Homeostasis and Homeodynamism

M.F. DIN

WHAT IS LIFE?

- **PHILOSOPHICAL DEFINITION**
- **THEOLOGICAL DEFINITION**
- **BIOLOGICAL DEFINITION**

LIFE

- **RESPIRATION**
- **NUTRITION & EXCRETION**
- **IRRITABILITY**
- **GROWTH & DEVELOPMENT**
- **LOCOMOTION**
- **REPRODUCTION**
- **DEATH**

ORIGIN OF LIFE

OVER >3 BILLION YEARS

INORGANIC

↓

ORGANIC

↓

BIOCHEMICAL

↓

‘LIVING’

- **SELF-DUPLICATION**
  - **DNA**
  - **RNA**
  - **CODES FOR OTHER PROTEIN FORMATION**

Structure of DNA

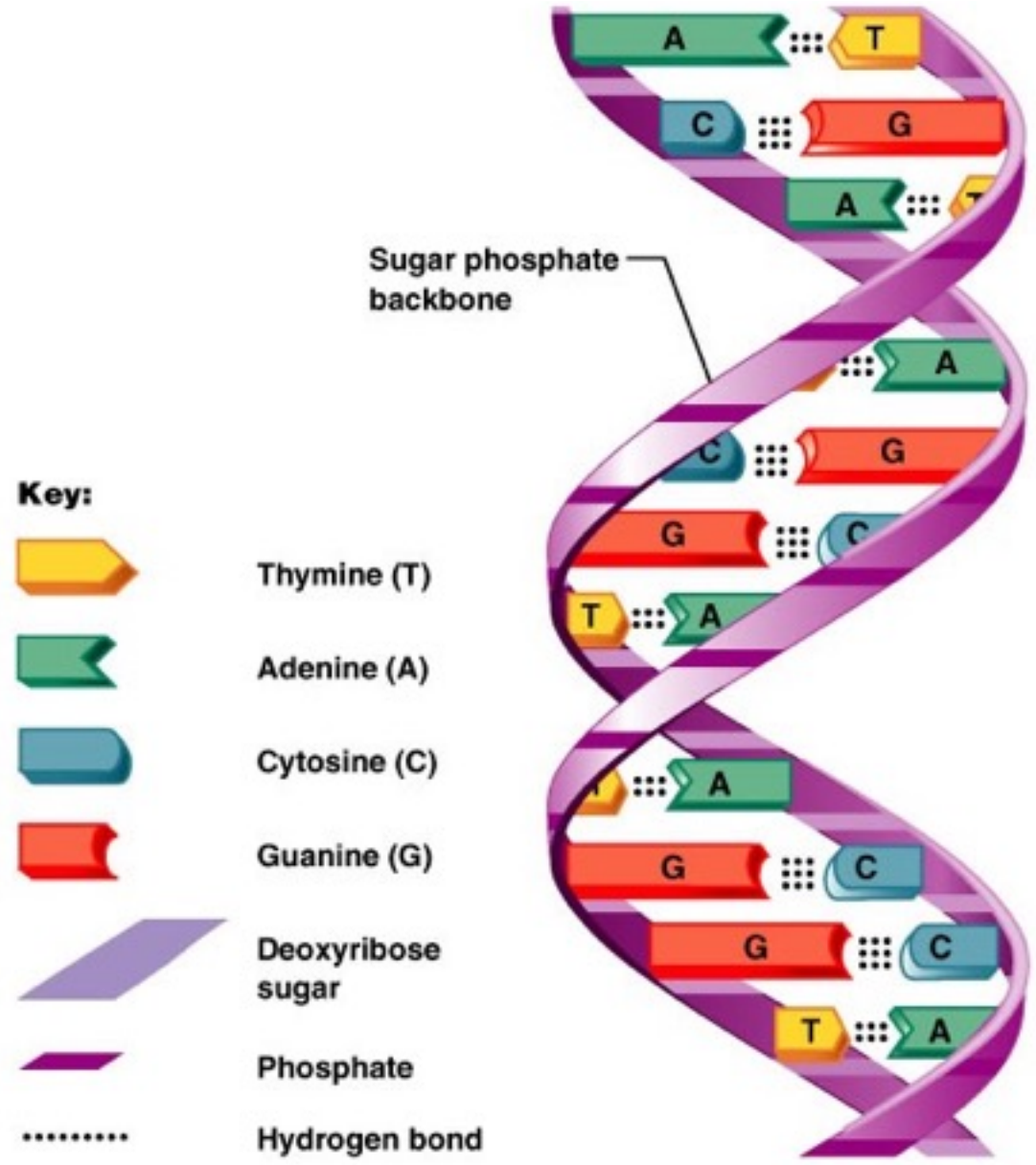


Figure 2.21b

BODY ORGANISATION I

- **SUB-CELLULAR**
  - **Organelles**
- **CELL**
  - **BASIC UNIT**
  - **HAS INTEGRITY**
  - **ABILITY TO COOPERATE**
  - **ABILITY TO REPRODUCE**
  - **CELLULAR RESPIRATION & OTHER METABOLIC PROCESSES ARE THE FUNDAMENTAL PRE-REQUISITES FOR LIFE IN A MULTI-CELLULAR ORGANISM**

BODY ORGANISATION II

- **TISSUES**
  - **COLLECTION OF CELLS WITH SIMILAR FUNCTION**
  - **e.g. EPITHELIUM, MUSCLE, SECRETORY, SUPPORTIVE, IMMUNE & OTHERS**

BODY ORGANISATION III

- **ORGANS**
  - **ANATOMICALLY DISTINCT COLLECTION OF DIFFERENT CELLS AND TISSUES TO PERFORM ONE OR MORE COLLECTIVE BUT LINKED FUNCTIONS**
  - **e.g. STOMACH, LUNG, HEART, KIDNEY, BRAIN, THYRIOD GLAND, EAR & OTHERS**

BODY ORGANISATION IV

- **ORGAN SYSTEMS**
  - **COLLECTION OF VARIOUS ORGANS THAT PERFORM ONE OR MORE RELATED FUNCTIONS WHICH HAVE OVERALL BODY IMPORTANCE**
  - **e.g. RESPIRATORY ~, CARDIOVASCULAR ~, GASTRO-INTESTINAL~, URINARY~, CENTRAL NERVOUS~ & OTHERS**

