

BIOSENZORI: JUČER, DANAS I SUTRA

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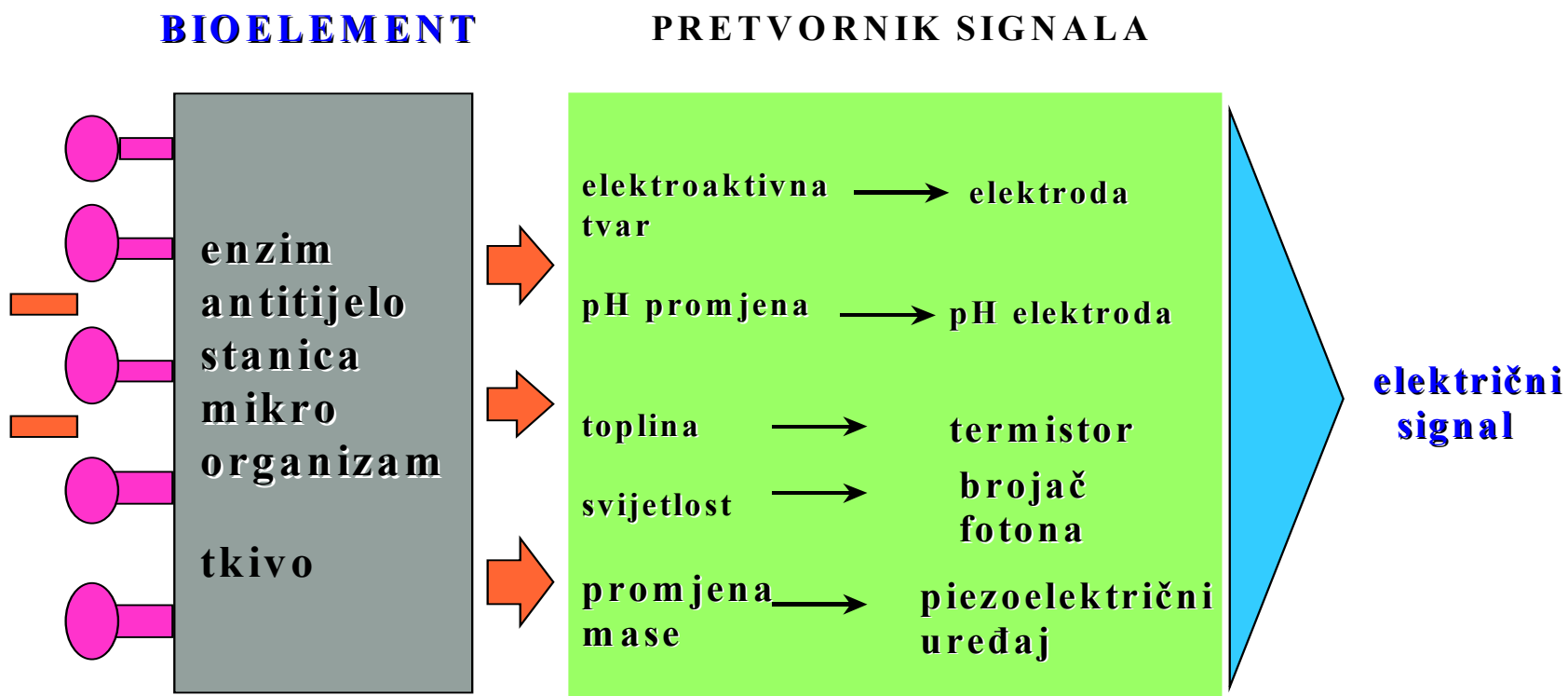
Fakultet kemijskog inženjerstva i tehnologije
Sveučilište u Zagrebu

Senzori :



- male naprave koje informaciju o koncentraciji jednog ili više analita pretvaraju u signal koji je jednostavno elektronički obrađivati, transportirati i sl.

Biosenzori:





IMOBILIZACIJA AKTIVNIH TVARI ZA BIOLOŠKO PREPOZNAVANJE

- ENZIMI
- ANTITIJELA
- RECEPTORI
- MIKROORGANIZMI
- ŽIVOTINJSKE ILI BILJNE STANICE
- ŽIVOTINJSKA I BILJNA VLAKNA
- DNA, RNA



