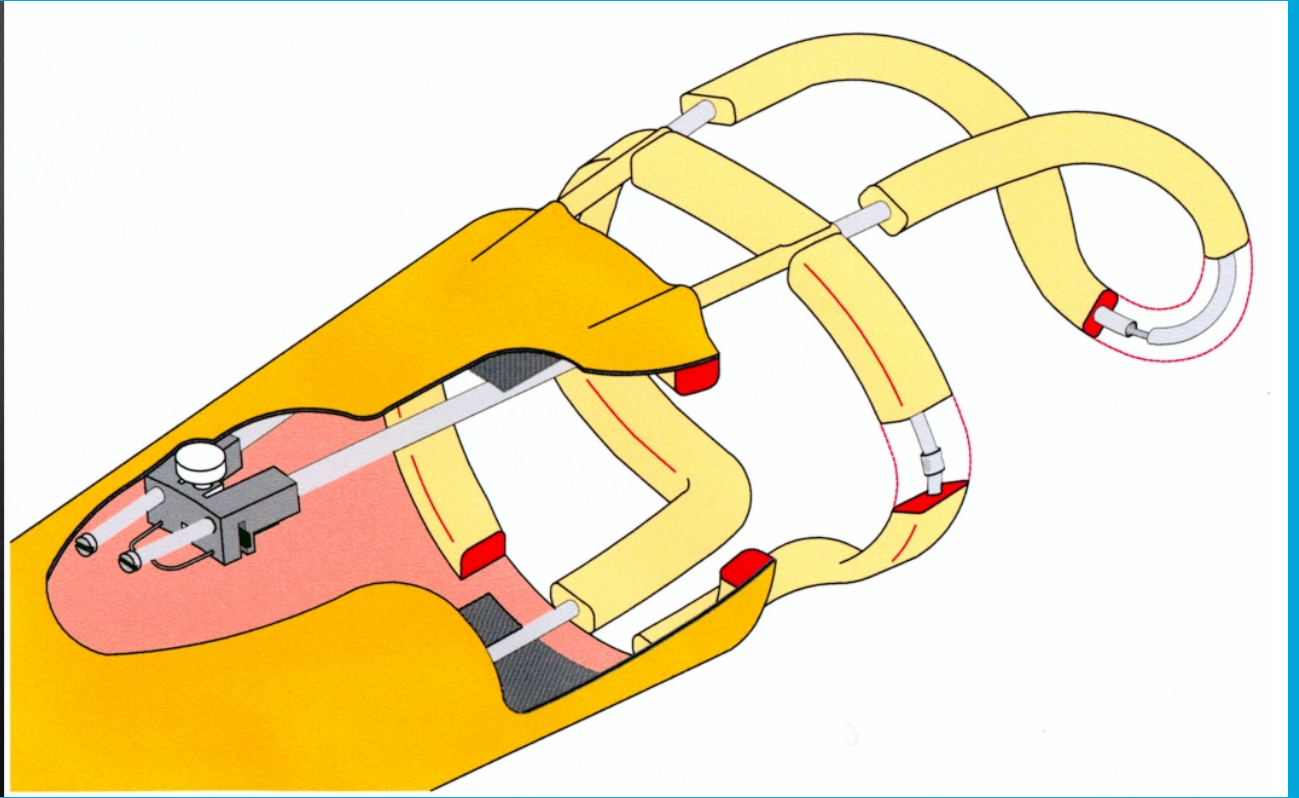




# STATE of the ART



# STATE of the ART



COSMESIS

COMFORT

CONTROL

## COSMESIS, COMFORT, CONTROL

- History
- Time

## 1967: start of Rehab Treatment Team [WOP], De Hoogstraat

- Rehab Physician, Physical Therapist, Occupational Therapist, Social Worker, Prosthetist
- sometimes also Orthopaedic Surgeon, Psychologist
- involvement of MFI-TNO and TU-Delft
- patient-centered!

Today:

Collaboration in 4 teams,  
for children and adults.

