



バイオメディカル情報工学

第2部 生体情報技術入門

第1章 生体情報の基礎

Basis of Biomedical Information

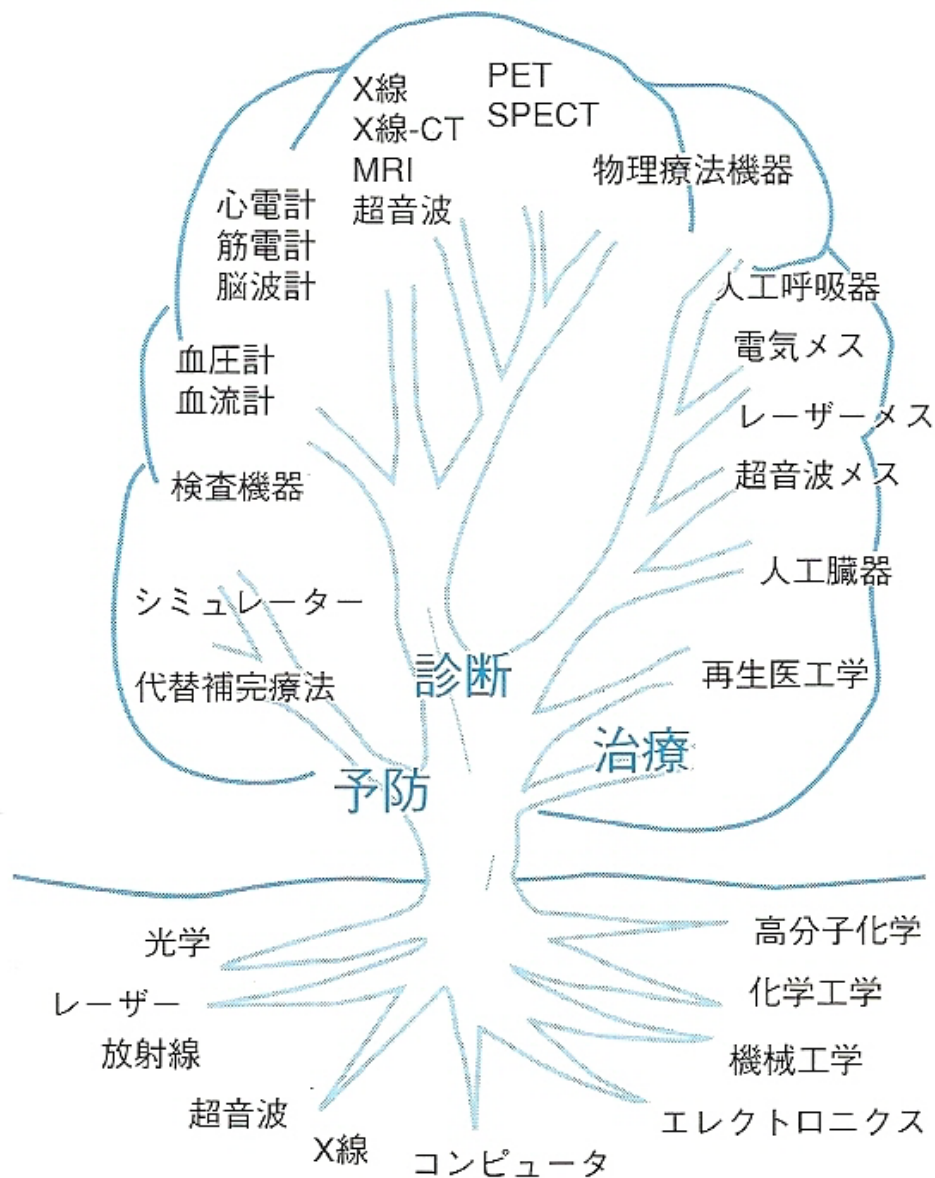
生体情報学講座
陳 文西

第2部授業予定

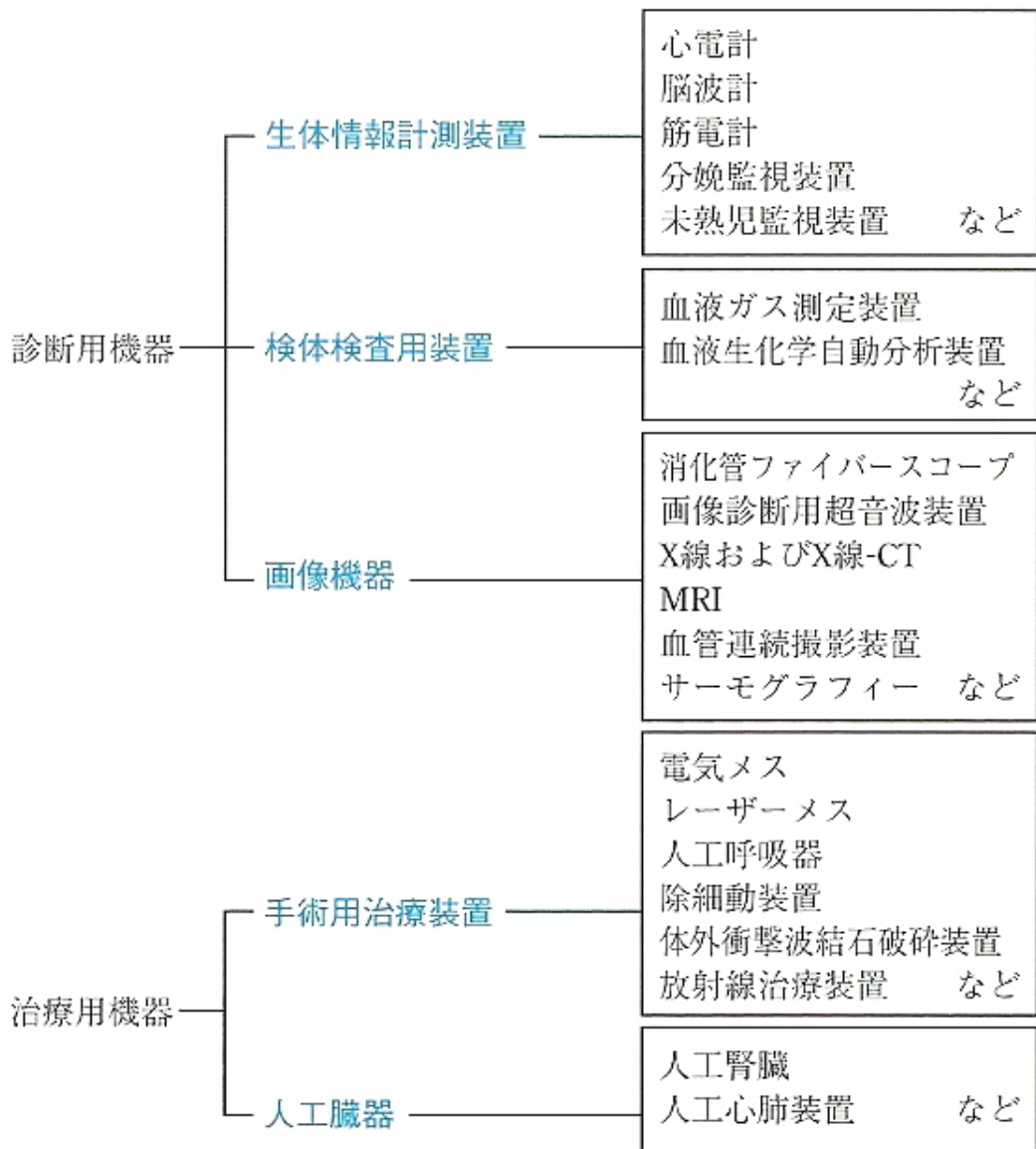
回	章・節	講義	演習
1	1	生体情報の基礎	各種医療機器の見学と演示(心電計、脳波計、睡眠計PSG、連続血圧計、ベッドサイドモニタ、各種開発試作機器)
2	2.1	血圧と心電	各種血圧計を用いて、所定実験プロトコルに沿って、血圧と心拍数などの生体信号を計測し、実験報告書を作成と提出
3	2.2	体温と血中酸素飽和度	
4	3.1	内視鏡, 眼底カメラ, 超音波画像, サーモグラフィ	
5	3.2	CT, MRI, PET, SPECT	ベッドサイドモニタを用いて、所定実験プロトコルに沿って、複数の生体信号を同時に計測し、実験報告書を作成と提出
6	4.1	自動体外式除細動器, ペースメーカ, 人工臓器	
7	4.2	ESWL, MRIgFUS, ガンマーナイフ	