Područja primjene biosenzora

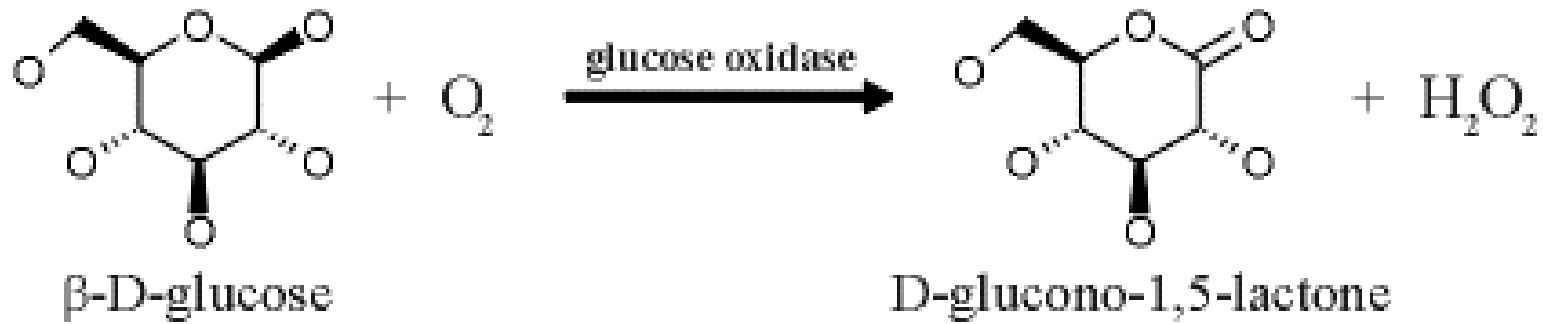
- Medicinska primjena (2.8 milijardi \$ u 2003)
(5 milijardi \$ u 2005, 86% za mjerenje glukoze)
- Farmaceutska istraživanja
- Vojna primjena
- Industrijska proizvodnja hrane
- Zaštita okoliša



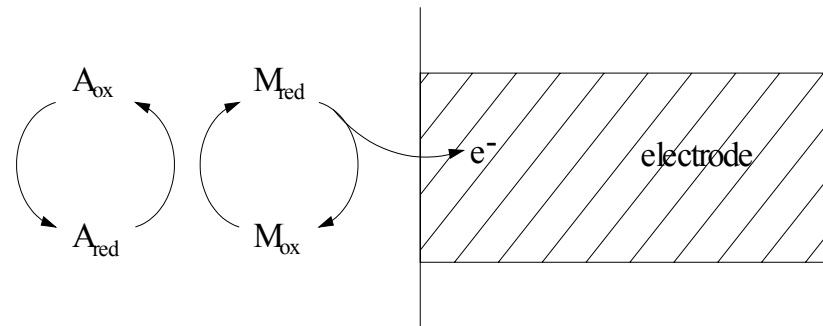
Razvoj biosenzora

- uporabljene biološke matrice (elementi)
- uporabljeni pretvornički elementi
- vrsta senzorske tehnologije
- izvedba mjerenja (neprotično, protično)
- način ostvarivanja kontakta redoks-centra enzima i pretvorničkog elementa
- ostali

Kemizam glukoznog biosenzora



Shematski prikaz rada enzimskog biosenzora

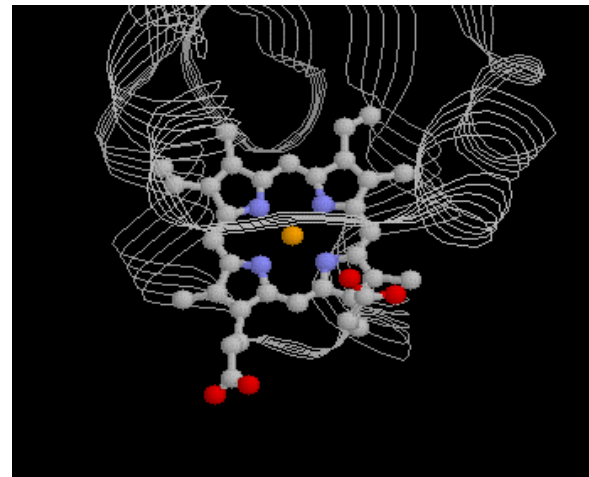
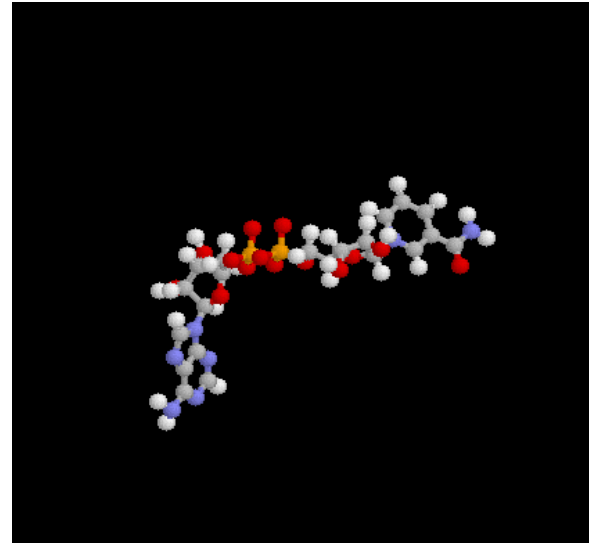
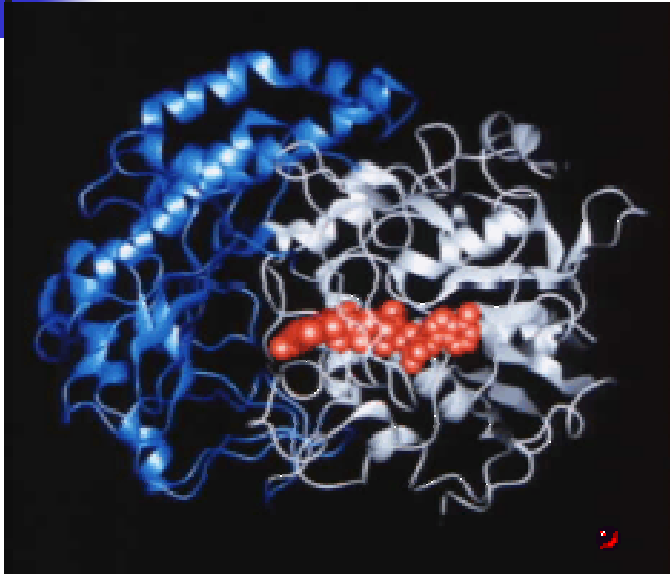