WHOLE BODY

- **ORGAN SYSTEMS, ORGANS, TISSUES AND CELLS CO-EXISTING TO ENSURE SURVIVAL AND PROPAGATION.**

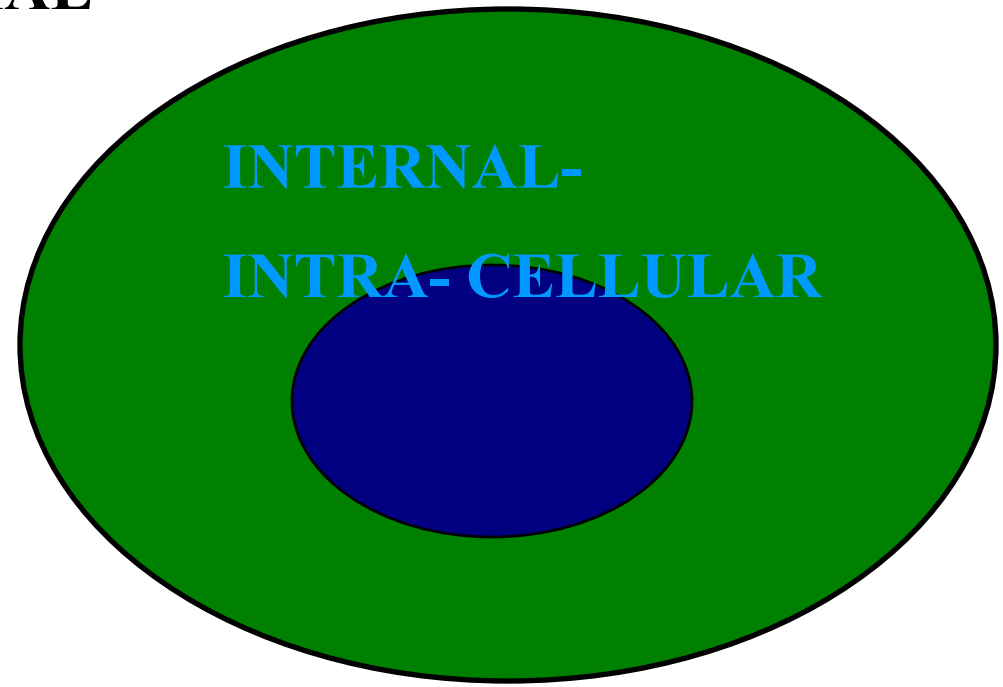
INTERNAL ENVIORNMENT

- **CLAUDE BERNARD 1878**
  - **'MIILEU INTERIEURE'**
  - **DISTINCT FROM EXTERNAL ENVIORNMENT**
  - **SPECEFIC FOR**
    - **PARTICULAR ORGANISM**
    - **PARTICULAR LEVEL e. g. CELL, ORGAN, WHOLE BODY**

CELLULAR LEVEL

EXTERNAL-

INTERSTITIAL



ORGAN LEVEL

- **STOMACH**
  - **INTERNAL - ACIDIC pH**
- **THYROID GLAND**
  - **HIGH IODINE LEVEL**

ORGAN SYSTEM LEVEL

- **CVS**
  - **Blood pressure**
  - **Blood volume**
- **Respiratory system**
  - **Oxygen & carbon dioxide levels**

WHOLE BODY LEVEL

- **INTERNAL**
  - **TEMPERATURE**
  - **FLUID**
  - **ELECTROLYTES**
  - **OXYGEN**
- **EXTERNAL**
  - **ATMOSPHERE**
  - **TEMPERATURE**
  - **RADIATION**

INTERNAL ENVIORNMENT

- **RELATIVELY CONSTANT**
  - **RANGE OF NORMALITY**
- **GIVES THE ORGANISM A GREATER VERSATALITY AND FREEDOM OF CHOICE OF EXTERNAL ENVIORNMENT**

HOMEOSTASIS

- **WALTER CANNON**
- **‘SIMILAR CONDITION’**
- **IS THE MAINTENANCE OF INTERNAL ENVIORNMENT WITHIN A NARROW, PHYSIOLOGICAL RANGE OF PARAMETERS**

HOMEODYNAMISM

- **IMPLIES THAT THE MECHANISMS AND THE MAINTENANCE OF THE INTERNAL ENVIONMENT ARE DYNAMIC OR IN ACTION RATHER THAN STATIC**

HOMEODYNAMISM

- **THERE ARE MEANS OF CONTROLLING THE VARIOUS PARAMETERS**
- **REQUIRES THAT THERE IS ORDERLINESS AND ORGANISATION IN THE LIVING SYSTEM**

PHYSIOLOGICAL RANGE

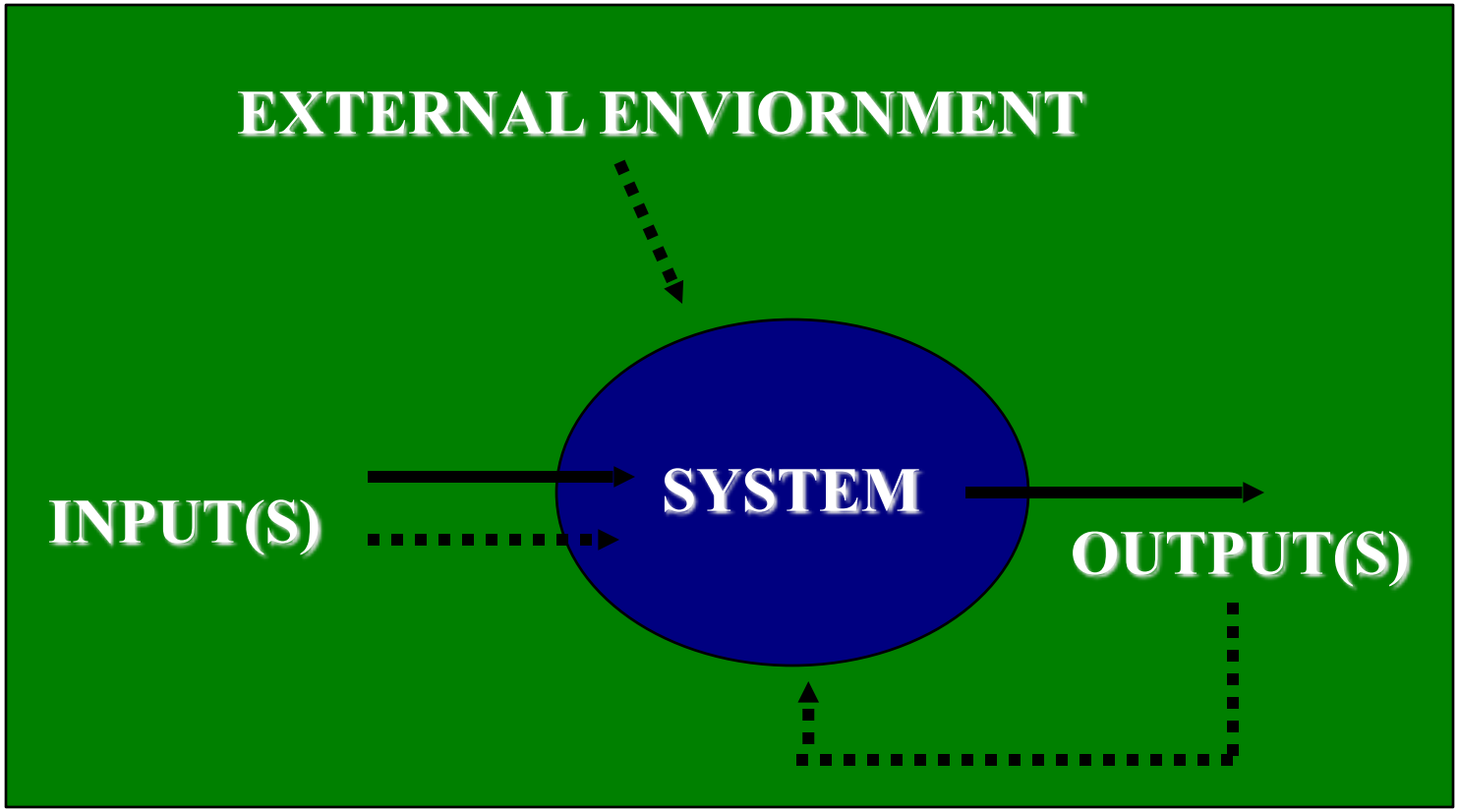
- **RANGE OF NORMALITY**
- **USUALLY NARROW**
  - **e.g. p H 7.40 +/- 0.02**
- **ACTUAL LEVEL MAY FLUCTUATE WITHIN RANGE**