Rehabilitation Center  
De Hoogstraat, Utrecht



Rehabilitation Center  
Sint Maartenskliniek, Nijmegen

# NEW DESIGN REQUIREMENTS

Light	Licht
Beautiful	Mooi
Quiet	Stil
Fast	Snel
Useful	Handig
Good	Goed
Small	Klein
Efficient	Zuinig
Clean	Schoon



1970 - 1975

31

# NEW DESIGN REQUIREMENTS

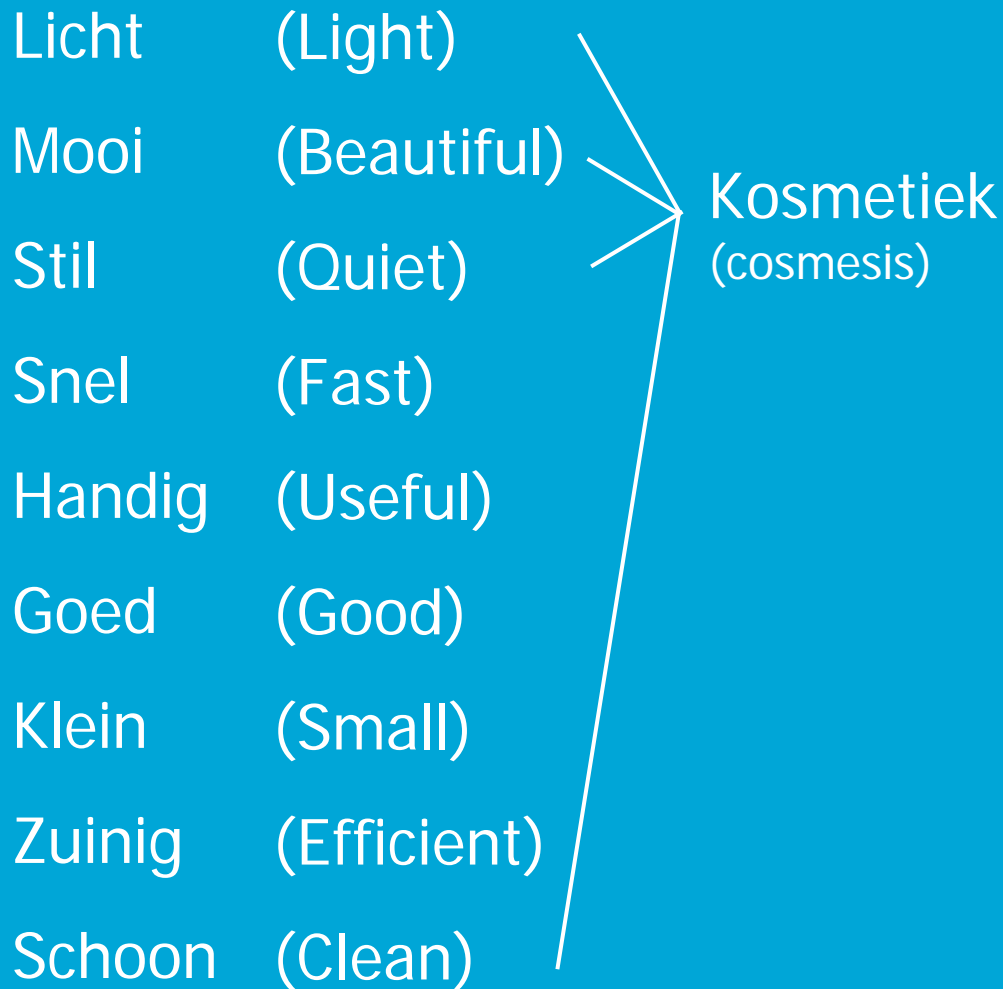
Light	About the weight
Beautiful	Natural appearance
Quiet	Unscipiscious
Fast	Slow = annoying
Useful	Functional gain
Good	Reliable
Small	Fits within normal anatomy
Efficient	energy consumption
Clean	No stains and wear of clothing

1970 - 1975

32



# NEW DESIGN REQUIREMENTS



1970 - 1975

33

# NEW DESIGN REQUIREMENTS



1970 - 1975

34

# NEW DESIGN REQUIREMENTS

Licht (Light)

Mooi (Beautiful)

Stil (Quiet)

Snel (Fast)

Handig (Useful)

Goed (Good)

Klein (Small)

Zuinig (Efficient)

Schoon (Clean)



Bedieningsgemak  
(ease of operation)

1970 - 1975

35

# NEW DESIGN REQUIREMENTS

Licht (Light)

Mooi (Beautiful)

Stil (Quiet)

Snel (Fast)