MEDIJATORI PRIJENOSA ELEKTRONA

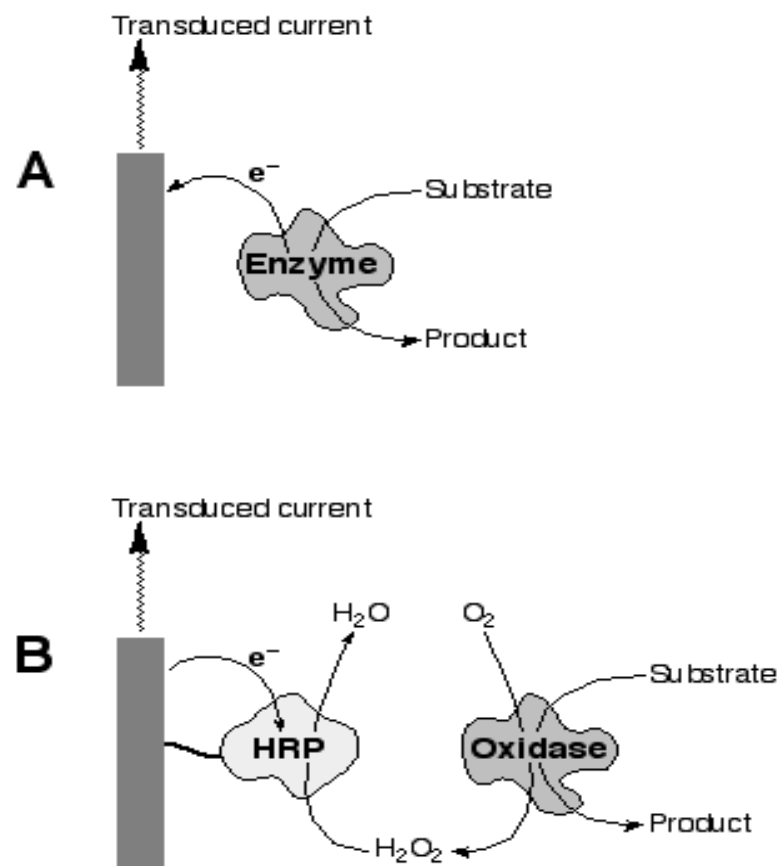
- - redoks centar – nalazi se u dubini proteinskog lanca
- - nema električnog kontakta između redoks centra i površine elektrode
- - tanki proteinski lanac stvara kinetičku barijeru prijelazu elektrona (tunneliranju elektrona)

Glukoza-oksidaza- FAD Peroksidaza-HEM



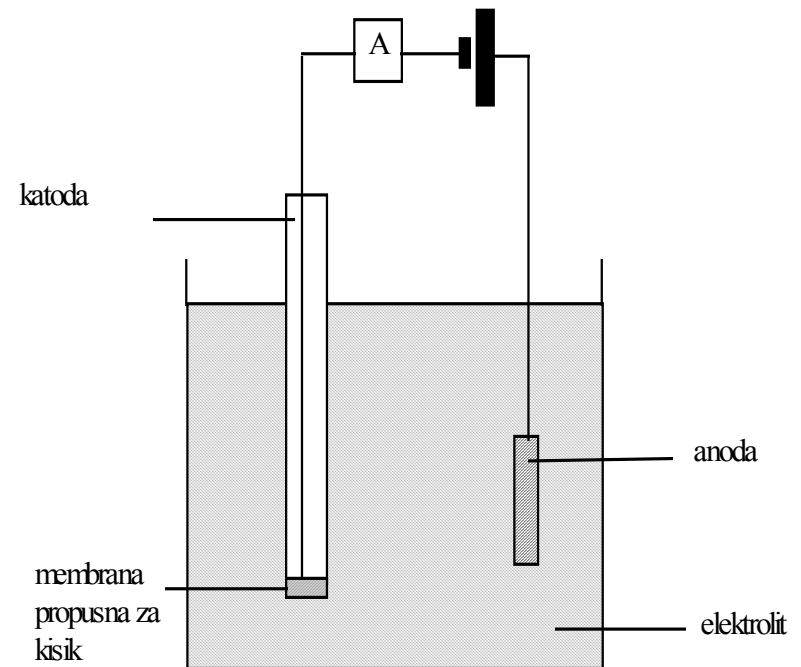
Direktni kontakt površine elektrode i enzimskog redoks centra - *biosenzori bez medijatora elektrona*