CONTROL THEORY I

- **'SYSTEM'**
  - ASSEMBLY OF PROCESSES THAT INTERACT AND RESULT IN A CHANGE IN A MEASURED QUANTITY OR VARIABLE

INPUT ⟶ **SYSTEM** ⟶ **OUTPUT**

(VARIABLE)


EXTERNAL ENVIORNMENT
INPUT(S)
SYSTEM
OUTPUT(S)

CONTROL SYSTEMS

- **OPEN LOOP ~**
- **CLOSED LOOP ~**
  - **FEEDBACK ~**
    - **NEGATIVE FEEDBACK ~**
    - **POSITIVE FEEDBACK ~**
  - **FEED FORWARD ~**
  - **ADAPTIVE ~**

CONTROL SYSTEMS

- **OPEN LOOP**

  INPUT ⟶ SYSTEM ⟶ OUTPUT

  (CONTROLLED VARIABLE)

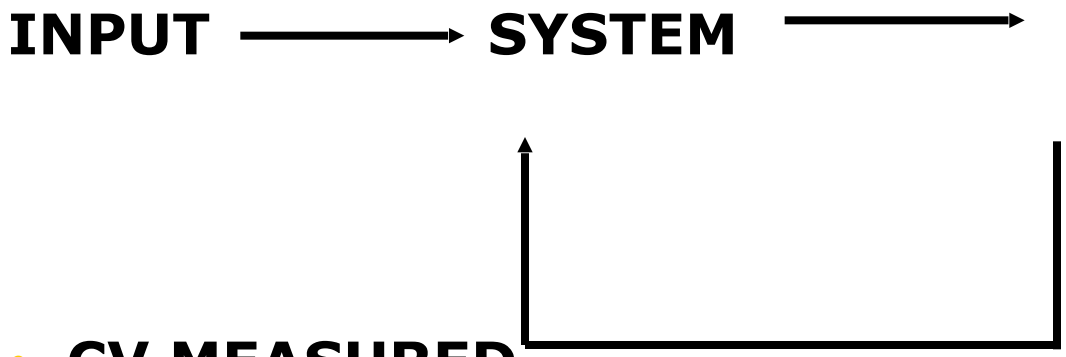
  - **NO CV MEASUREMENT**
  - **VALUE OF CV BASED ON A 'DESIRED VALUE', NOT ON AN ACTUAL VALUE**

Open loop

- **In non-vital situations**
- **Examples**
  - **Hair growth**
  - **Nail growth**

CONTROL SYSTEMS

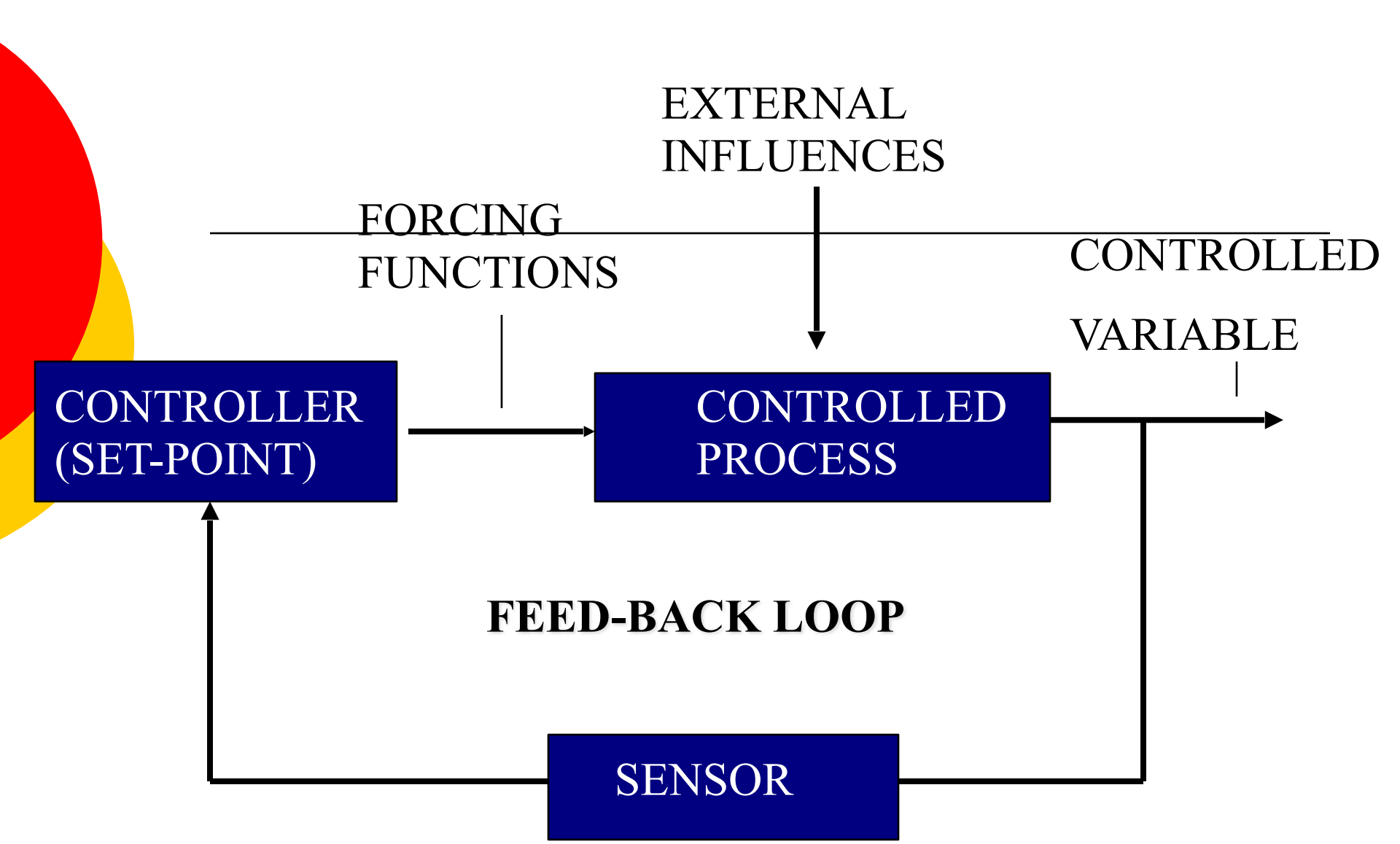
- **CLOSED LOOP**



  - **CV MEASURED**
  - **Level of the CV may influence the activity of the controlled system**
  - **CV LEVEL BASED ON ACTUAL VALUES**