Handig (Useful)

Goed (Good)

Klein (Small)

Zuinig (Efficient)

Schoon (Clean)

Kosmetiek  
(cosmesis)

Draagcomfort  
(wearing comfort)

Bedieningsgemak  
(ease of operation)

1970 - 1975

1980 - 1985

36

# NEW DESIGN REQUIREMENTS

Licht (Light)

Mooi (Beautiful)

Stil (Quiet)

Snel (Fast)

Handig (Useful)

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Schoon (Clean)

Kosmetiek  
(cosmesis)

Draagcomfort  
(wearing comfort)

Bedieningsgemak  
(ease of operation)

Cosmesis

Comfort

Control

1970 - 1975

1980 - 1985

1990 - 1994

COSMESIS

COMFORT

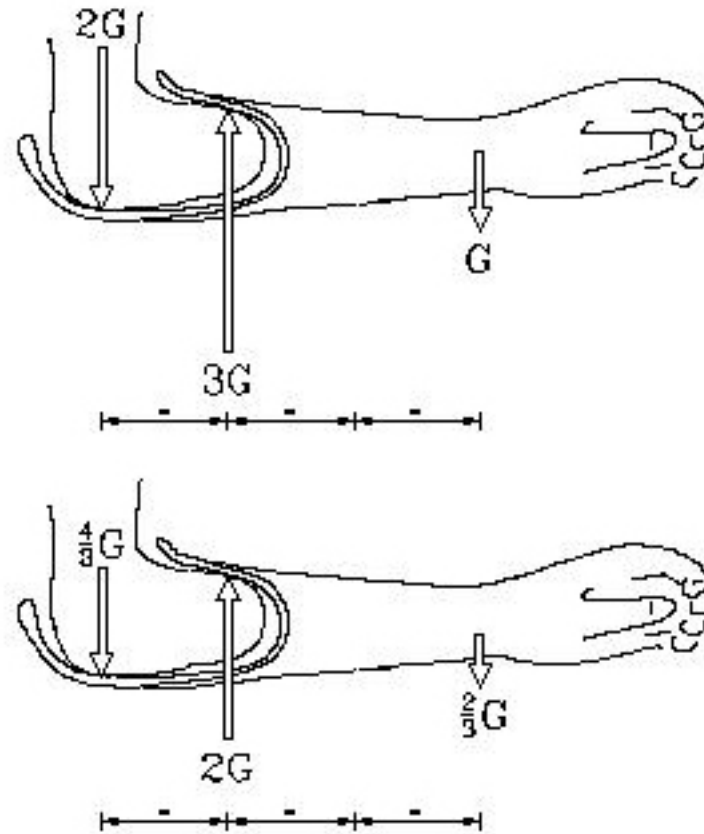
CONTROL

- NATURAL APPEARANCE,  
BOTH STATICAL & DYNAMICAL
- SMALL & FLAT, CLOSE TO SKIN
- LOW MASS
- LOW WEAR & TEAR OF CLOTHING
- NO OIL, GREASE, ETC.