- *elektroredukcija O_2 i H_2O_2 biokatalizirana lakazom i peroksidazom*

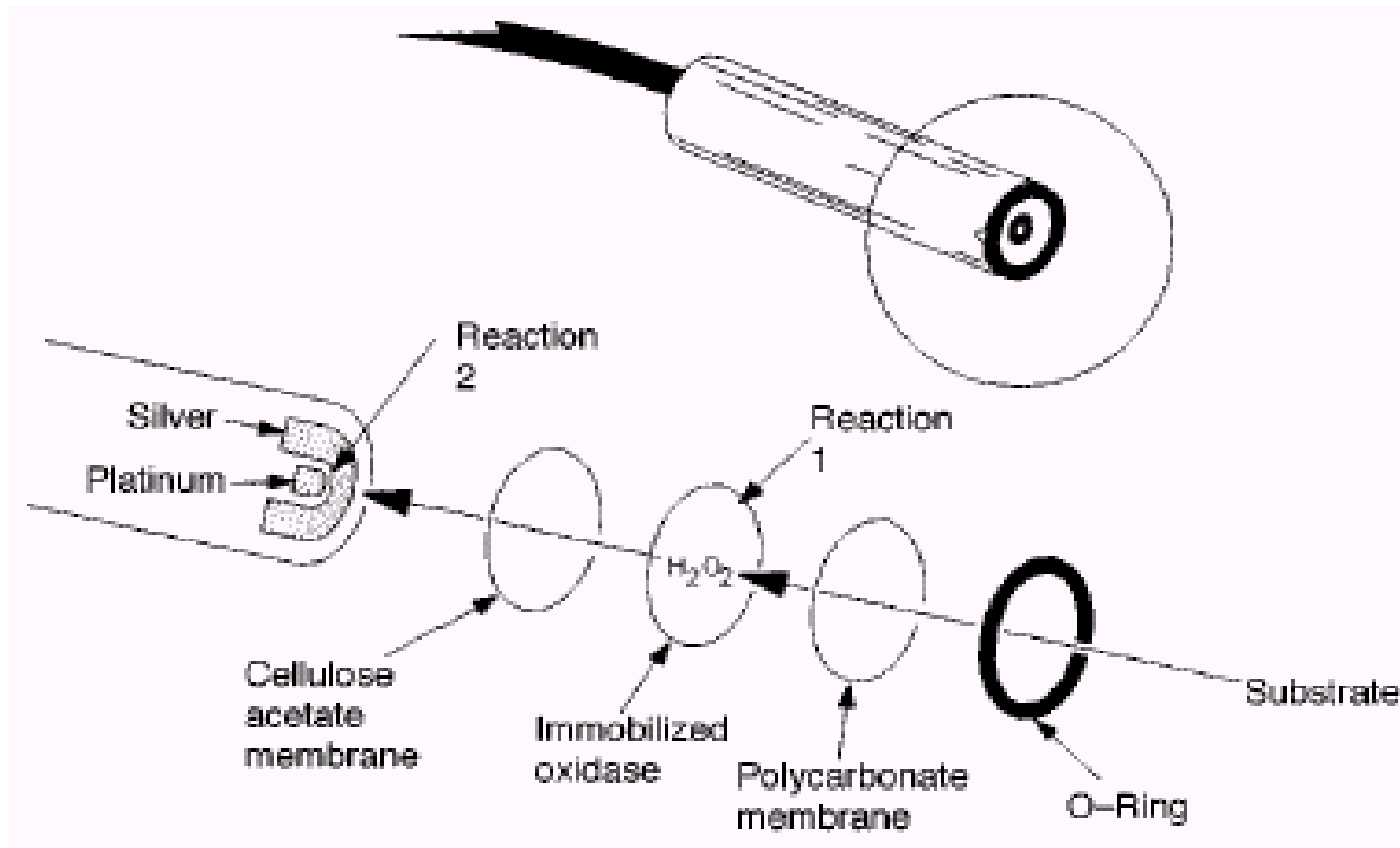


Amperometrijski biosenzori

- Clark (1956)
- Katodna reakcija:
 - $O_2 + H_2O + 4 e^- \rightarrow 4OH^-$
- Anodna reakcija:
 - $Ag \rightarrow Ag^+ + e^-$
 - $Ag^+ + Cl^- \rightarrow AgCl$



Glukoзни biosenzor (YSI)





Reakcijska shema YSI glukoznog biosenzora

- $\text{Glukoza} + \text{GOD (FAD)} \rightarrow \text{glukolakton} + \text{GOD (FADH}_2\text{)}$
- $\text{O}_2 + \text{GOD(FADH}_2\text{)} \rightarrow \text{H}_2\text{O}_2 + \text{GOD(FAD)}$
- $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2\text{H}^+ + 2\text{e}^-$