TYPES OF CLOSED LOOP CONTROL SYSTEMS

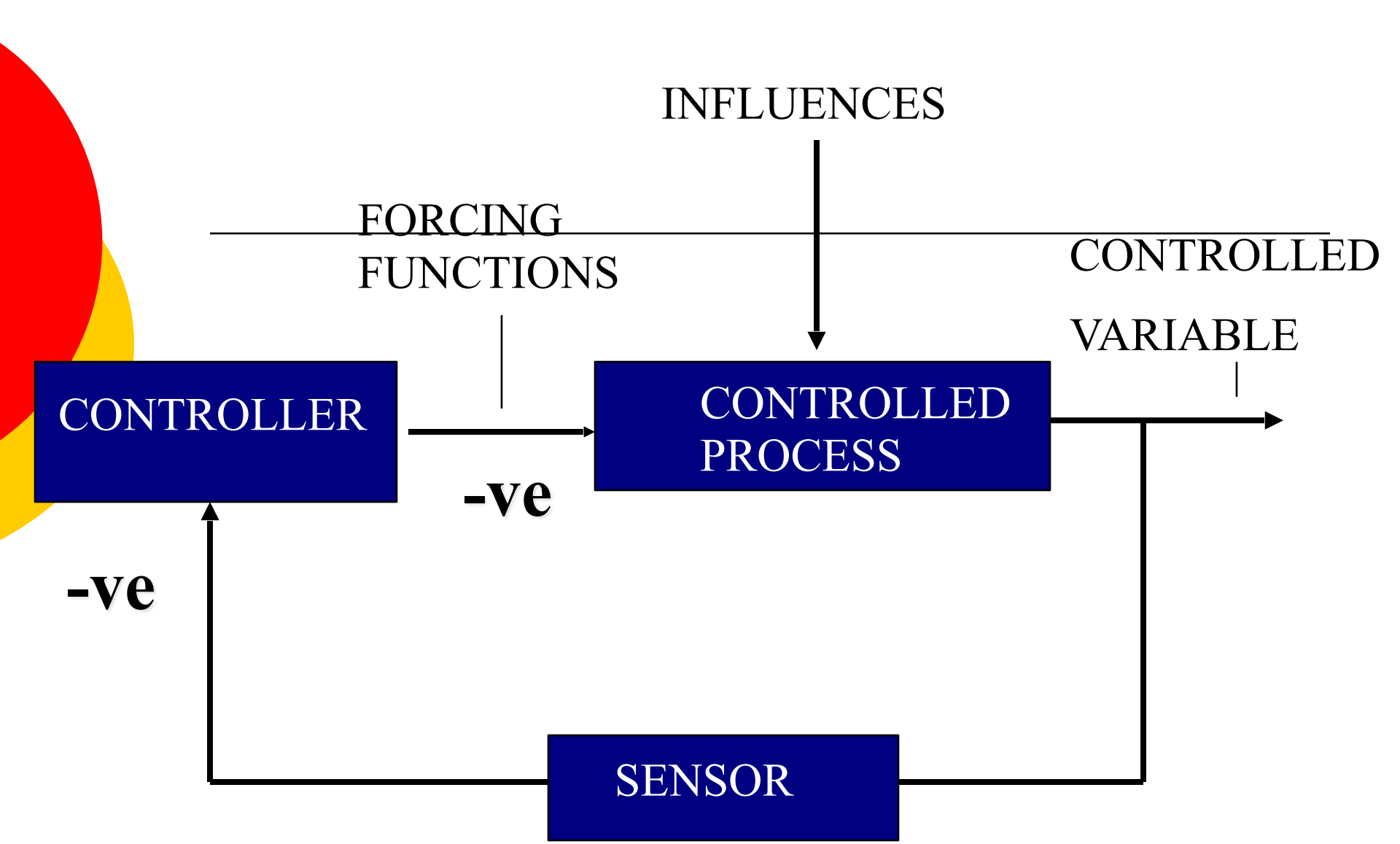
- **FEED-BACK**
  - **NEGATIVE FEED-BACK**
  - **POSITIVE FEED-BACK**
- **FEED-FORWARD**
- **ADAPTIVE CONTROL**
- **COMBINATIONS OF ABOVE**