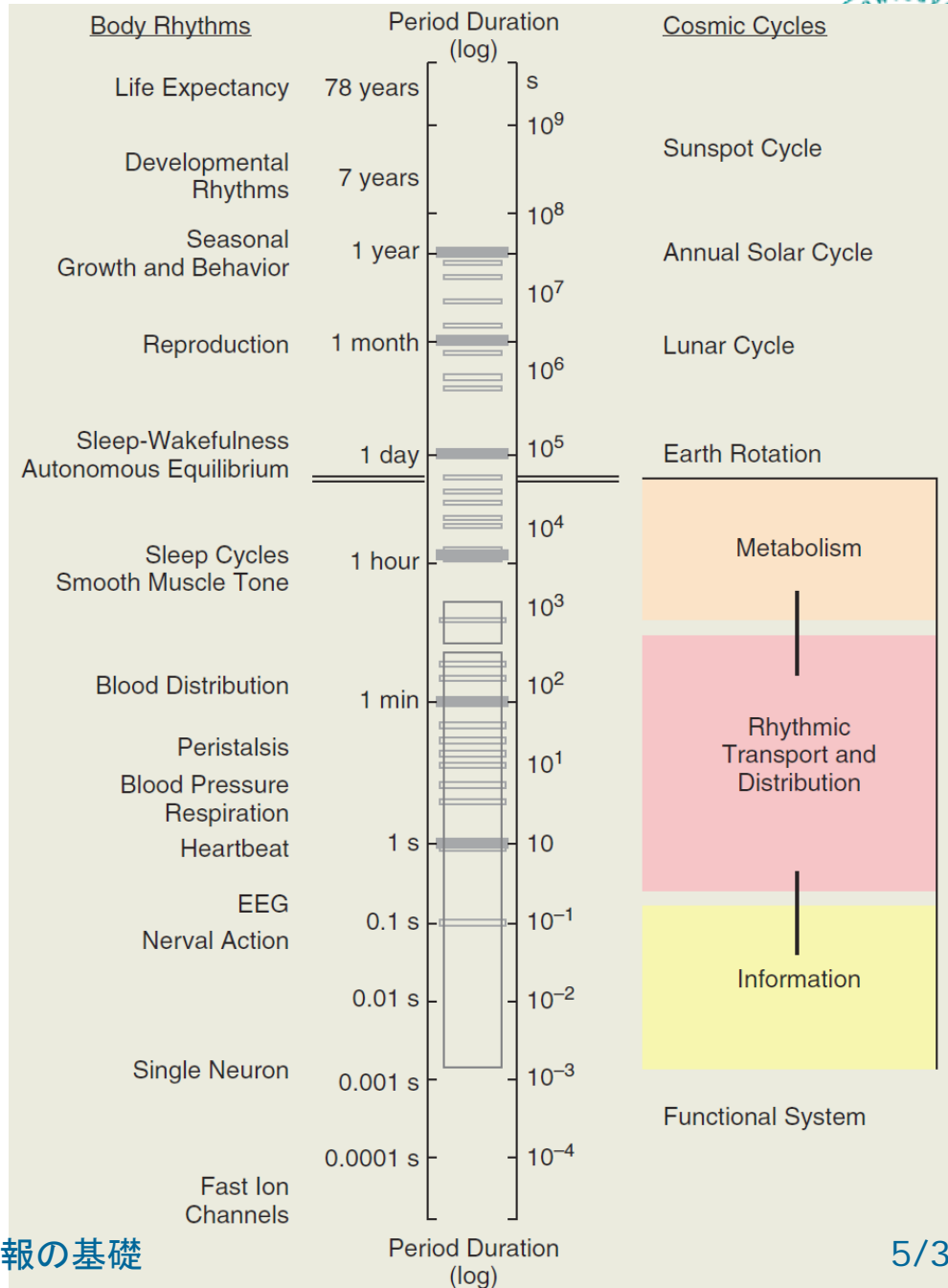
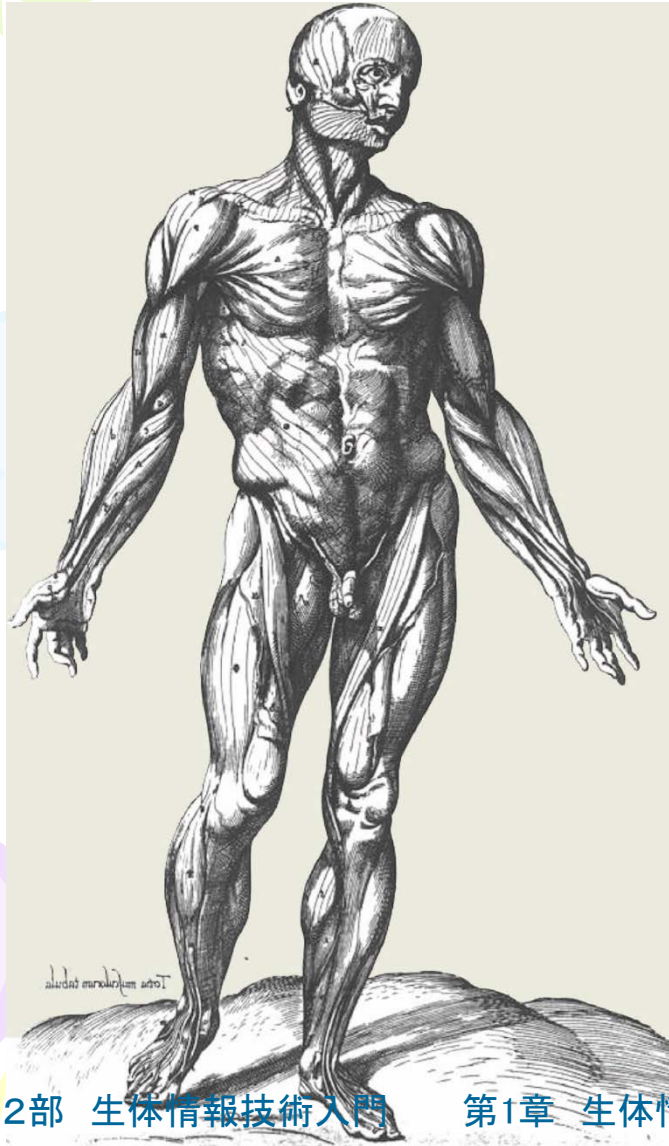
医工学の樹



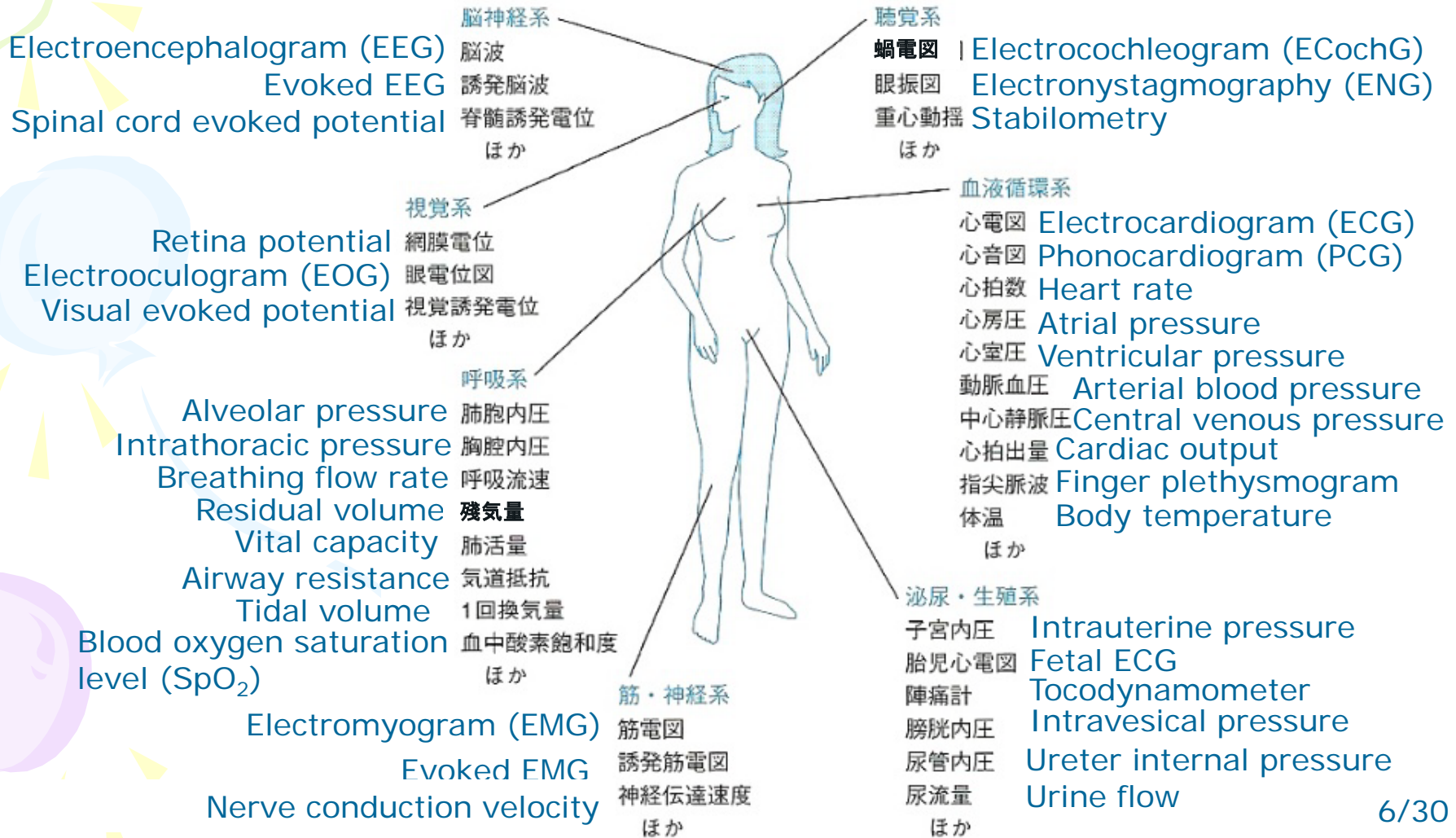
各種診断・治療用医療機器



信号の多様性



様々な生体信号 Various Vital Signs



生体信号の特性とセンサ



Biosignal		Range	Freq., Hz	Sensor
心弾動図 Ballistocardiogram (BCG)		0-7 mg	0-40	Accelerometer, strain gage
		0-100 μm	0-40	Displacement (LVDT, Linear Variable Differential Transformer)
膀胱圧 Bladder pressure		1-100 cm H ₂ O	0-10	Strain gage manometer
血流 Blood flow		1-300 ml/s	0-20	Flowmeter (electromagnetic or ultrasonic)
動脈血圧 Blood pressure, arterial	直接	10-400 mm Hg	0-50	Strain-gage manometer
	間接	25-400 mm Hg	0-60	Cuff, auscultation
静脈血圧 Blood pressure, venous		0-50 mm Hg	0-50	Strain gage

Biosignal		Range	Freq., Hz	Sensor
血液ガス Blood gases	PO ₂	30-100 mm Hg	0-2	Specific electrode, volumetric or manometric
	PCO ₂	40-100 mm Hg	0-2	
	PN ₂	1-3 mm Hg	0-2	
	PCO	0.1- 0.4mm Hg	0-2	
血液pH Blood pH		6.8-7.8 pH units	0-2	Specific electrode
心拍出量 Cardiac output		4-25 liter/min	0-20	Dye dilution, Fick
心電図(ECG) Electrocardiogram		0.5-4 mV	0.01-250	Skin electrodes
脳波(EEG) Electroencephalogram		5-300 μV	0-150	Scalp electrodes