# COMFORT

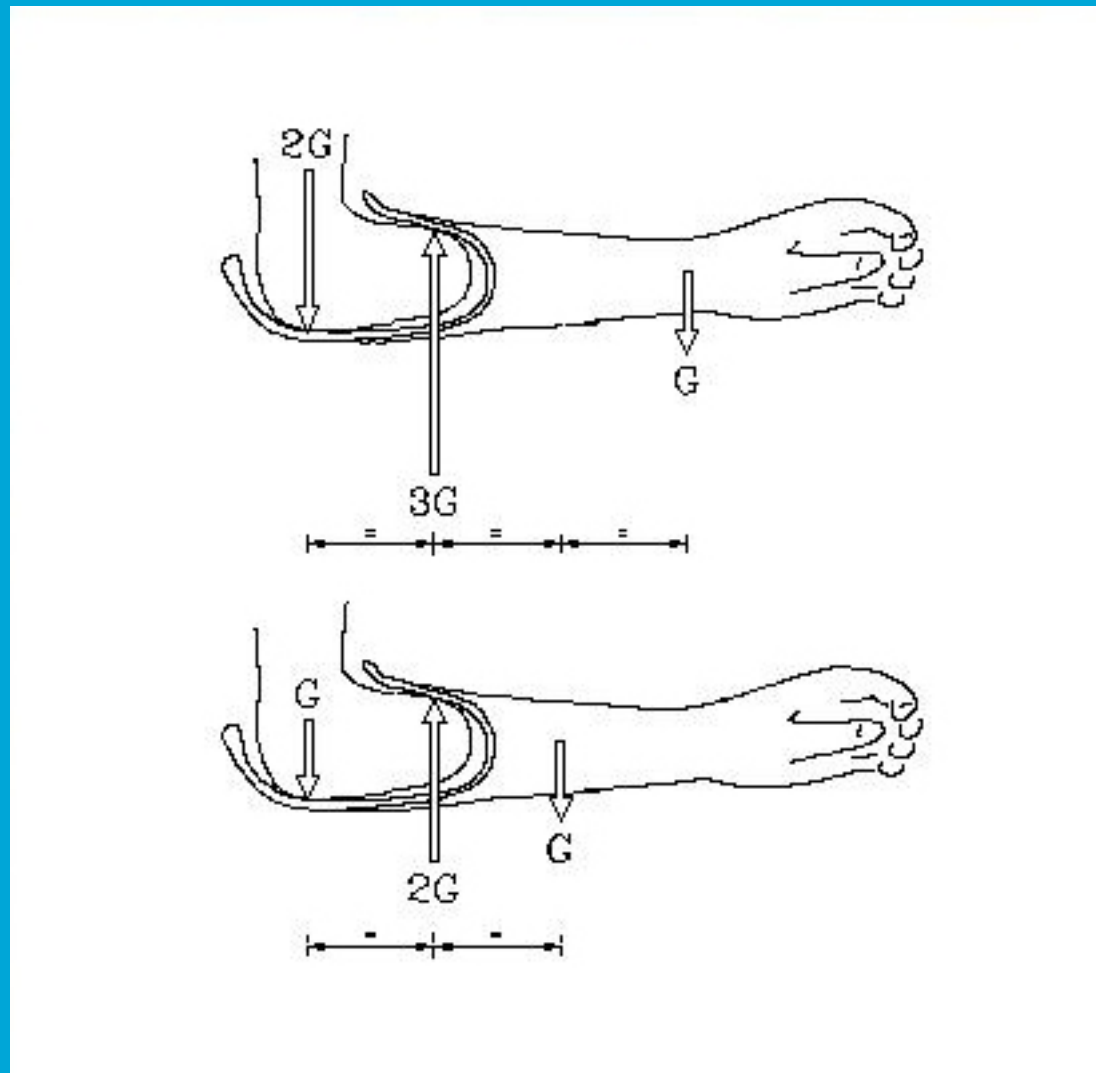
- NORMAL FORCES ONLY; NO SHEAR FORCES
- MINIMUM NUMBER OF SMALL FITTINGS
- MAXIMIZE FITTING DISTANCE
- LOW MASS





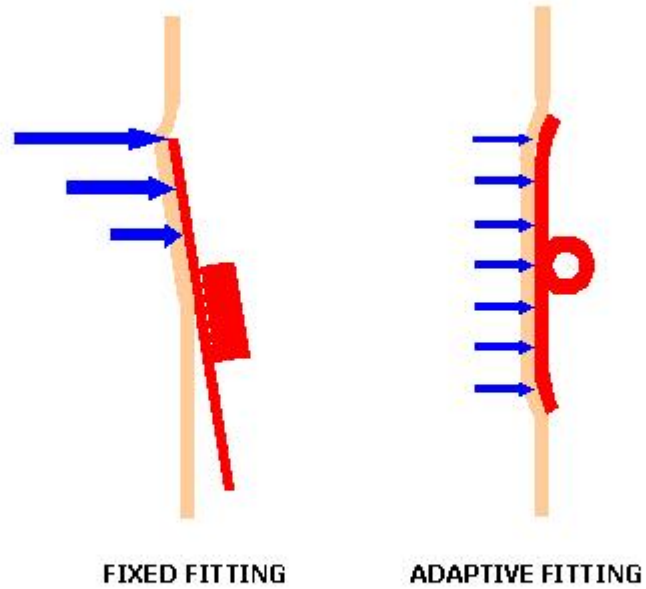
# COMFORT

- NORMAL FORCES ONLY; NO SHEAR FORCES
- MINIMUM NUMBER OF SMALL FITTINGS
- MAXIMIZE FITTING DISTANCE
- LOW MASS
- PROXIMAL CENTER OF GRAVITY