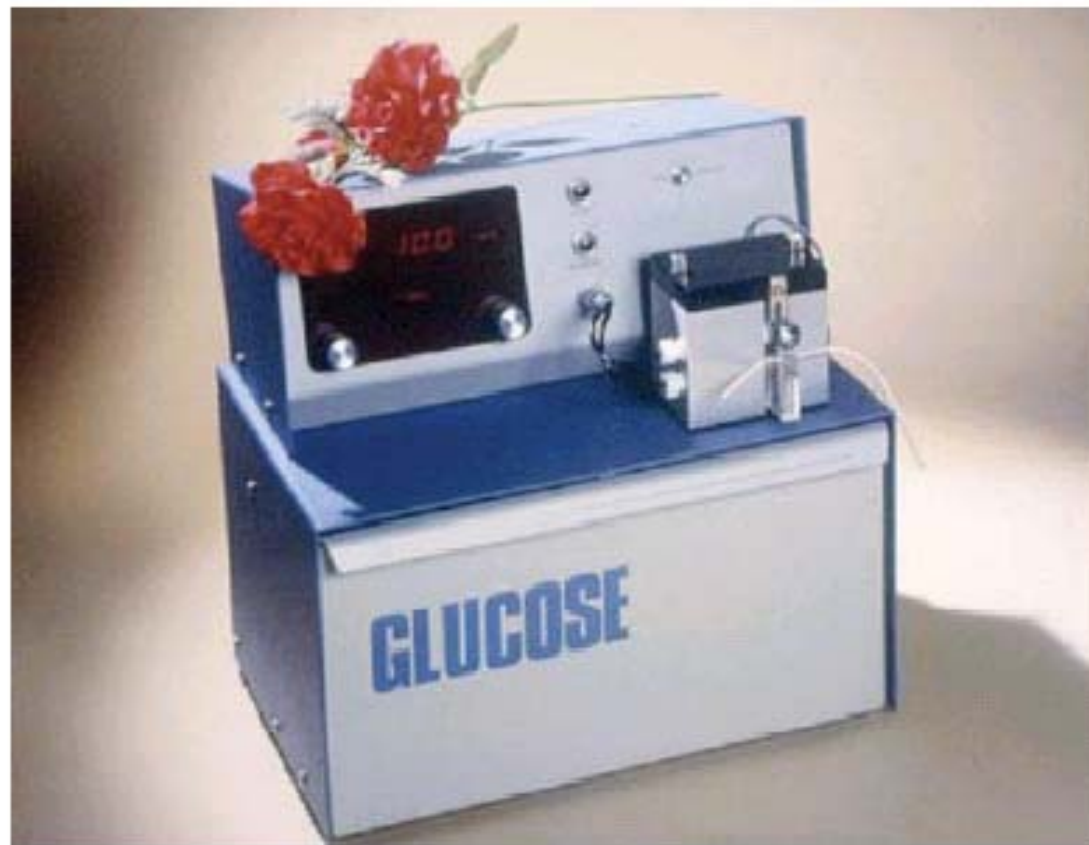
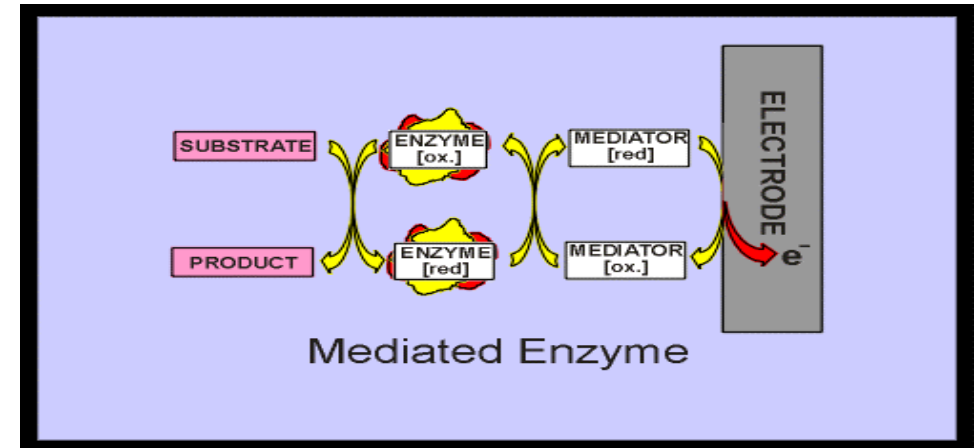