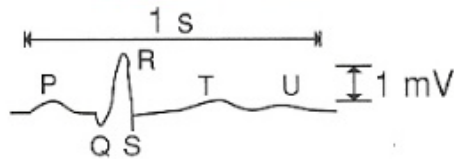
Biosignal	Range	Freq., Hz	Sensor
皮質脳波(EECoG) Electrocorticogram	10-5000 μ V	0-150	Brain-surface or depth electrodes
筋電図(EMG) Electromyogram	0.1-5 mV	0-10,000	Needle electrodes
眼電図(EOG) Electrooculogram	50-3500 μ V	0-50	Contact electrodes
網膜電図(ERG) Electroretinogram	0-900 μ V	0-50	Contact electrodes
電気皮膚反応(GSR) Galvanic skin response	1-500 k Ω	0.01-1	Skin electrodes
胃筋電図(EGG) Electrogastrogram	10-1000 μ V	0-1	Skin-surface electrodes
	0.5-80 mV	0-1	Stomach-surface electrodes
Gastrointestinal pressure 胃腸圧	0-100 cm H ₂ O	0-10	Strain-gage
Gastrointestinal forces 胃腸力	1-50 g	0-1	Displacement system, LVDT
胃pH Gastric pH	3 - 13 pH units	0-1	pH electrode, antimony electrode

Biosignal		Range	Freq., Hz	Sensor
神経電位 Nerve potentials		0.01- 3 mV	0-10,000	Surface or needle electrodes
心音図 Phonocardiogram (PCG)		Dynamic range 80 dB, threshold about 100 μ Pa	5-2000	Microphone
容積脈波 Plethysmogram (volume change)		Varies with organ	0-30	Displacement chamber or impedance change
呼吸機能 Respiratory functions	Flow rate	0-600 liter/min	0-40	Pneumotachograph head and differential pressure
	Respiratory rate	2-50 breaths/min	0.1-10	Strain gage on chest, impedance, nasal thermistor
	Tidal volume	50-1000 ml/breath	0.1-10	Above methods
体温 Body temperature		32-40 $^{\circ}$ C 90-104 $^{\circ}$ F	0-0.1	Thermistor, thermocouple

典型的な生体信号パターン

Typical Patterns of Various Vital Signs

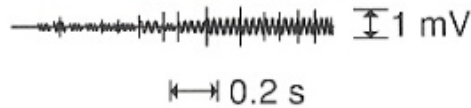
心電図 (ECG)



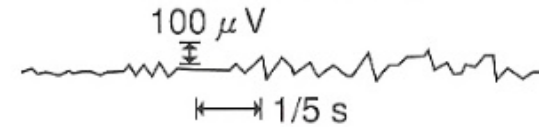
網膜電位図



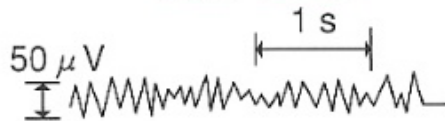
筋電図 (EMG)



活動電位 (膀胱)



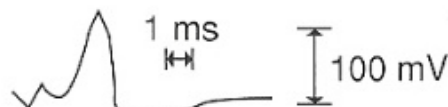
脳波 (EEG)



活動電位 (唾液腺)



活動電位 (神経)



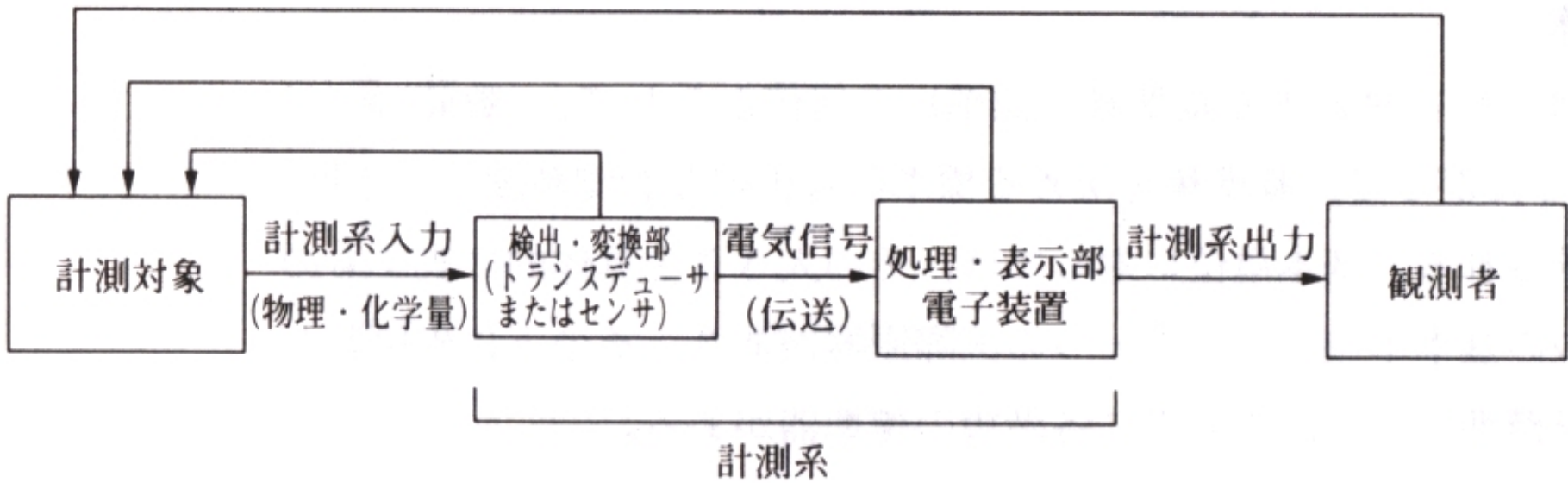
損傷電流 (皮膚)



計測システムの基本構成

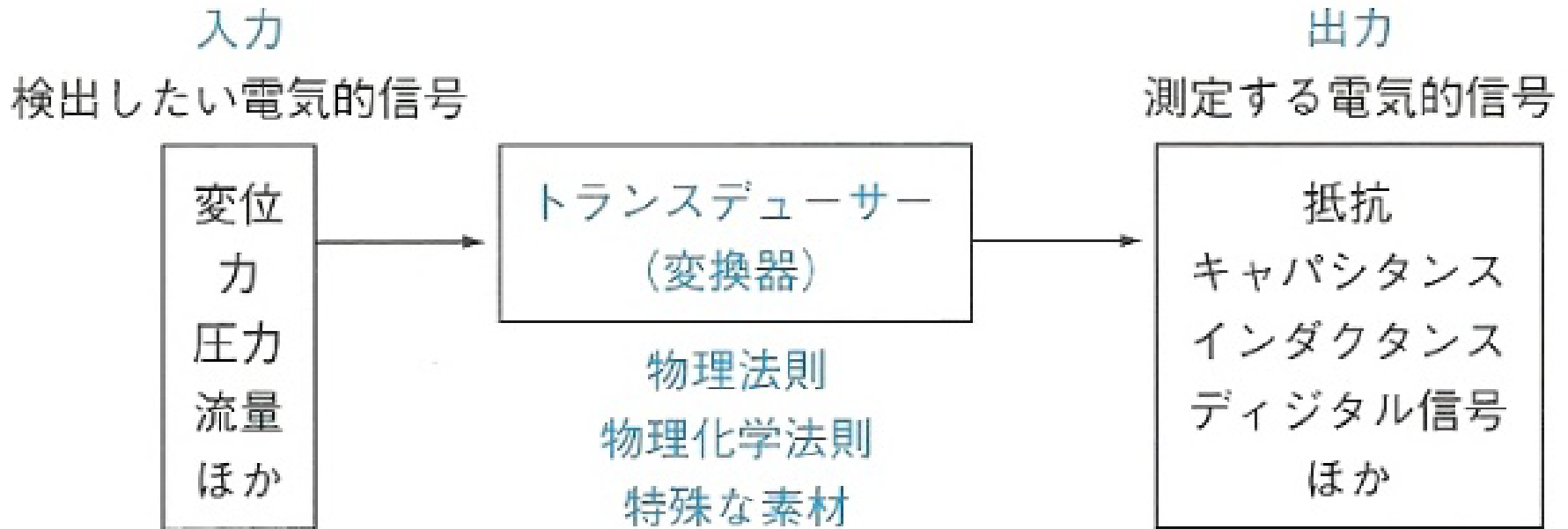
Basic Configuration of a Measurement System

