

### Tinta

È quello che comunemente chiamiamo colore

Ruota dei colori

Diciamo che sono tutti verdi: hanno la stessa tinta

... ma non basta...

questo è "meno" verde →

Sono 2 verdi,  
ma ci verrebbe da dire che...

questo è "più" verde →

### Saturazione

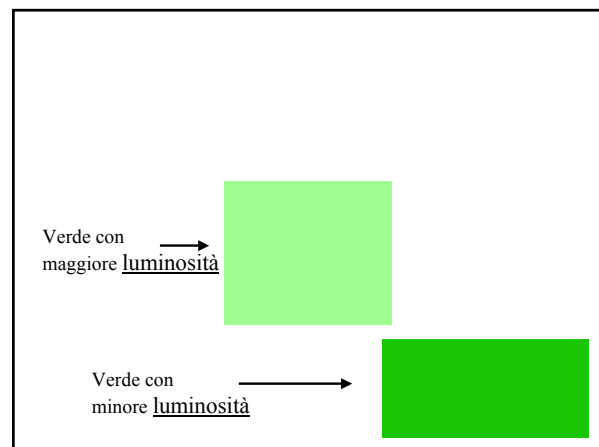
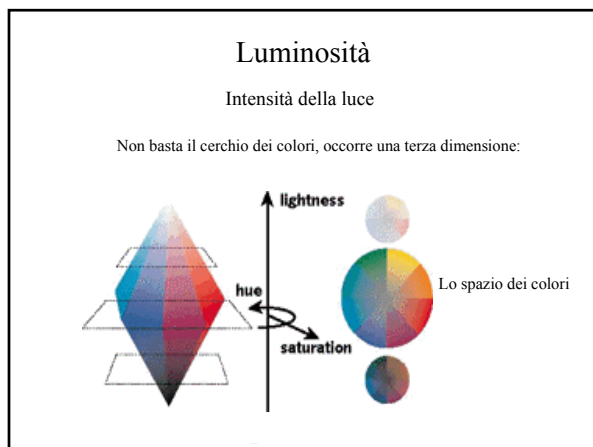
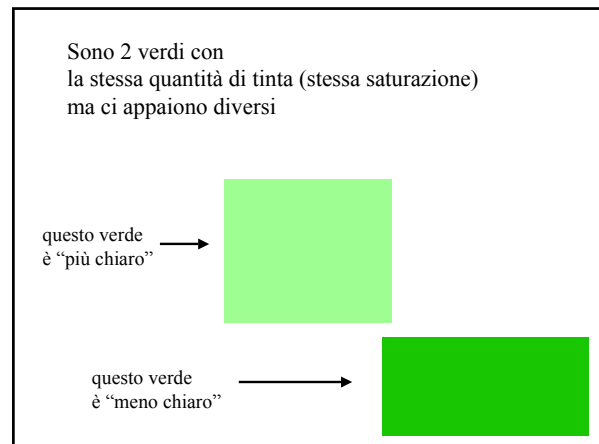
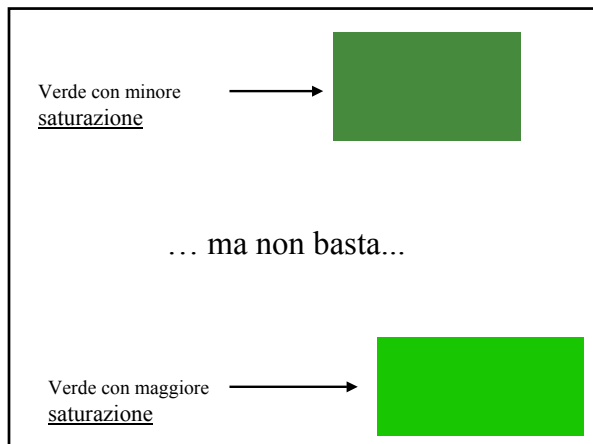
Quantità di tinta pura che deve essere mescolata al bianco per produrre il colore percepito