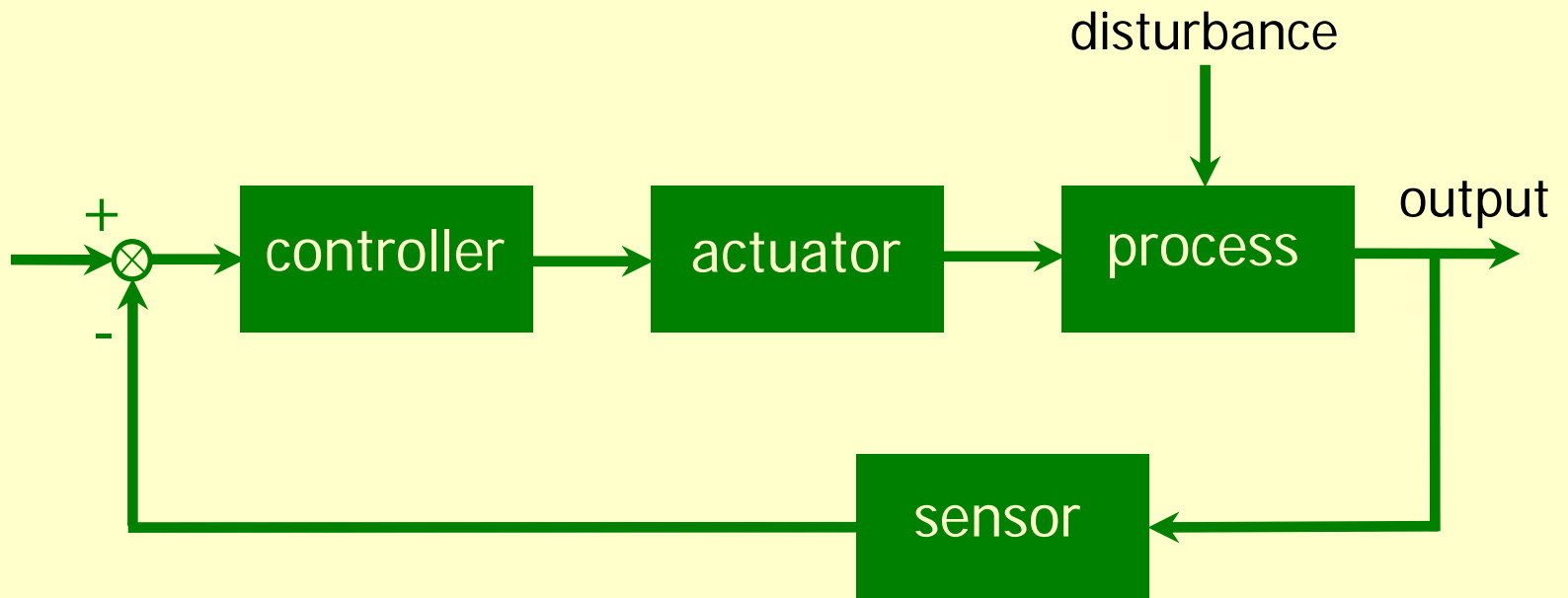


# COMFORT

- NORMAL FORCES ONLY; NO SHEAR FORCES
- MINIMUM NUMBER OF SMALL FITTINGS
- MAXIMIZE FITTING DISTANCE
- LOW MASS
- PROXIMAL CENTER OF GRAVITY
- ADAPTIVE FITTINGS