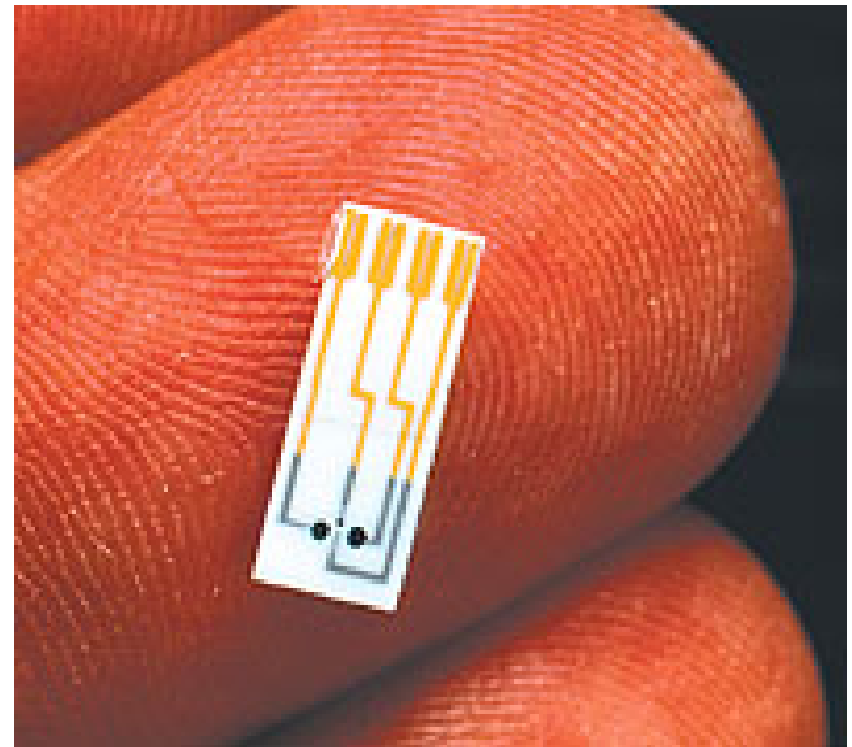
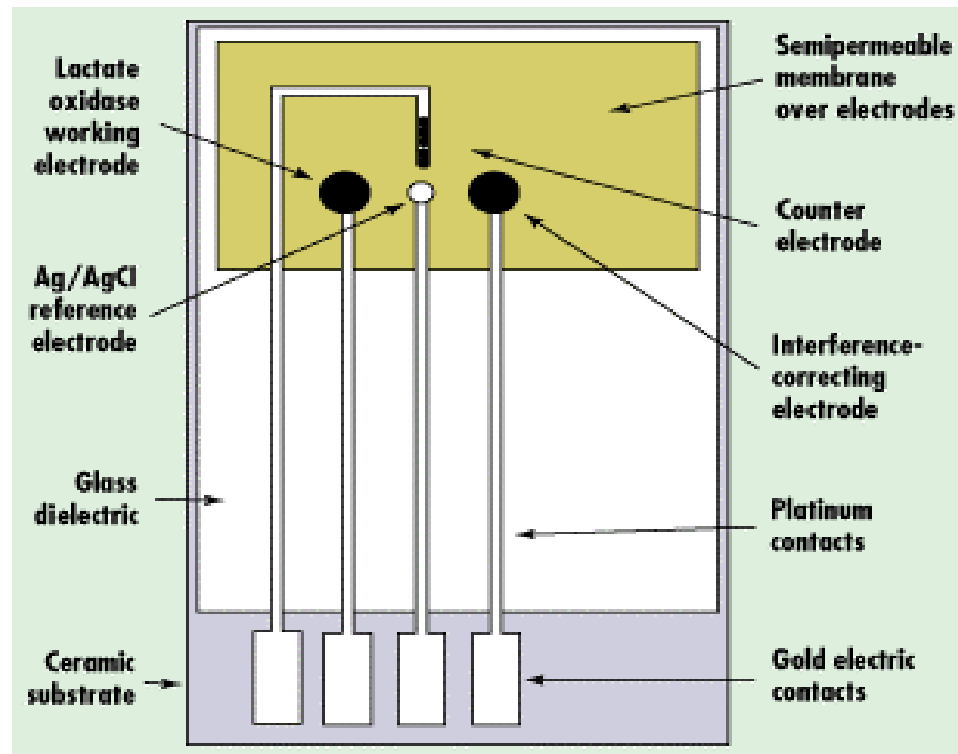
Exhibit 2.1 First Yellow Springs Instrument Glucose Analyser, circa 1975

Biosenzor s difuzijskim medijatorom

- Feroceni
- Organske boje
- Heksacianoferati
- Ru-kompleksi
- Ostali
- Medijator difundira od redoks centra do elektrode
- medijator je otopljen unutar enzimskog sloja
- imobiliziran u monosloju ili multi sloju na elektrodi
- uklopljen u poroznoj matrici



Glukoзни biosenzor izveden planarnom tehnologijom



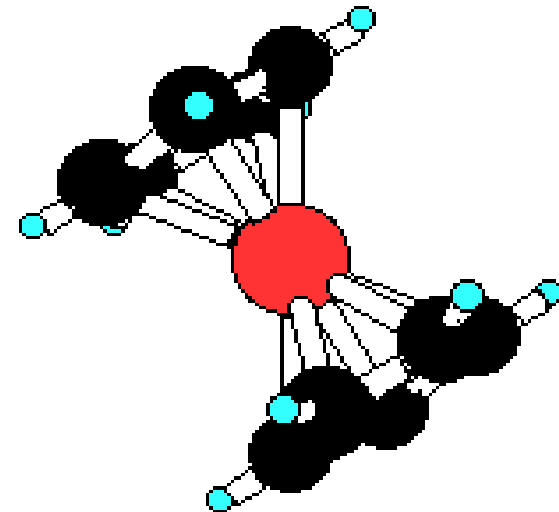
Glukočni analizator za osobnu uporabu

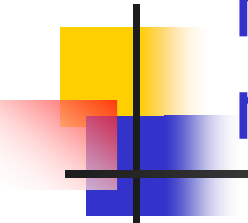


Exhibit 2.2 MediSense glucose meters and test strips

Reakcijska shema glukoznog senzora (MediSense, 1987)

- Glukoza + GOD (FAD) → glukolakton + GOD (FADH₂)
- 2Fc⁺ + GOD(FADH₂) + → 2Fc + GOD(FAD)