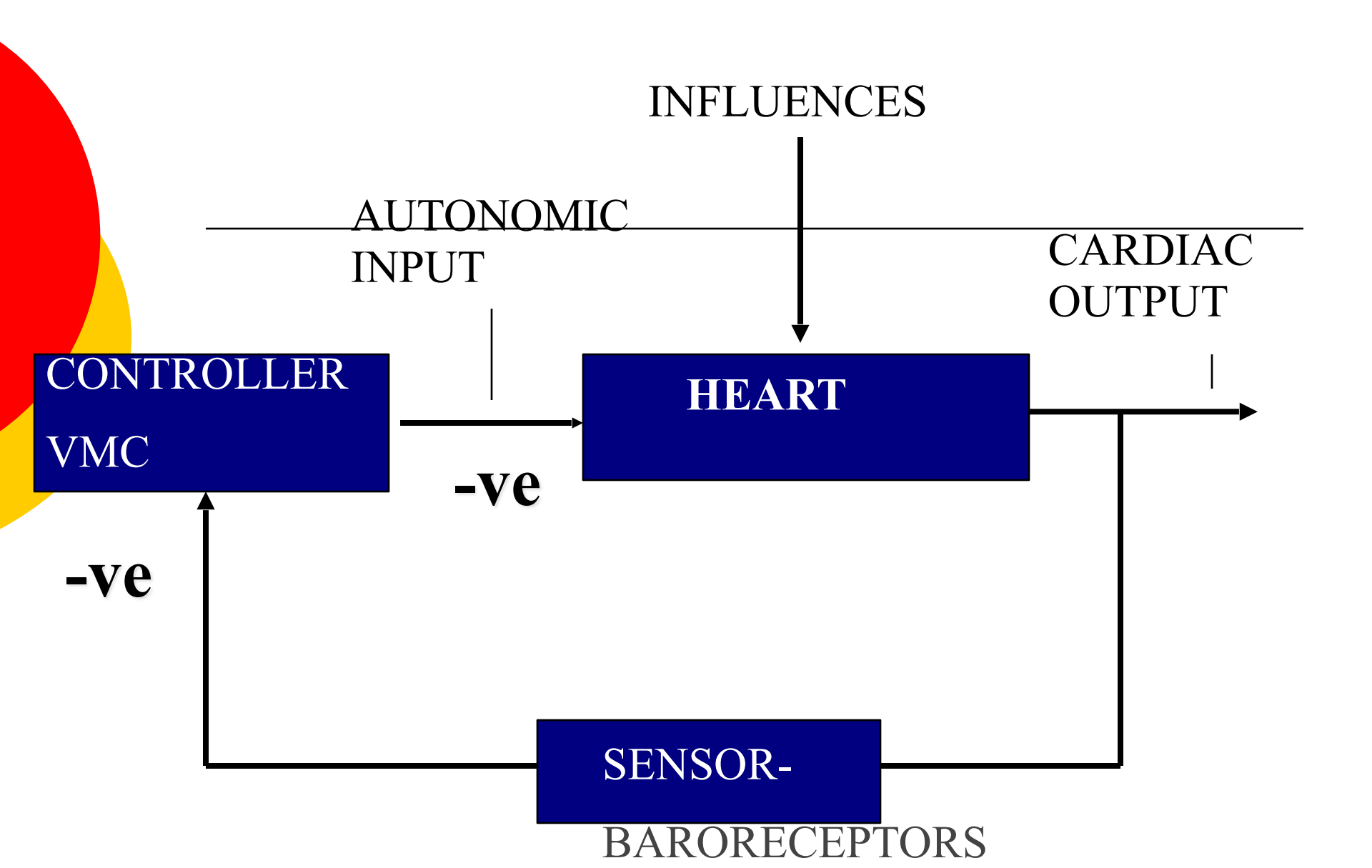
BASIC FEED-BACK CONTROL MODEL

NEGATIVE FEED-BACK

- **THE RESPONSE OF THE SYSTEM IS IN AN OPPOSITE DIRECTION TO THE CHANGE IN CONTROLLED VARIABLE LEVEL**
- **MOST COMMON CONTROL SYSTEM**