# CONTROL

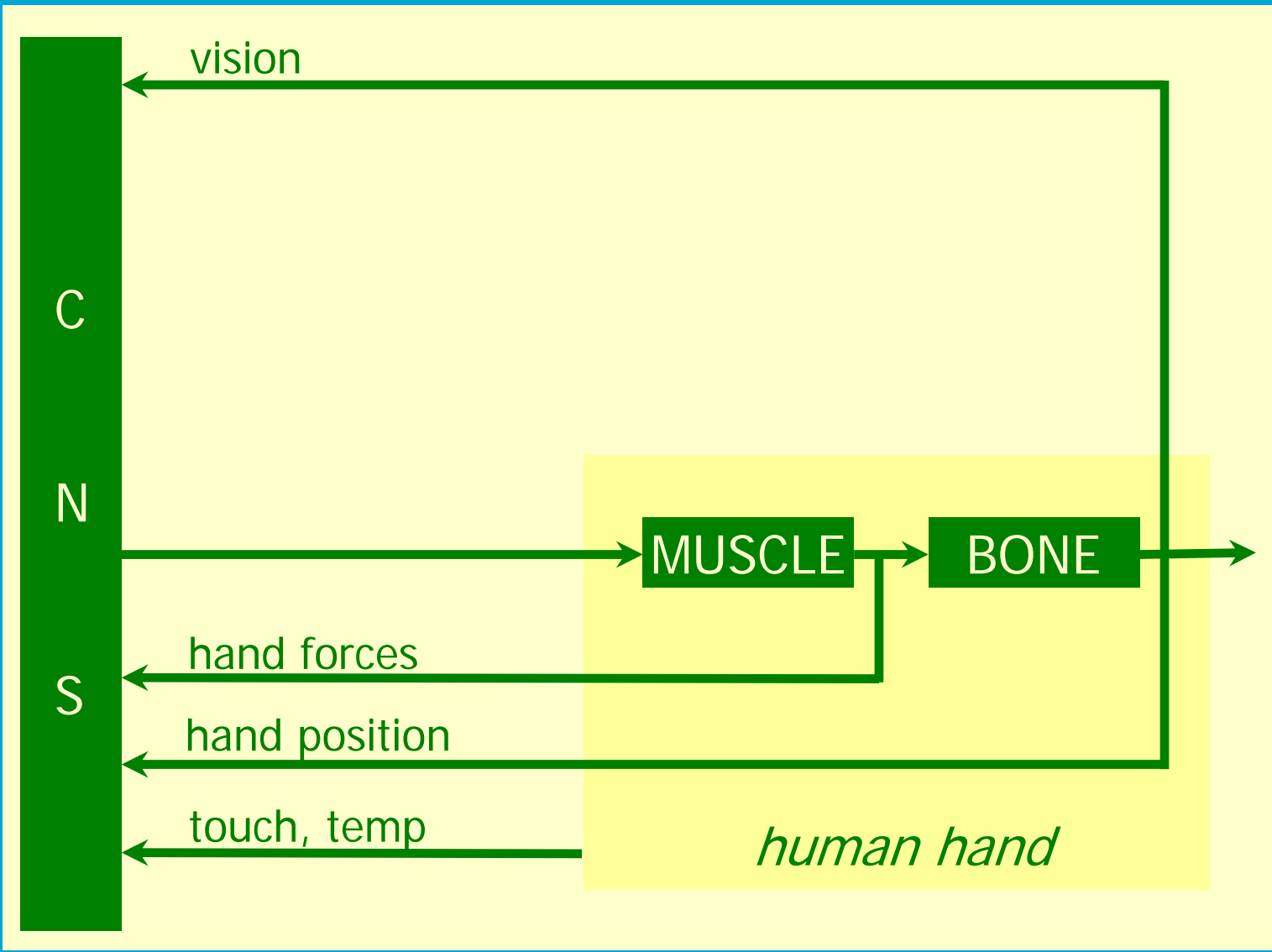


FEEDBACK IS IMPORTANT!

FEEDBACK IS **VERY** IMPORTANT!



FEEDBACK IS **A NECESSITY !**



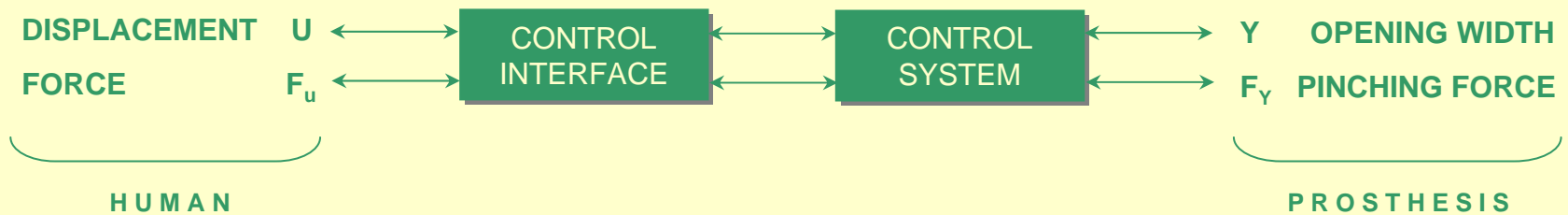
“Prostheses should act as a natural extension of the human body.