Non basta la ruota dei colori, occorre una seconda dimensione:

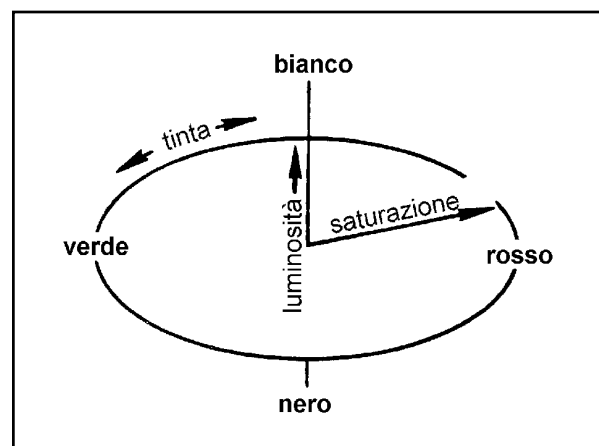
Il cerchio dei colori

### Esempio

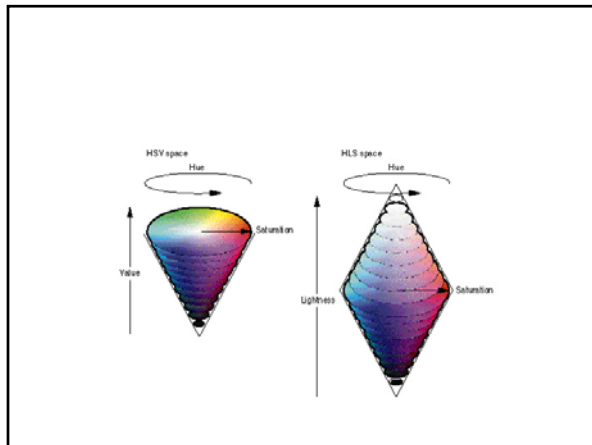
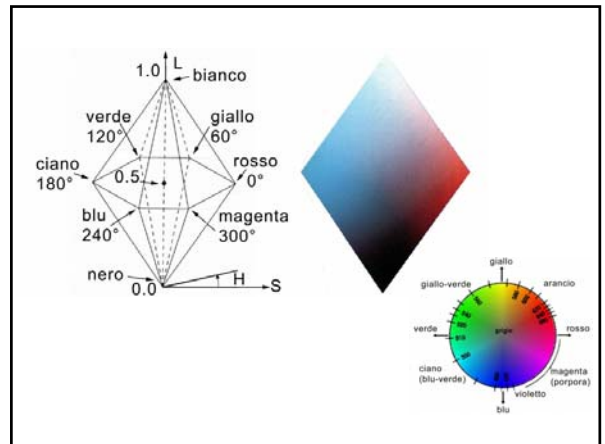
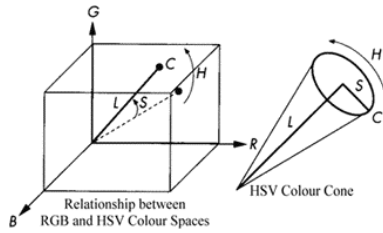
Tinta costante, saturazione decrescente



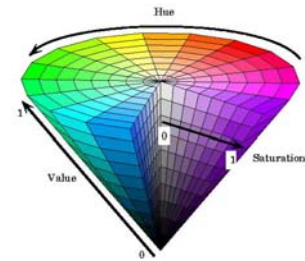
- Caratteristiche intuitive del colore
- 1) Tinta
  - 2) Saturazione
  - 3) Luminosità