各種物理的操作



生体信号の計測

Measurement of Vital Signs



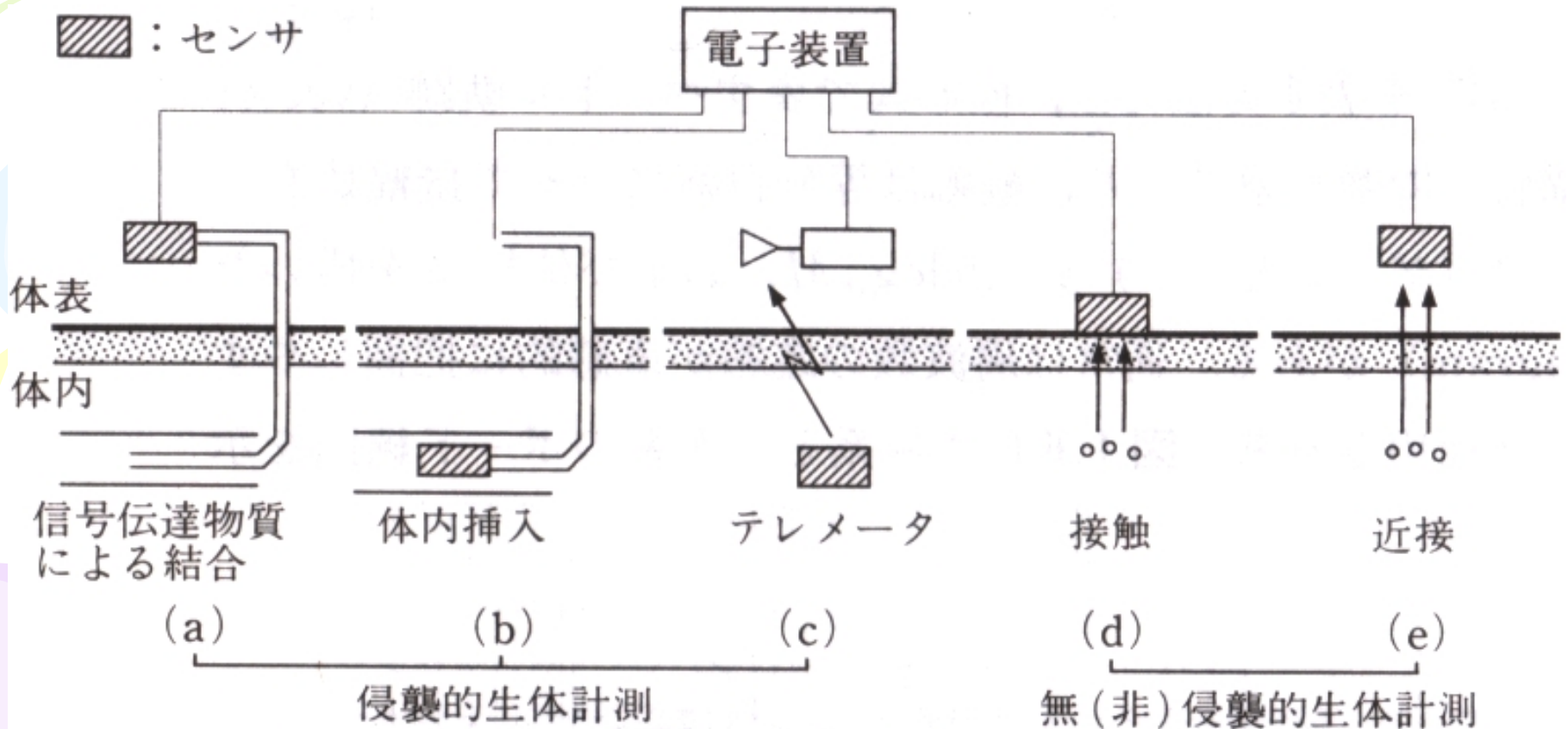
- | | | |
|---------------|--------------------|-----------|
| 筋肉の長さ；変位 | → ストレイン・ゲージ (ひずみ計) | → 電気抵抗の変化 |
| 血圧；受圧膜の変位 | → ストレイン・ゲージ (ひずみ計) | → 電気抵抗の変化 |
| 心音；マイクの受圧膜の変位 | → ピエゾ (圧電) 素子 | → 電気抵抗の変化 |
| 血流量；電磁誘導の法則 | → 電磁誘導コイル | → 電圧の変化 |

生体計測の特殊性

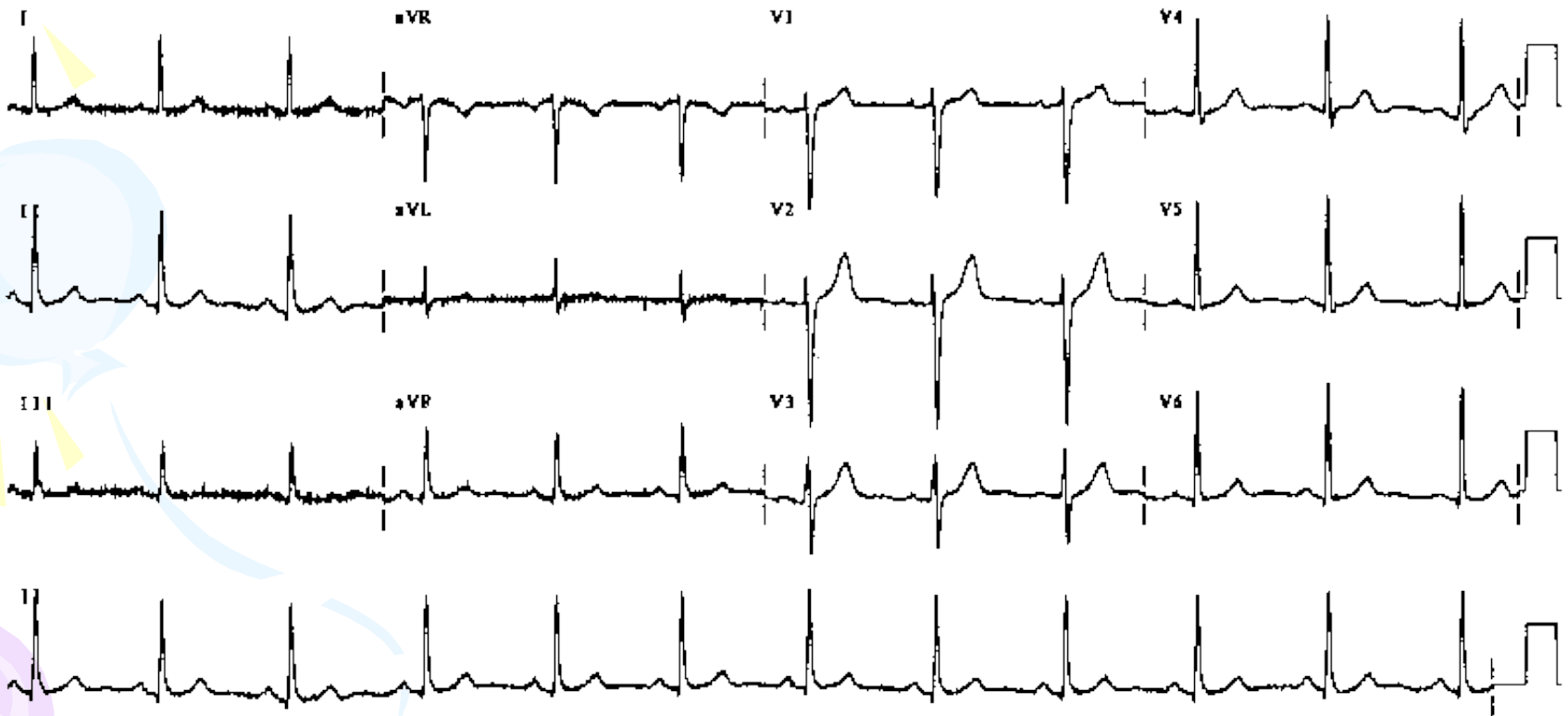
Particularity of Bio-measurement

- 組織・器官破壊や生理状態の乱れを最小限にする
- 生理量の変化は短時間の成分にも長時間の成分にも意味があり、計測システムの広い周波数応答性と高い生物的・化学的安定性が要求される
- 組織や器官が柔らかく壊れやすく、異物に対して拒絶反応のため、生体と直接接触するセンサ素材に生物親和性が要求される
- 人間に意思と感情があり、強制や拘束、不快や痛みを最小限にする

計測手法 Measurement Methods



心電図(ECG) Electrocardiogram



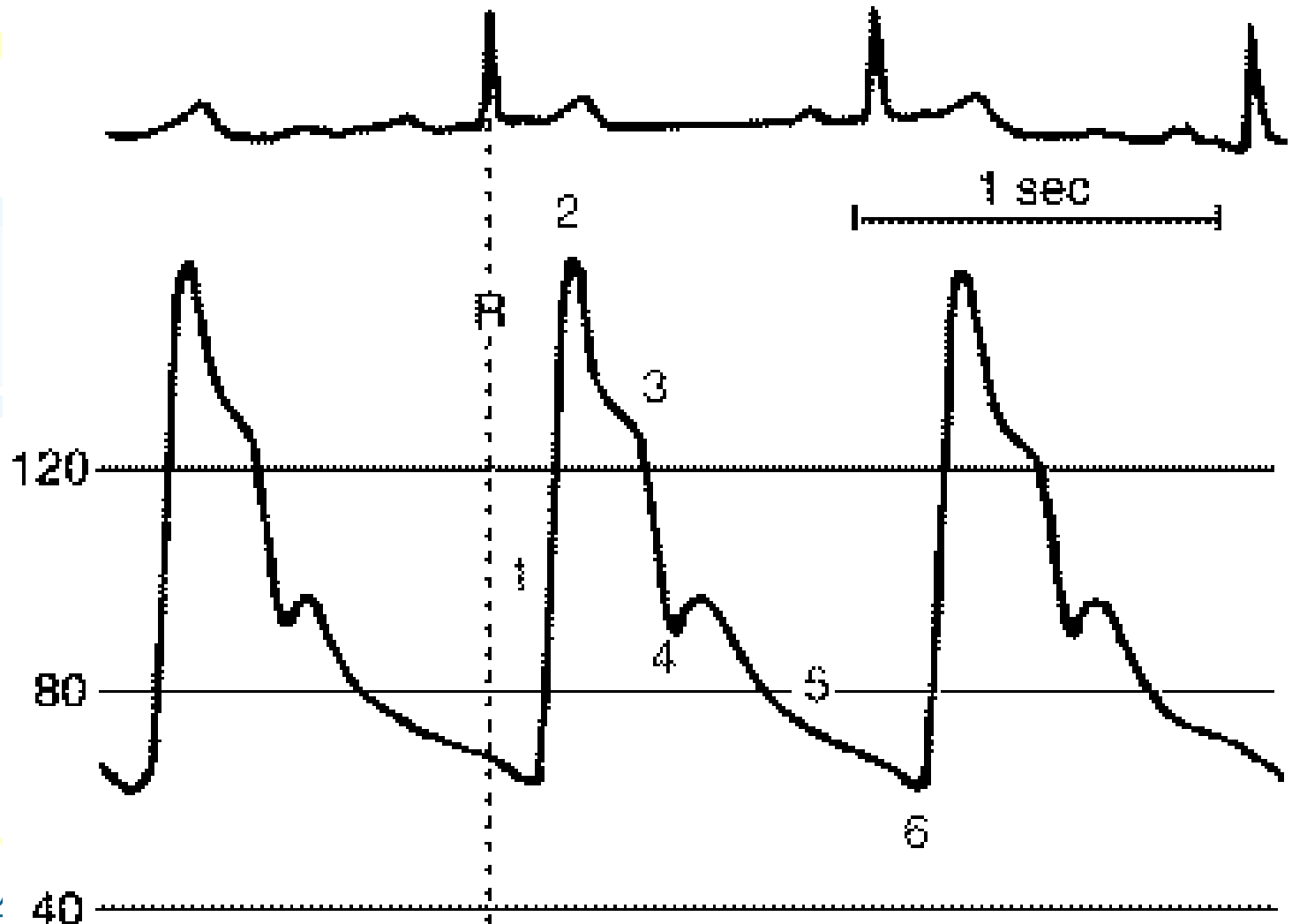
I OC 0000-0000 Speed: 25 mm/sec Limb: 10 mV Chest: 10 mm/mV