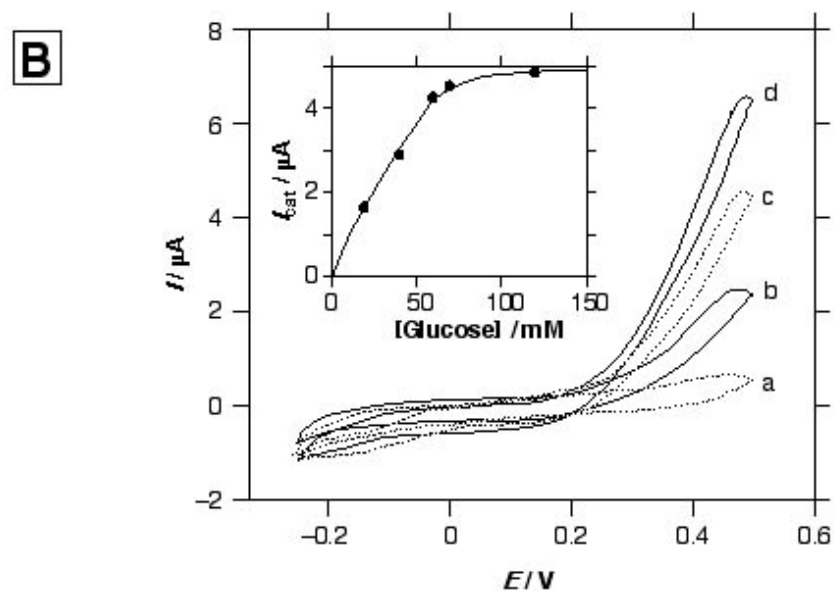
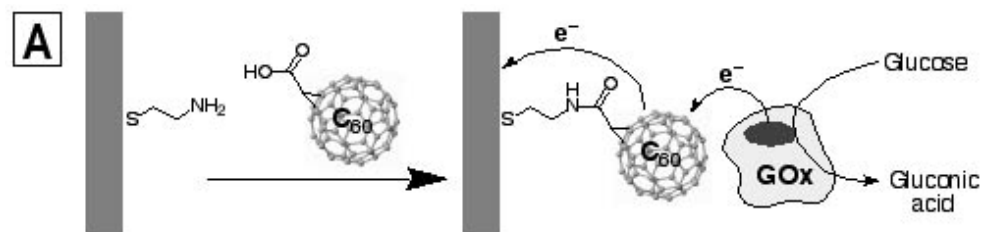




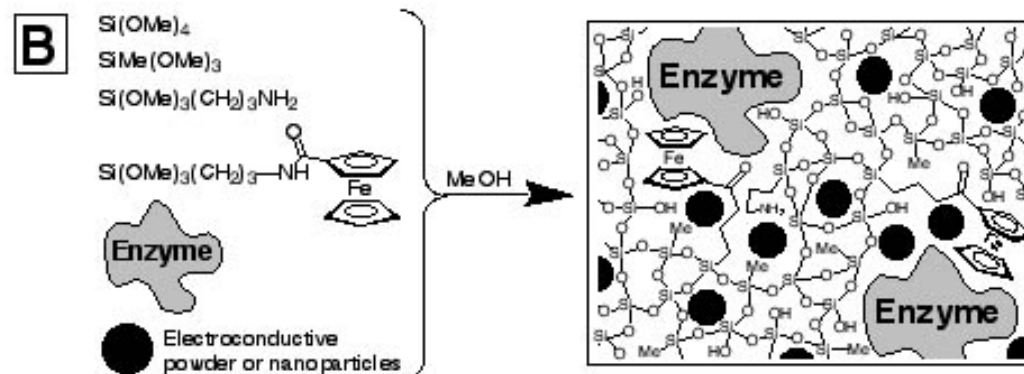
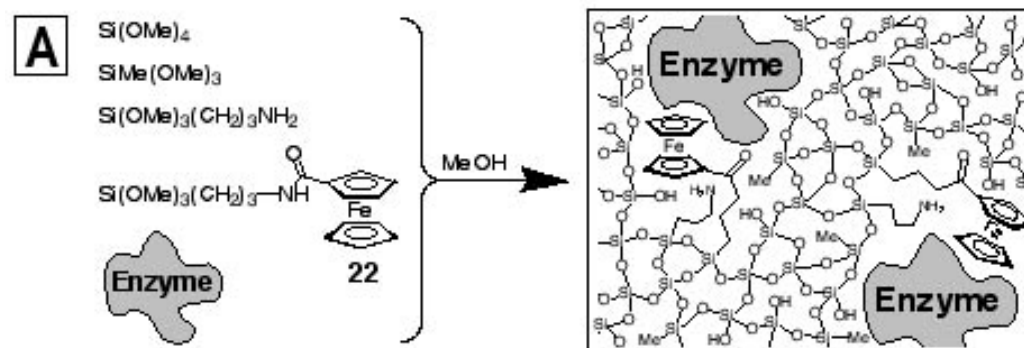
Biosenzor za glukozu s heksacianoferatnim difuzijskim medijatorom (Boehringer electrode, 1994)