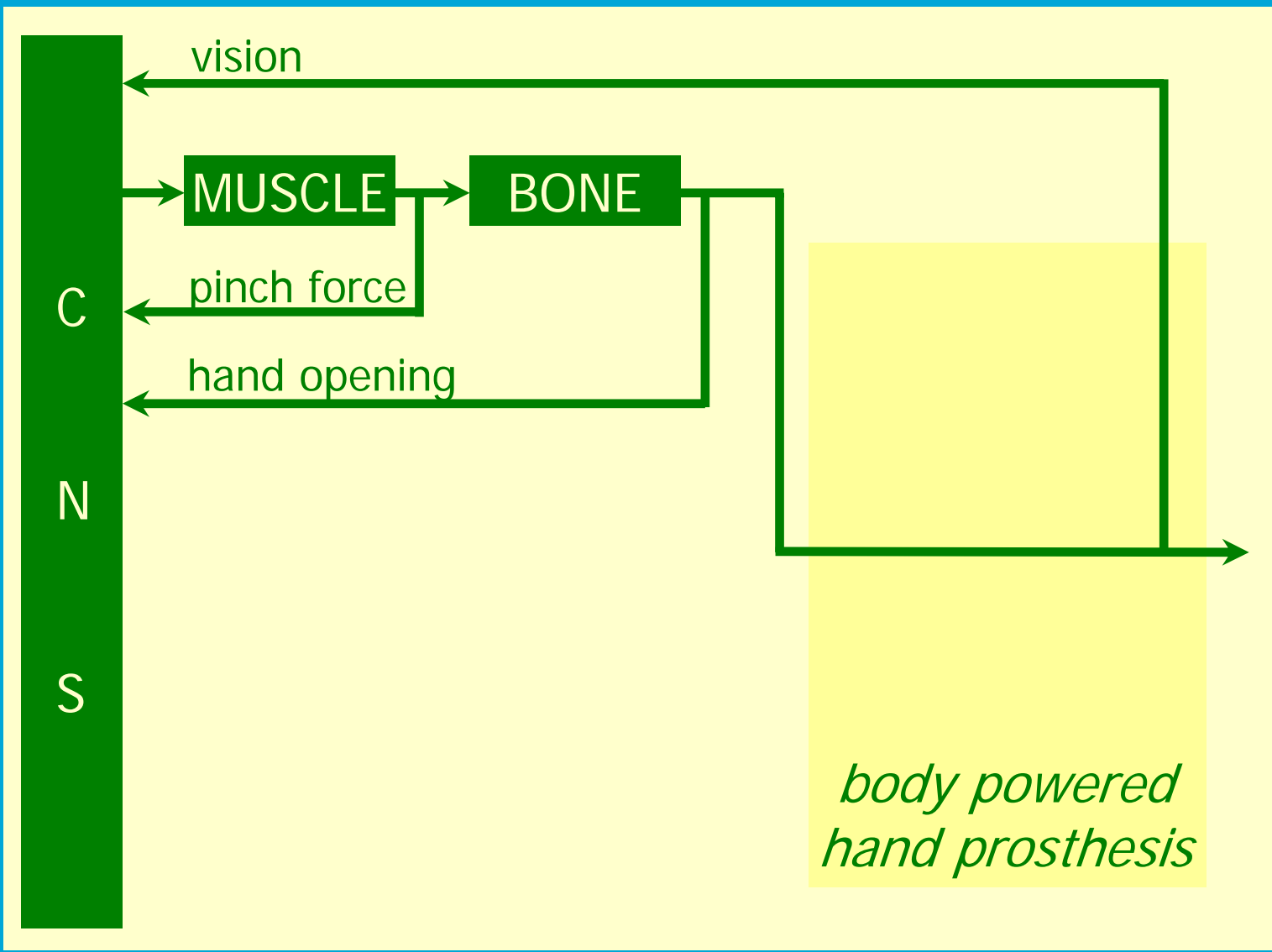
We pour ourselves out into them and assimilate them as parts of our own existence.”