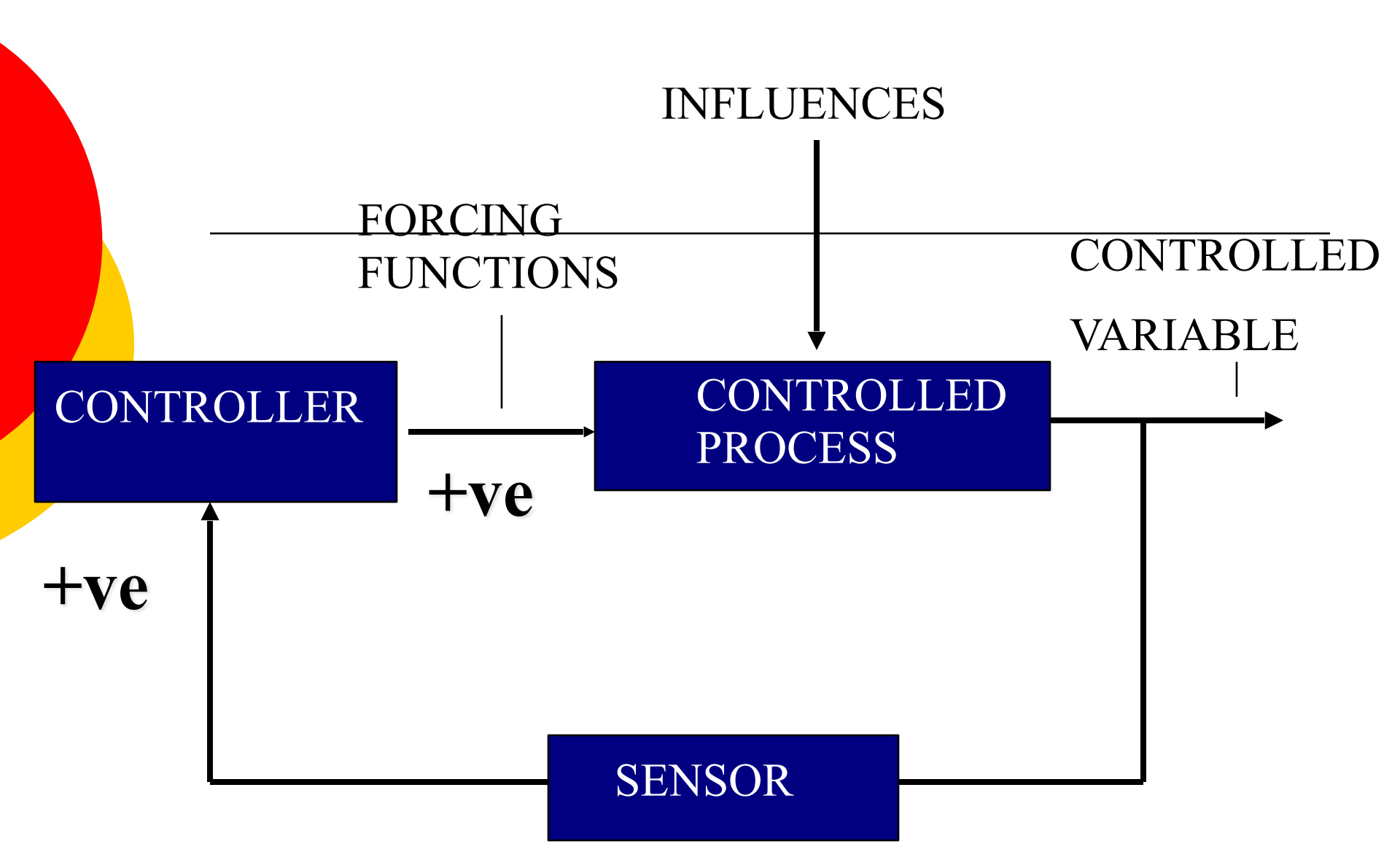
BASIC NEGATIVE FEED-BACK CONTROL MODEL



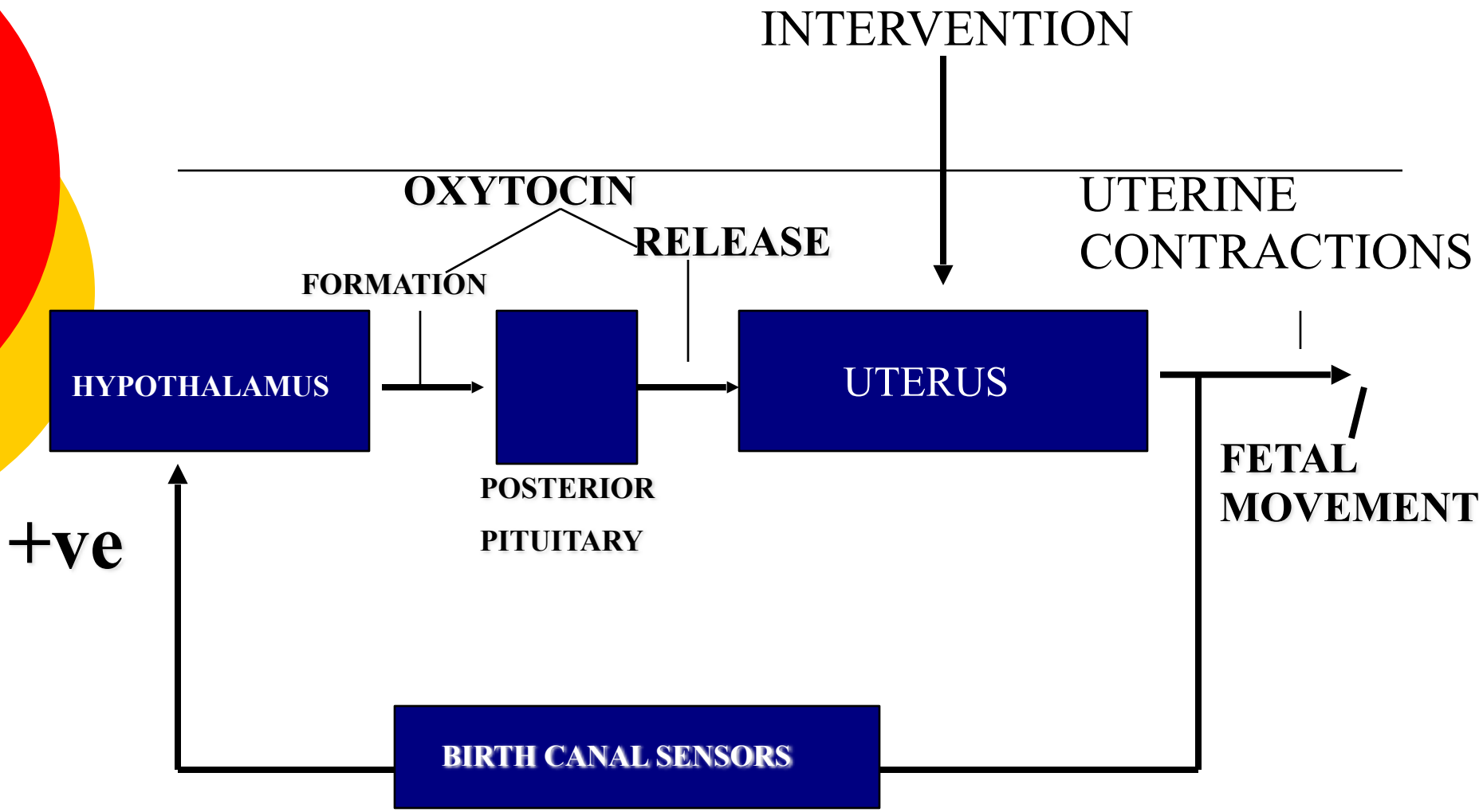
CARDIAC OUTPUT NEGATIVE FEED-BACK CONTROL MODEL

POSITIVE FEED-BACK

- **THE RESPONSE OF THE SYSTEM IS IN THE SAME DIRECTION AS THE INITIAL CHANGE IN THE LEVEL OF CONTROLLED VARIABLE**
- **THERE IS A STEADY BUILD-UP IN THE LEVEL OF CONTROLLED VARIABLE**
- **THIS ACHIEVES HIGH LEVELS OF CV**
- **!!!There has to be a 'Cut-off' point**
- **This cut-off occurs when a particular target has been achieved**