50% 0.15-150 Hz

16405

心電図と動脈血圧

ECGとABP (Arterial Blood Pressure)



心電図と呼吸

ECGとRESP(respiration)



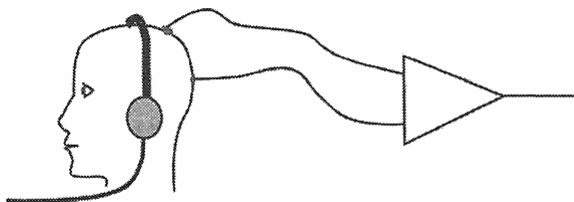
自発脳波 Spontaneous EEG (Electroencephalogram)



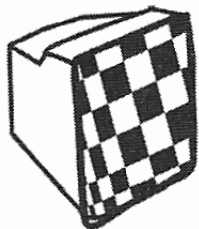
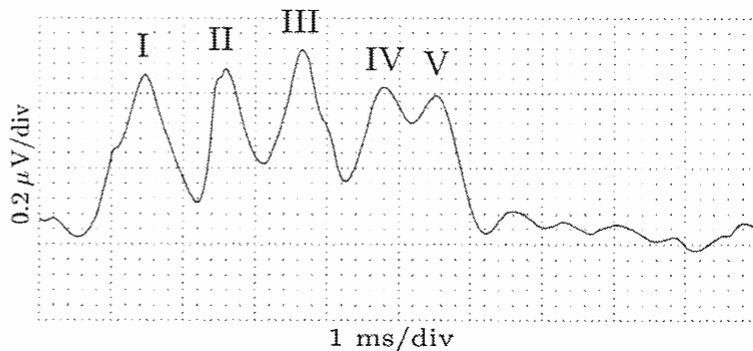
誘発脳波



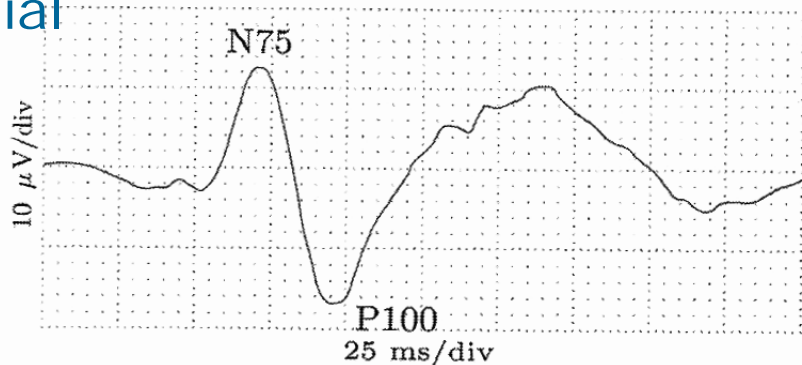
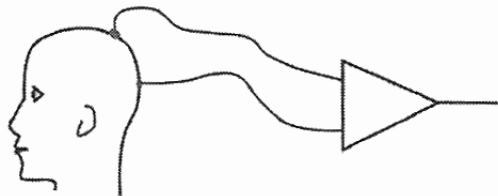
Evoked, Event-related EEG



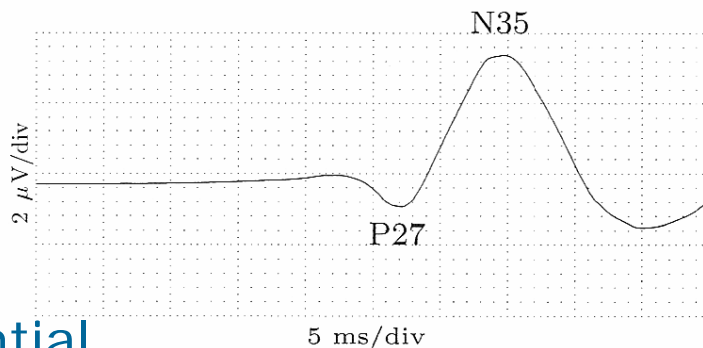
聴覚誘発電位 (AEP)
Auditory Evoked Potential



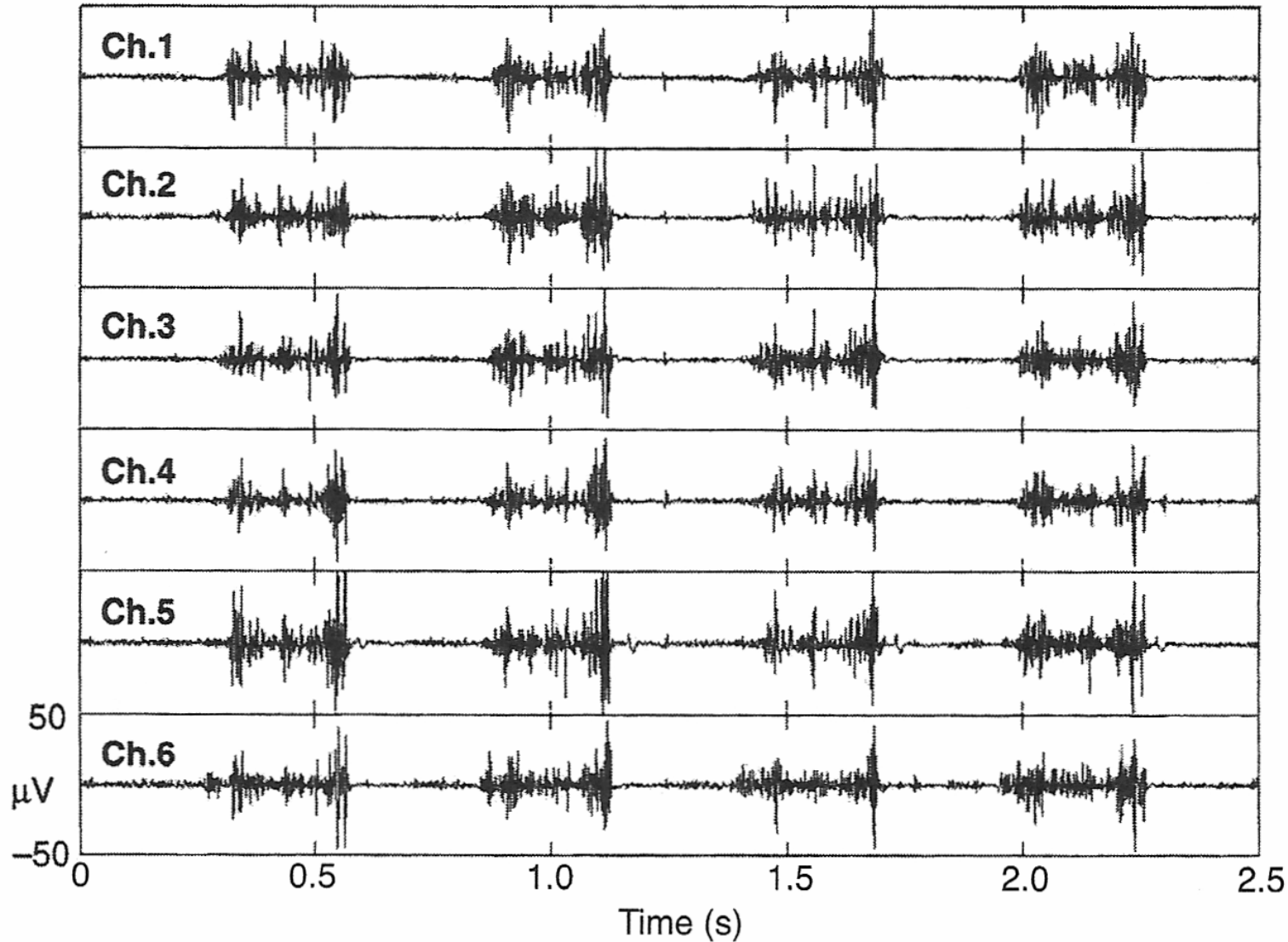
視覚誘発電位 (VEP)