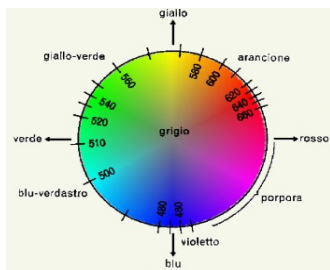
## Dall'RGB all'HSV



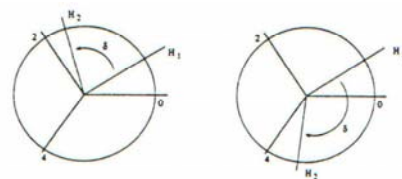
## Spazio HSV

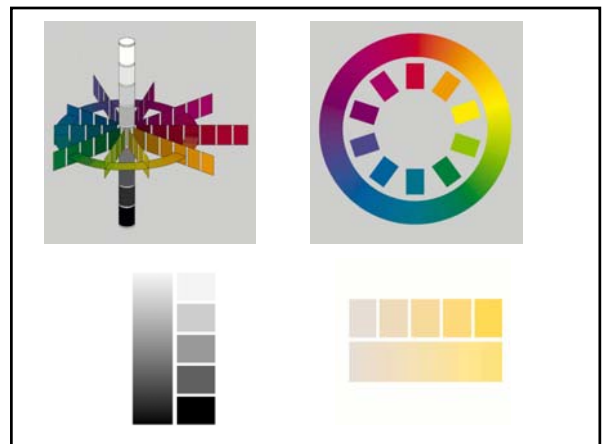
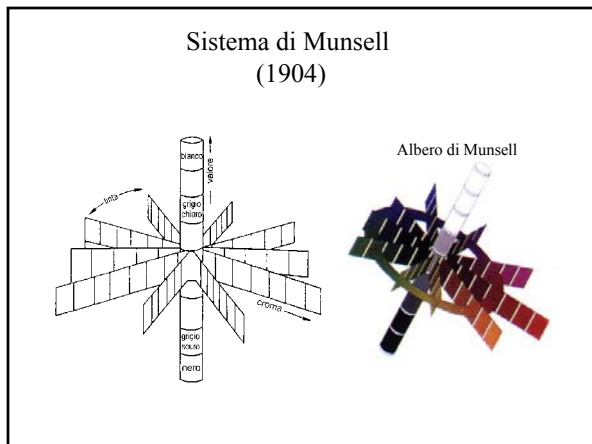
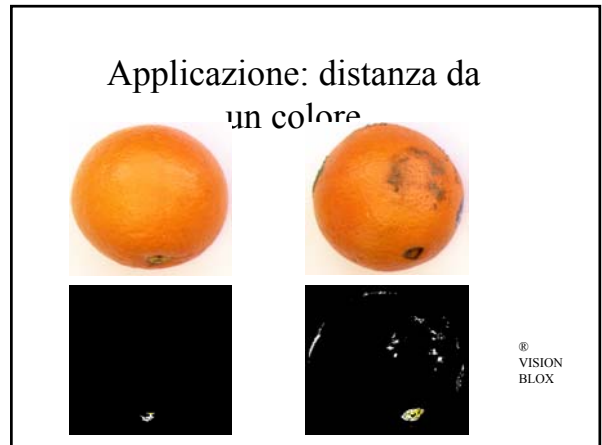
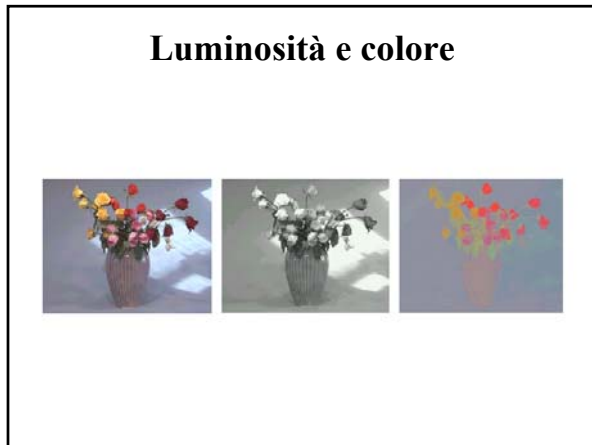
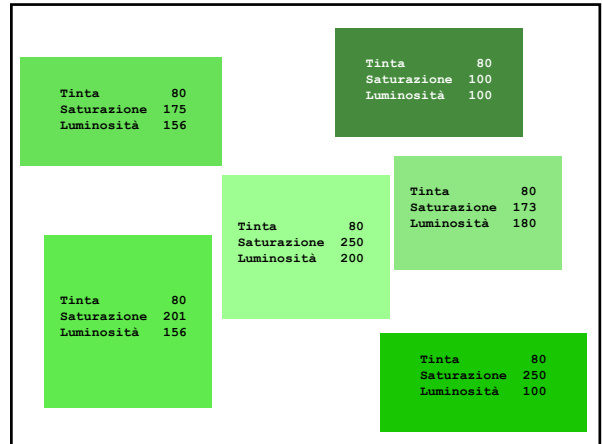
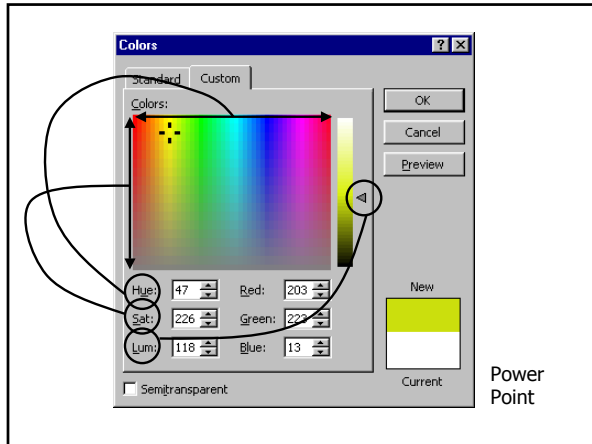