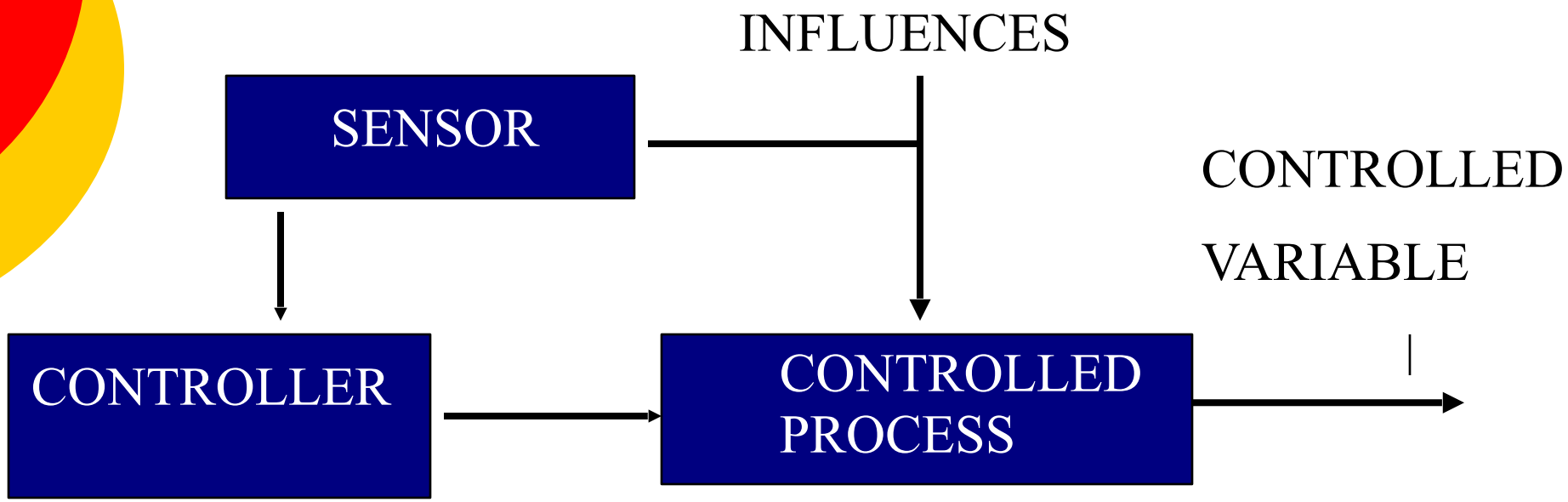
BASIC POSITIVE FEED-BACK CONTROL MODEL



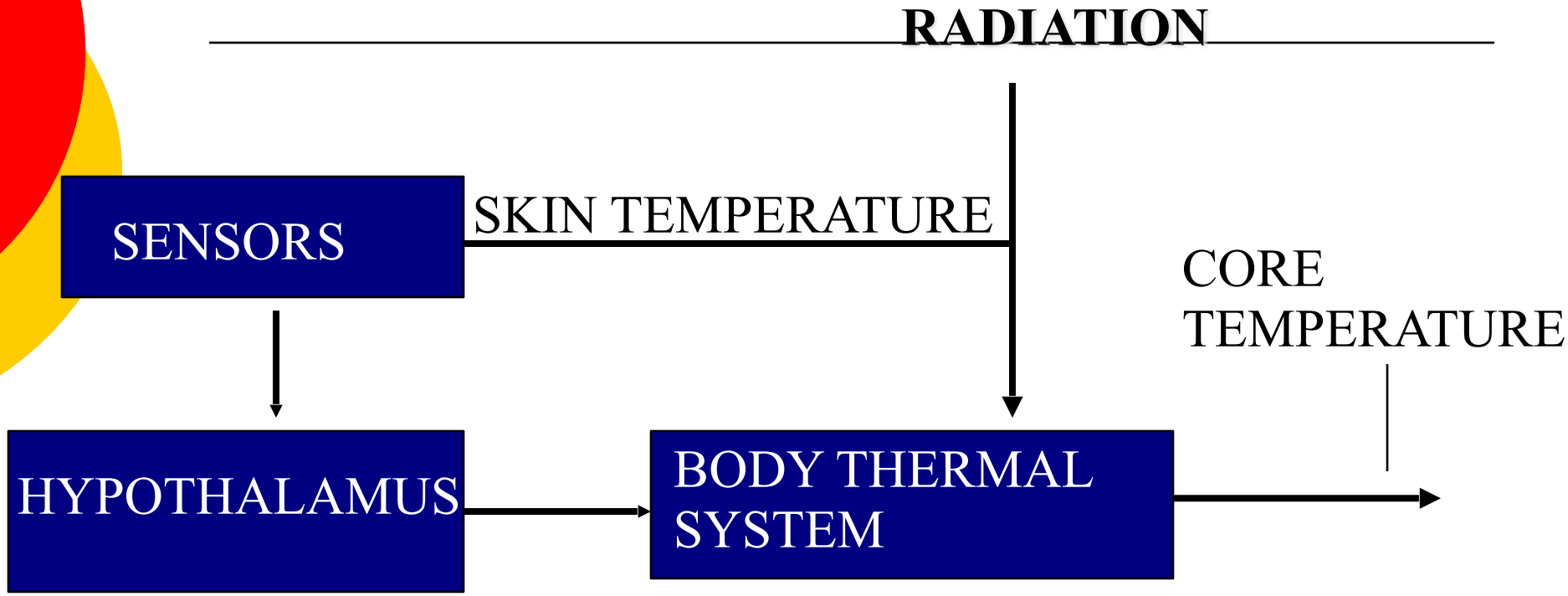
PARTURITION POSITIVE FEED-BACK CONTROL

FEED-FORWARD SYSTEM

- **PREVENTS CHANGE IN THE CV**
- **COMPENSATES FOR EXPECTED CV CHANGES BY MEASURING AND PREDICTING THE EFFECT OF POSSIBLE DISTURBING FACTORS**