体性感覚誘発電位 (SEP)
Somatosensory Evoked Potential

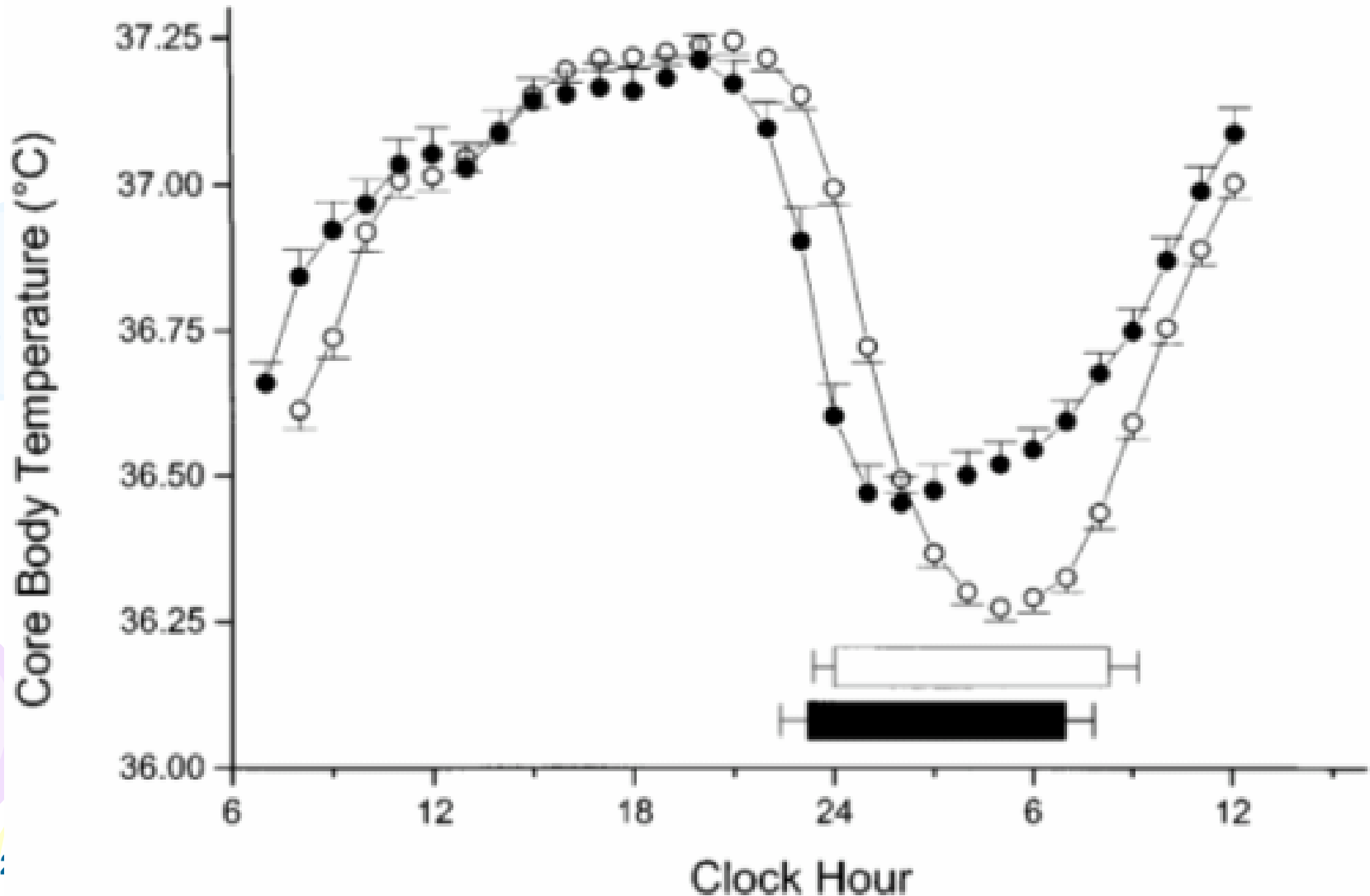


筋電図(EMG) Electromyogram



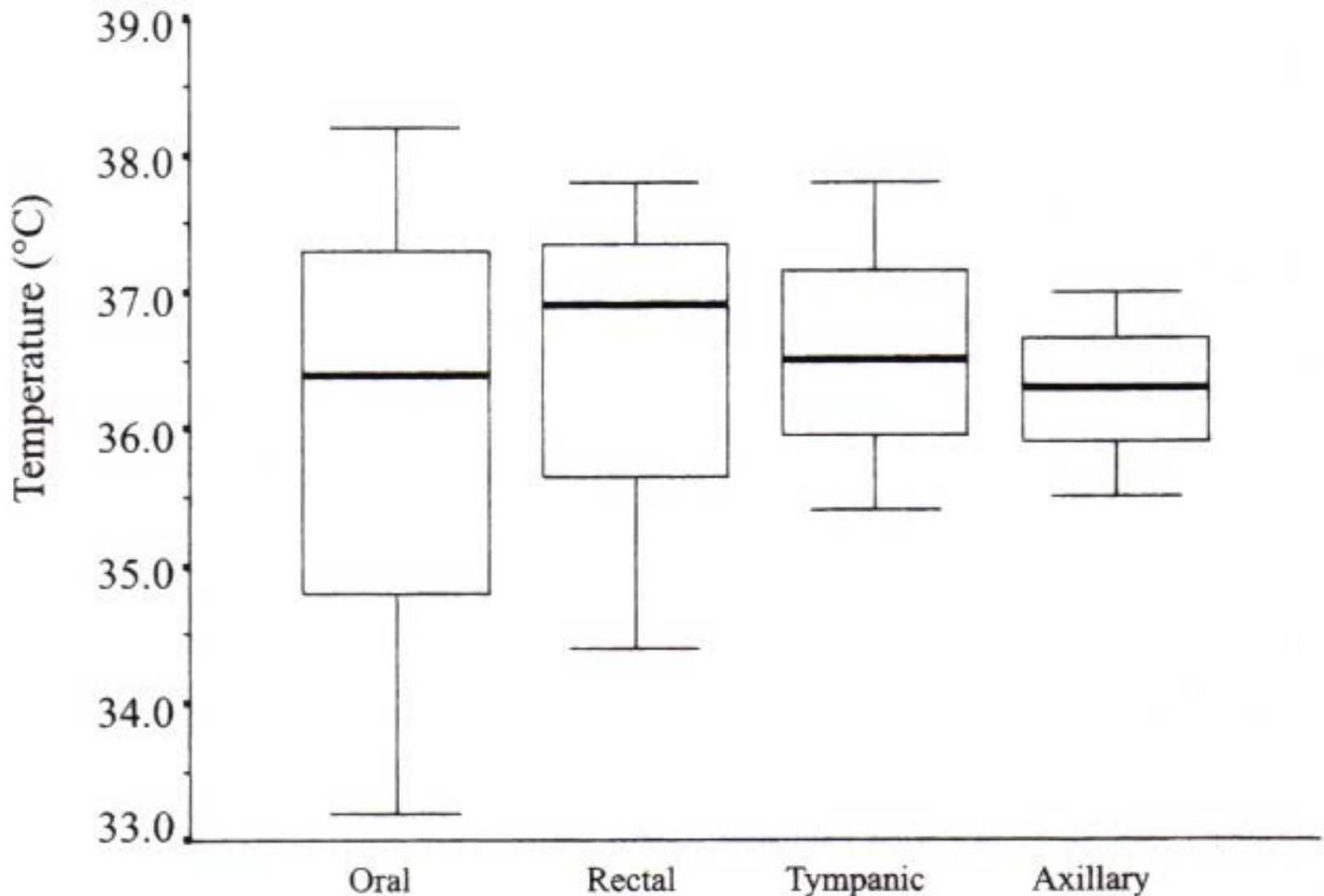
時間とともに変化する体温

Time-dependent Body Temperature

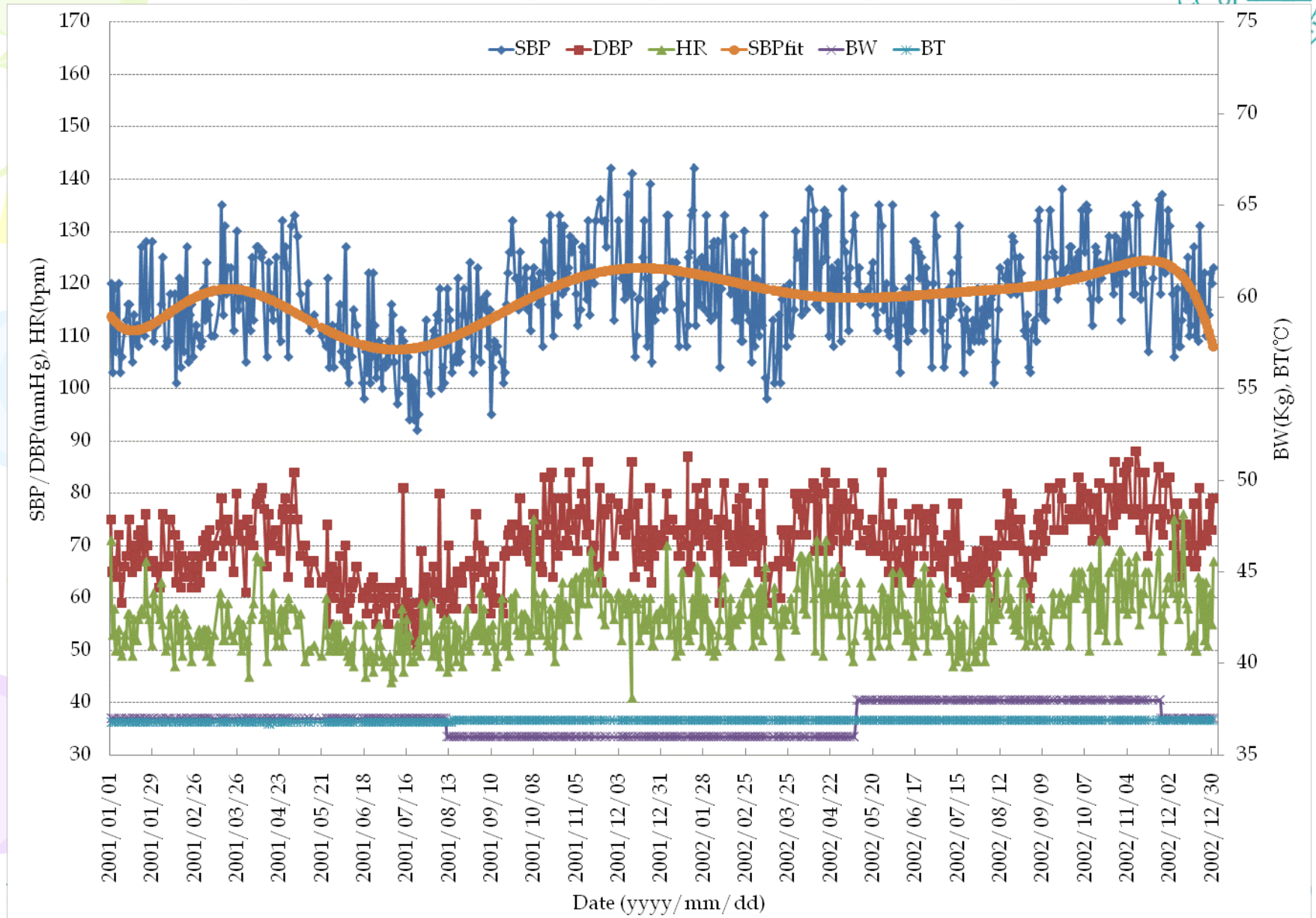


計測部位に依存する体温変化

Site-dependent Body Temperature



血压(BP),心拍数(HR),体重(BW),体温(BT)