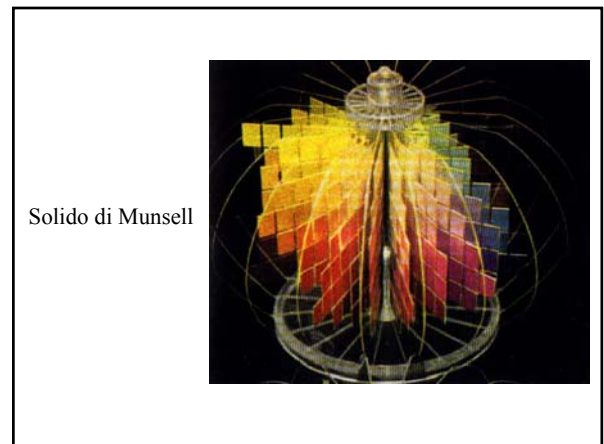
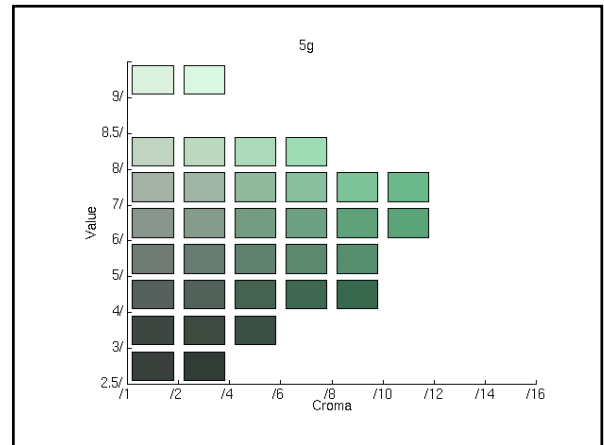
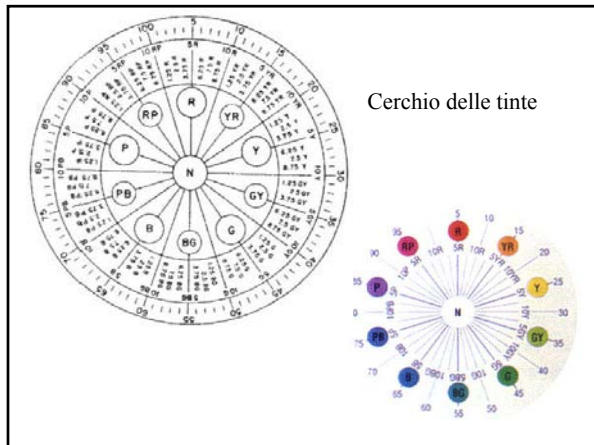
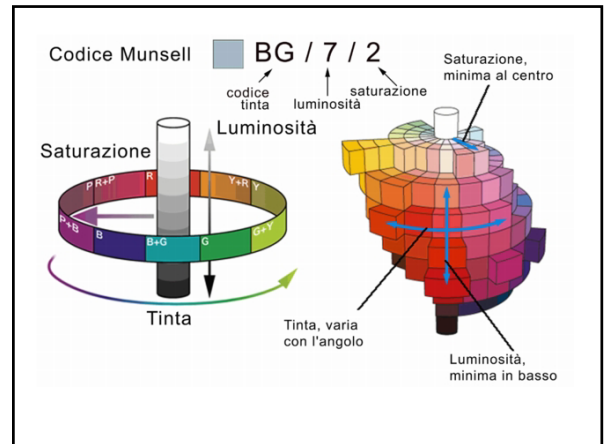
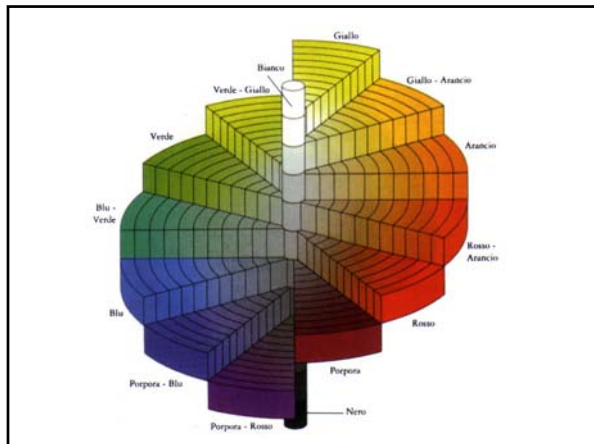
## Il cerchio delle tinte