BASIC FEED- FORWARD CONTROL MODEL

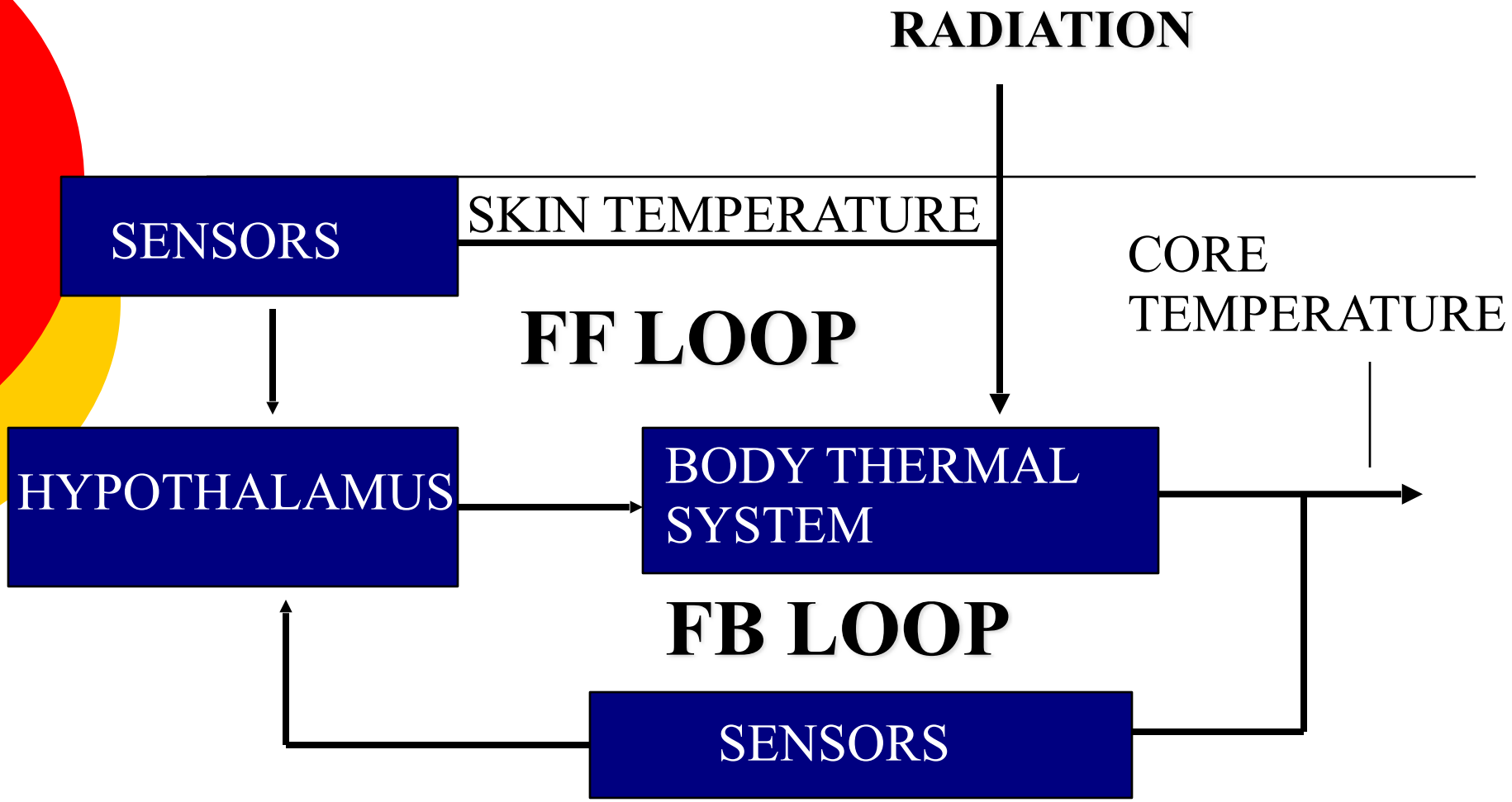


TEMPERATURE
FEED- FORWARD CONTROL MODEL

COMBINATION OF FB & FF

NOTE

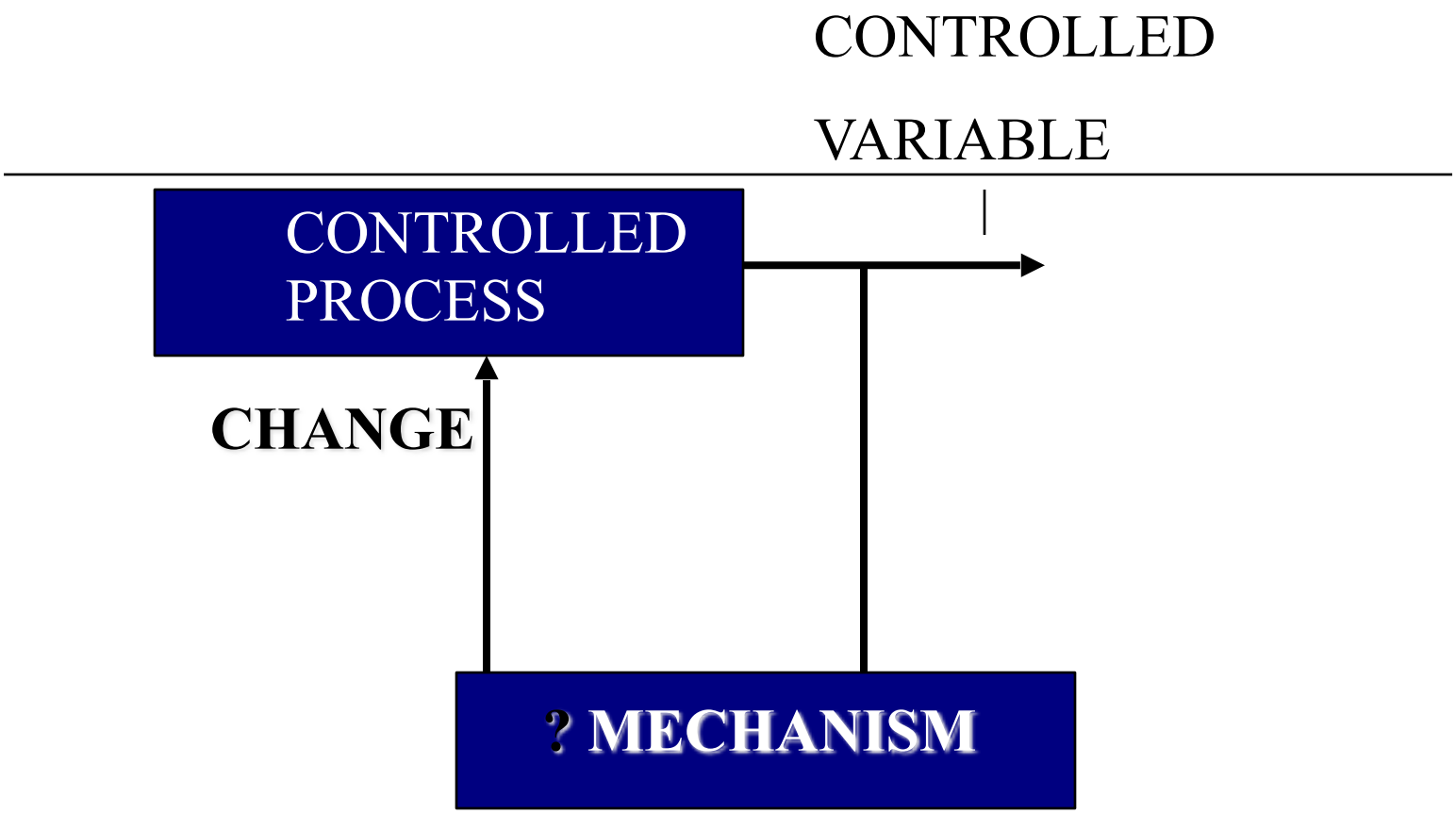
ADVANTAGES AND DISADVANTAGES OF NEGATIVE FEED-BACK AND FEED-FORWARD ARE COMPLEMENTARY AND COMBINATION OF THE TWO ARE VERY EFFECTIVE CONTROL SYSTEMS



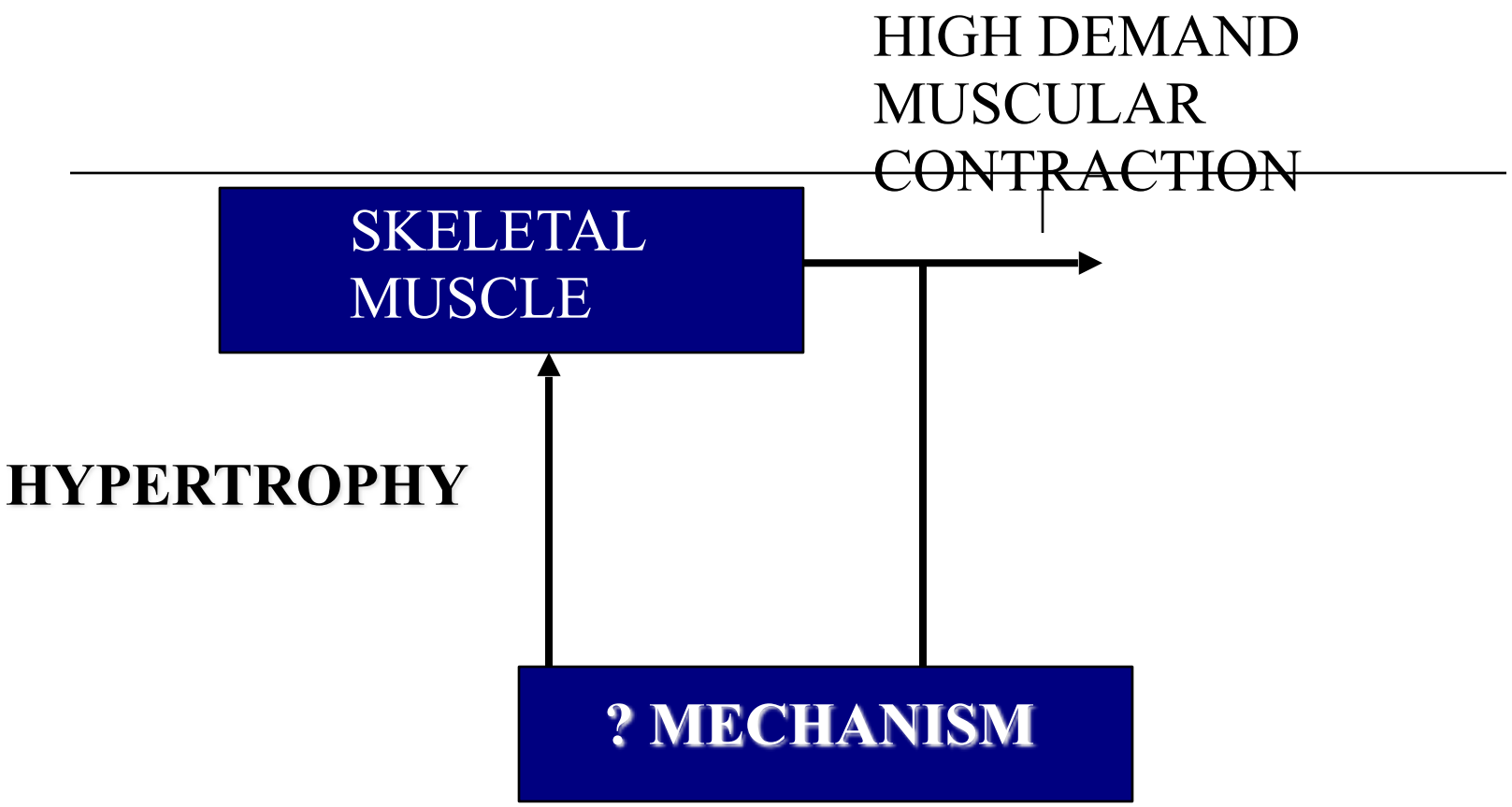
COMBINED FEED- FORWARD & FEED-BACK CONTROL

ADAPTIVE CONTROL

- **THE CONTROLLED SYSTEM CHANGES ITS CHARACTERISTICS IN RESPONSE TO DEMAND OF THE CONTROLLED VARIABLE**
- **IT 'LEARNS' FROM PREVIOUS EXPERIENCE**



BASIC ADAPTIVE CONTROL MODEL



ADAPTIVE CONTROL IN MUSCLE

CONTROL LEVELS

- SUB-CELLULAR
- CELLULAR
  - ELECTROLYTE LEVEL, GLUCOSE LEVEL
- ORGAN
  - pH, SECRETIONS
- SYSTEM
  - BLOOD PRESSURE, RESP. RATE
- WHOLE BODY
  - TEMPERATURE, FLUID

THANK YOU