信号とノイズ

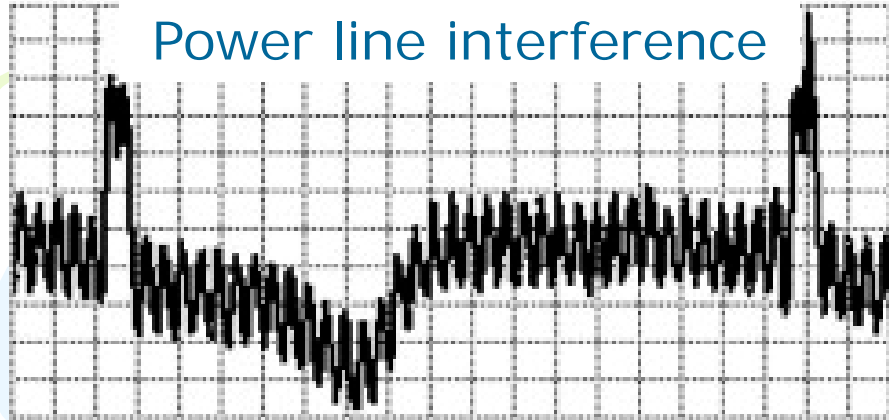
- Signal
 - the component of a variable that contains information about the object quantity
- Noise
 - a component unrelated to the object quantity
- Signal ↔ Noise
 - not defined by **physical nature** but by the intention of the **observer**
- Signal-to-Noise Ratio (SNR)

$$SNR(\text{dB}) = 10 \log_{10} \frac{P_S}{P_N} = 20 \log_{10} \frac{A_S}{A_N}$$

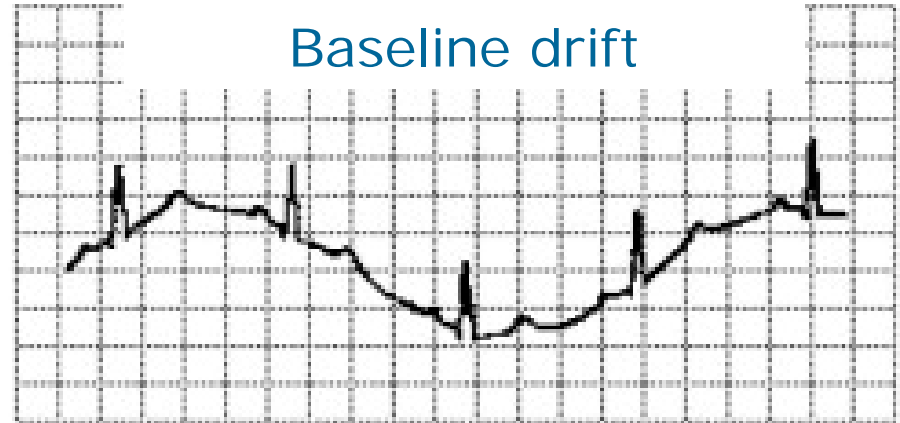
- P and A indicate power and RMS amplitude, respectively

ECGと各種雑音

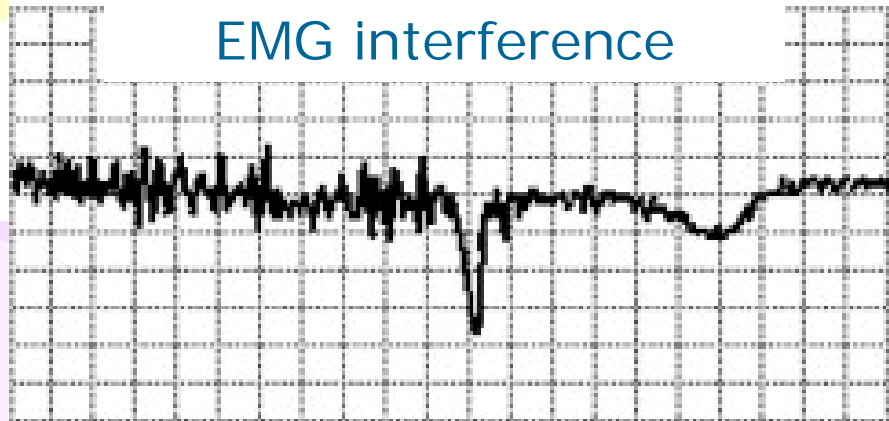
Power line interference



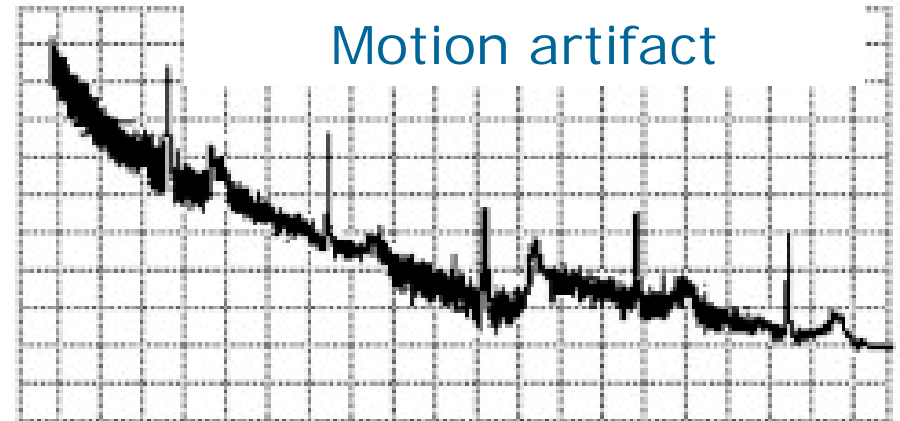
Baseline drift



EMG interference



Motion artifact

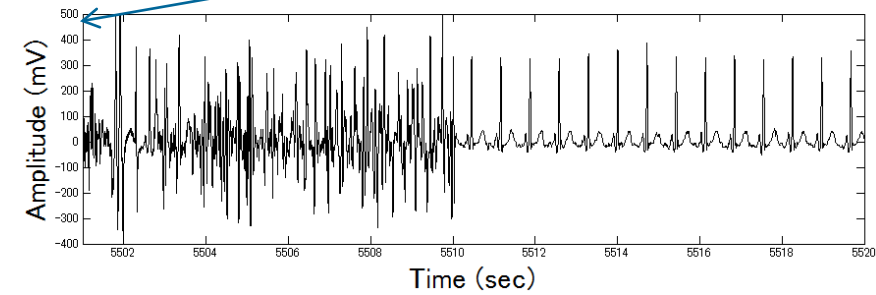
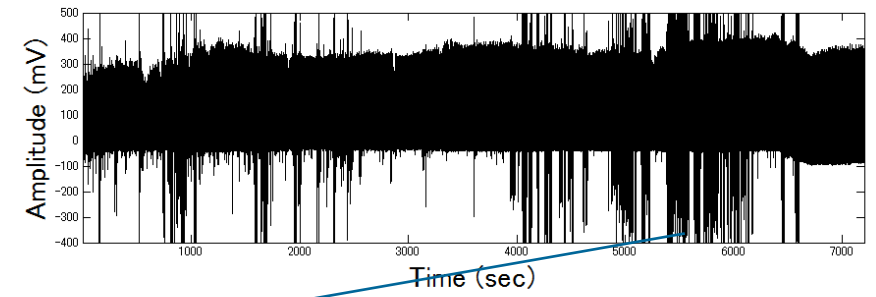
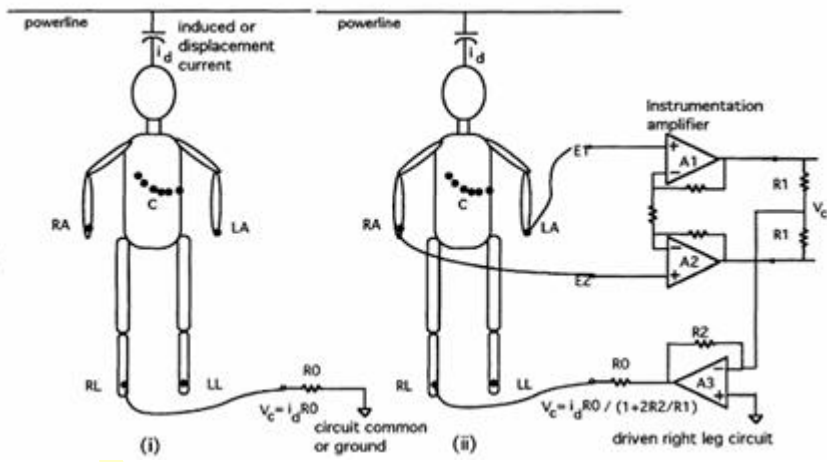
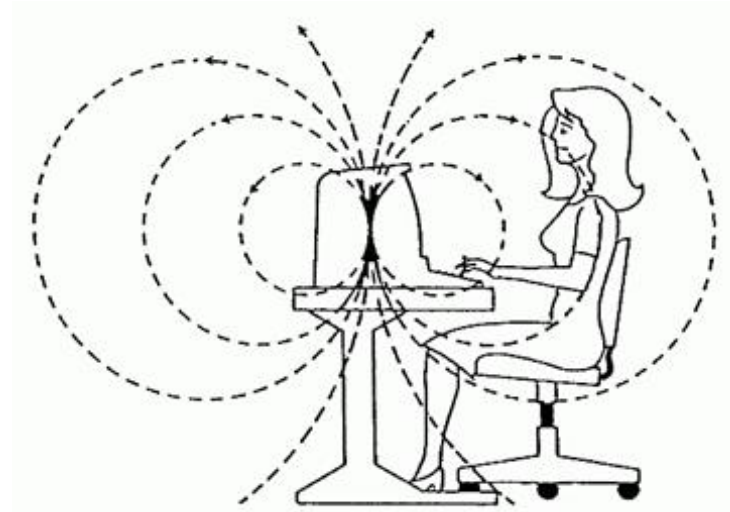
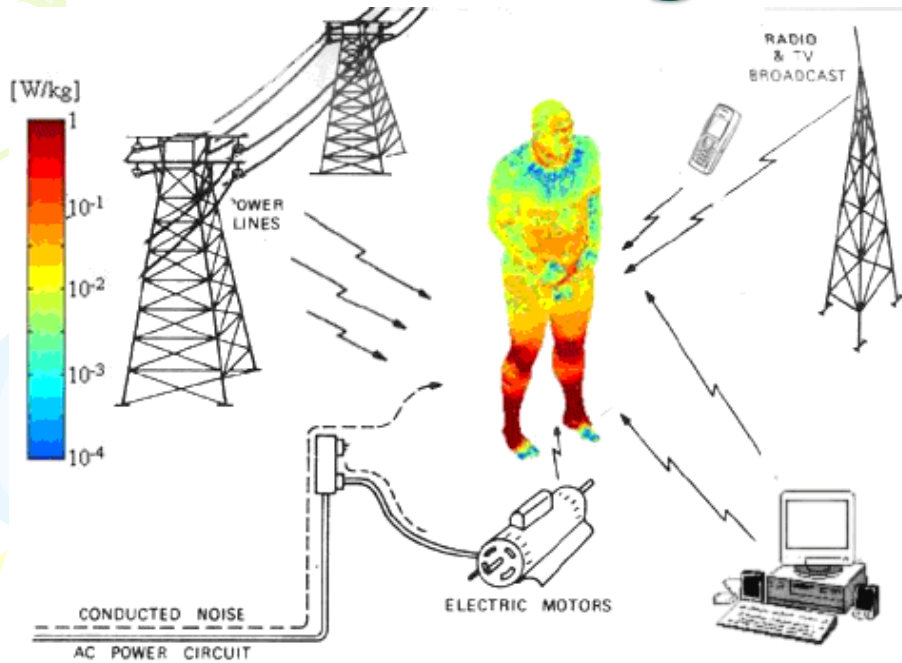