- **Glukoza + GOD (FAD) → glukolakton + GOD (FADH₂)**
- **O₂ + GOD(FADH₂) → H₂O₂ + GOD(FAD)**
- **H₂O₂ + 2 Fe(CN)₆⁴⁻ + 2H⁺ → 2H₂O + 2Fe(CN)₆³⁻**
- **2Fe(CN)₆³⁻ + e⁻ → 2 Fe(CN)₆⁴⁻**

ELEKTRIČKI KONTAKT MEDIJATOROM FUNKCIONALIZIRANE ELEKTRODE



Električki kontakt enzima i medijatora unutar sol-gel matrice

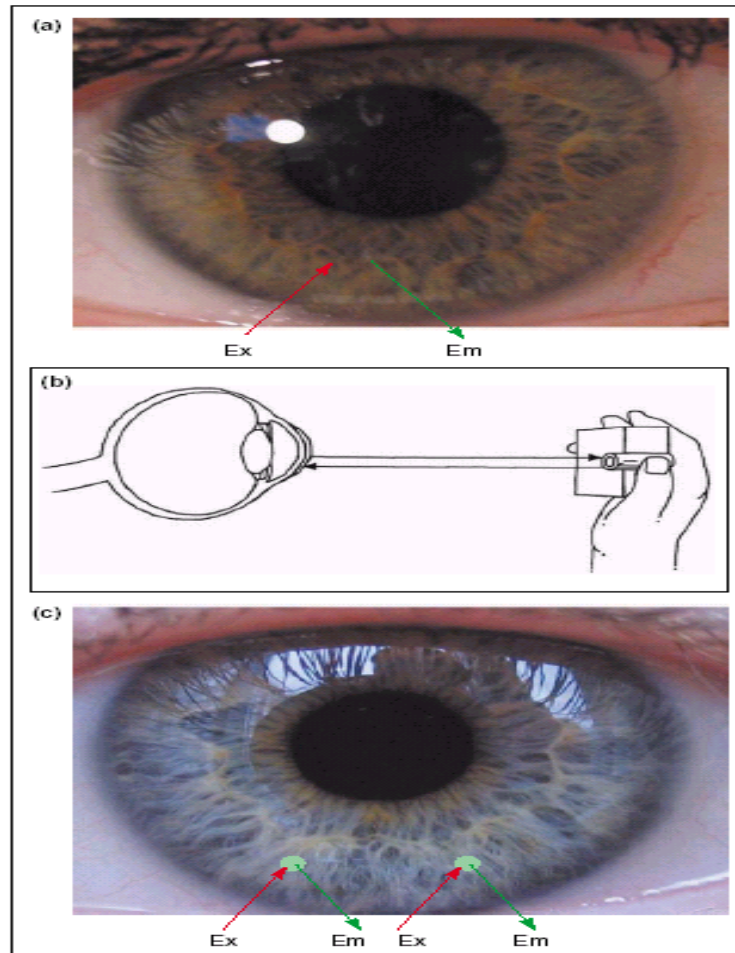




Buduće konstrukcije

- Direktna oksidacija analita (glukoze) na mjernoj elektrodi oslojenoj nanočesticama
- Direktna veza redoks centra i elektrode ostvarena nanočesticama (<100 nm)
- Imobilizacija DNA
- Optičke izvedbe

Kontaktne leće s fluorescentnim glukoznim senzorom



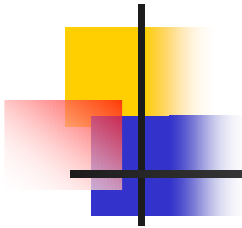


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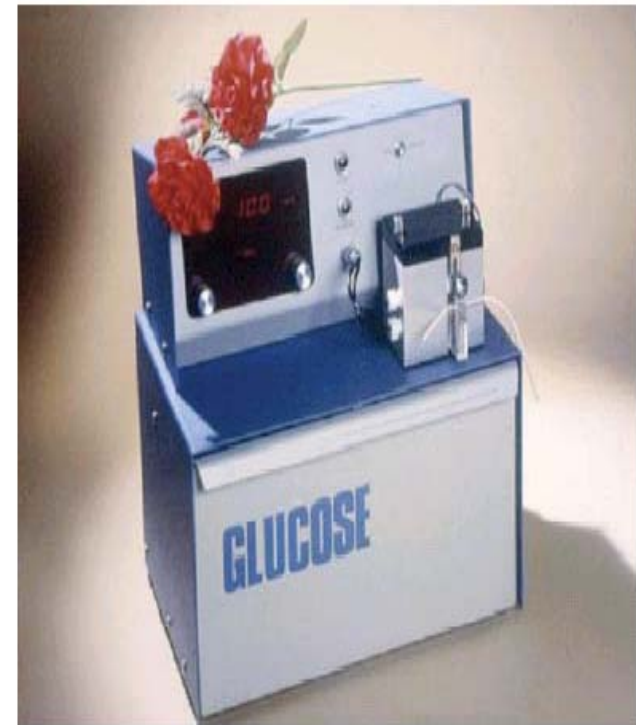


Exhibit 2.1 First Yellow Springs Instrument Glucose Analyser, circa 1975