Simpson, 1974

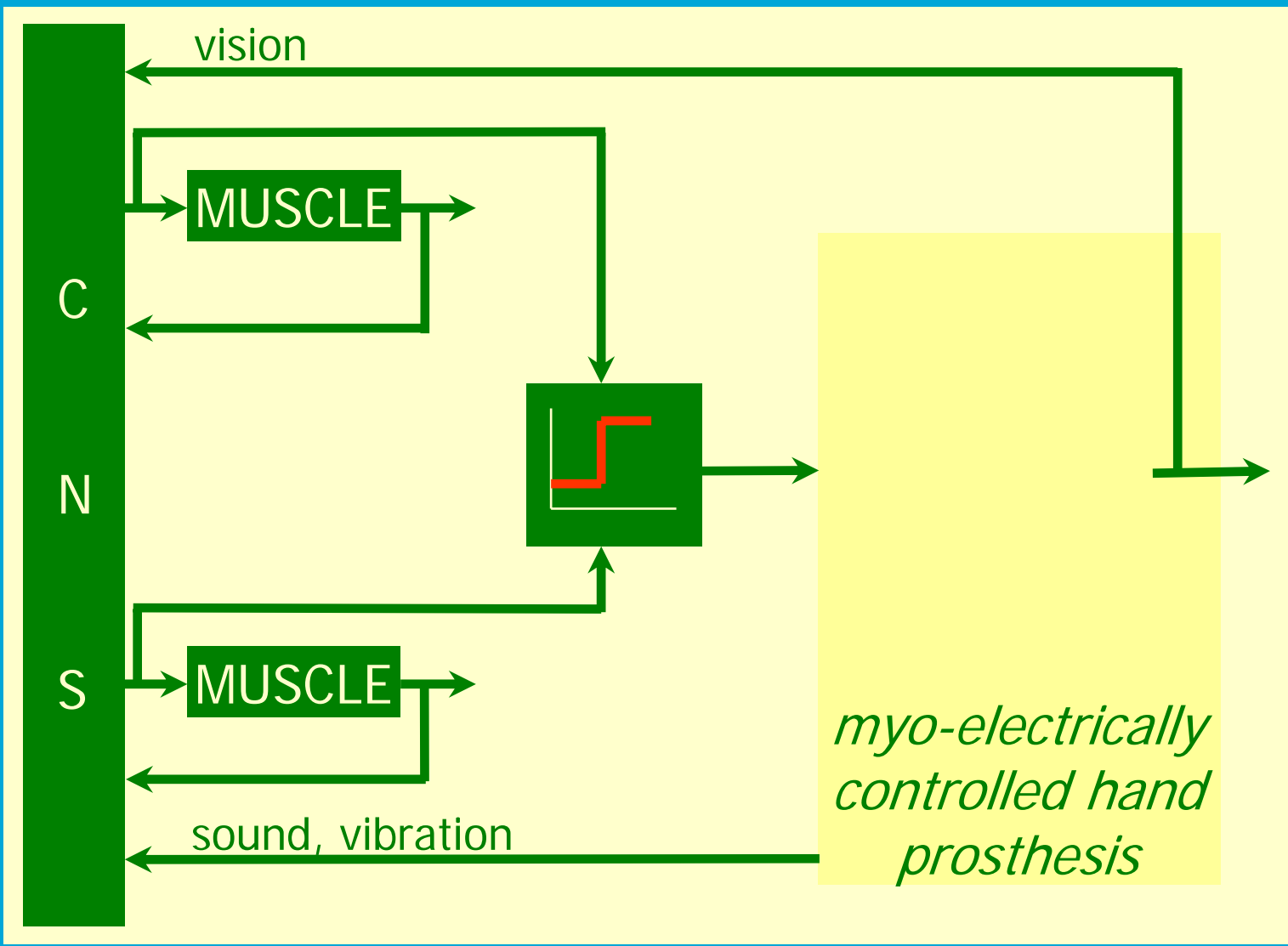
# CONTROL:

## EXTENDED PHYSIOLOGICAL PROPRIOCEPTION





# CONTROL



CONTROL BY BODY MOVEMENTS:  
PROVIDES FEEDBACK!

CONTROL WITH MYO-SIGNALS:  
NO FEEDBACK!

# BASIC REQUIREMENTS FOR PROSTHESES:

COSMESIS !

COMFORT !

CONTROL !