ノイズの種類

- Thermal Noise
 - Random thermal agitation relevant to temperature
 - Uniform distribution of power density
- 1/f Noise
 - Many natural phenomena
 - Power density is inversely proportional to the frequency
- Interference
 - Electromagnetic coupling - power line, fluorescent lamps
- Artifact
 - Superimposed on the object quantity and caused by external factors such as motion – skin-electrode contact

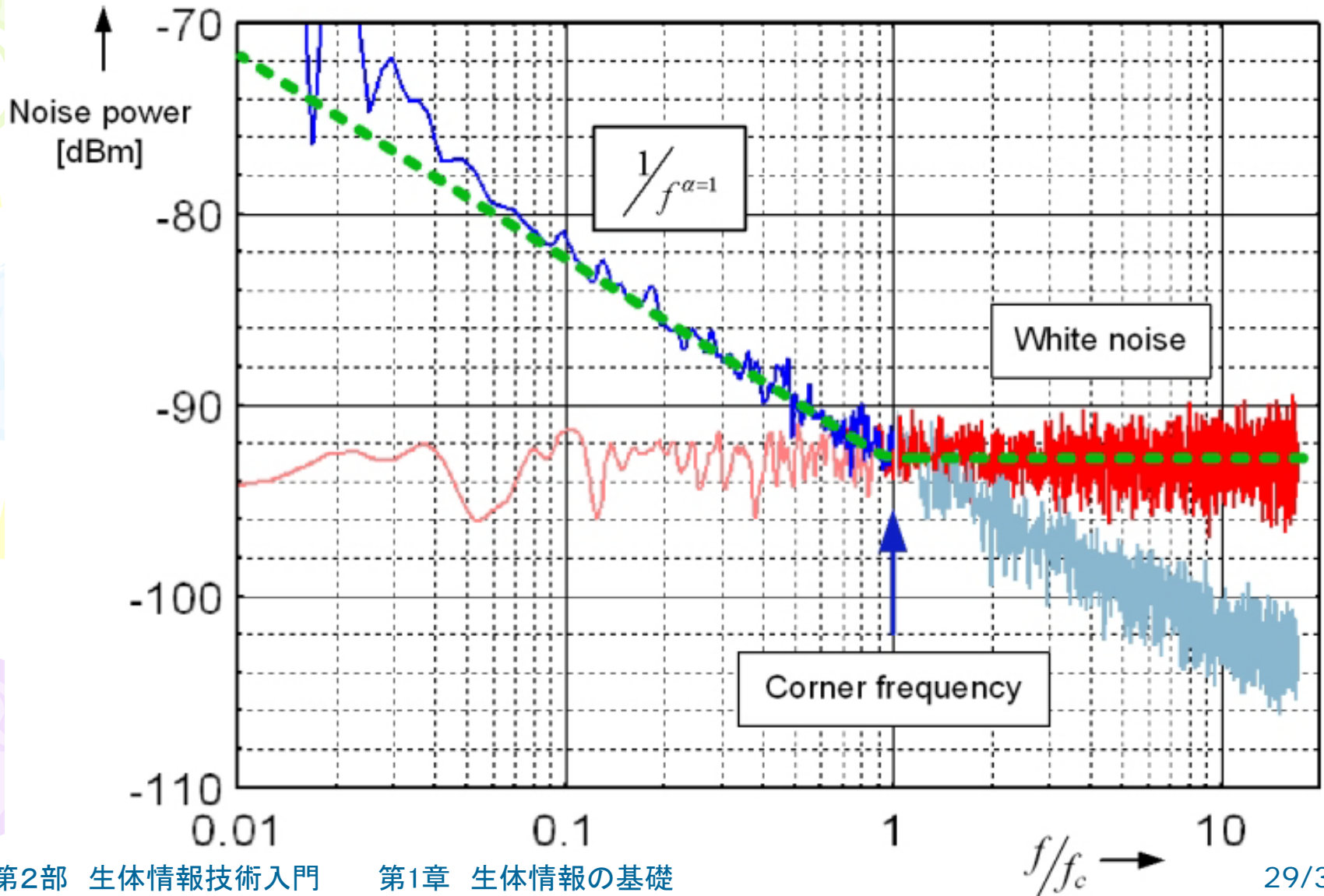
電磁ノイズ(EMI)

Electromagnetic Interference



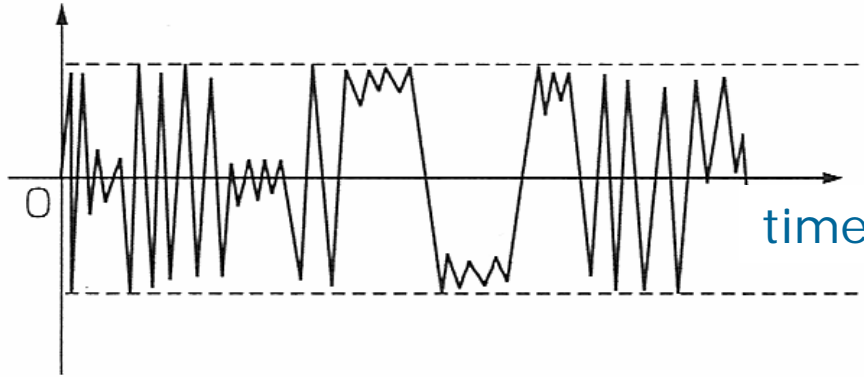
礎

1/f ノイズ

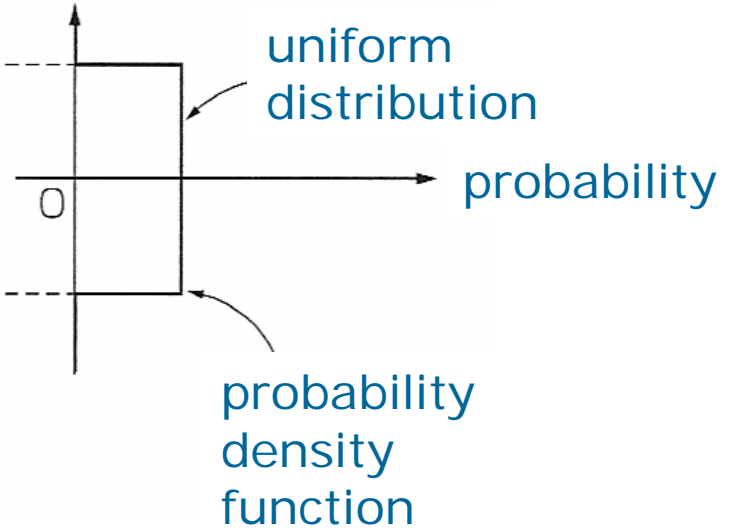


ノイズの確率分布

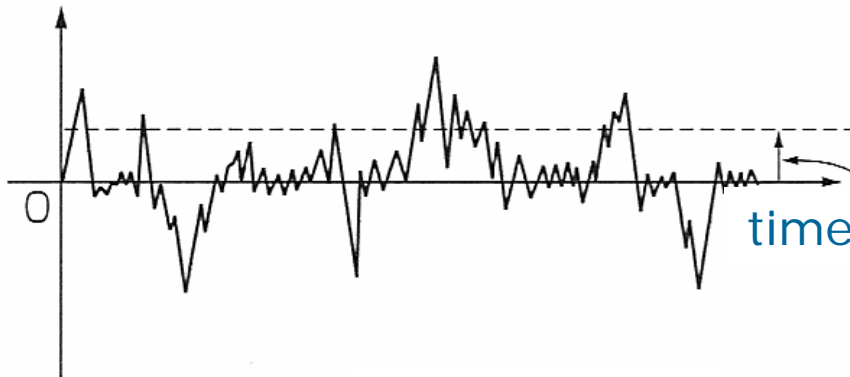
amplitude



amplitude



amplitude



amplitude