## La distanza fra le tinte



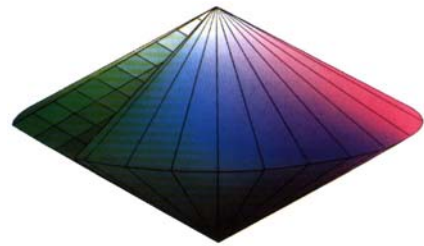




### Munsell Book



### Spazio di Ostwald



### Sistema di Munsell



Elegante ed intuitivo

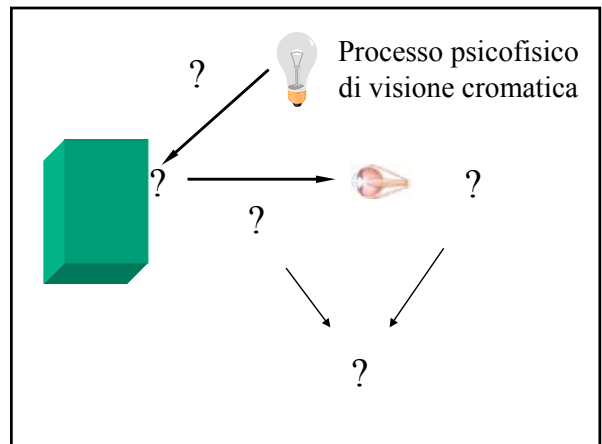
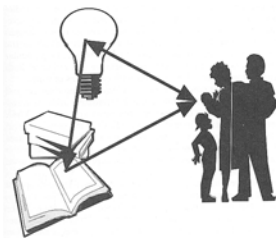
Soggettivo

#### Problema:

Ambientare i colori in uno spazio oggettivo (misurabile)  
con le caratteristiche positive del sistema di Munsell (intuitività)



### Formazione del colore



## Fisica del colore

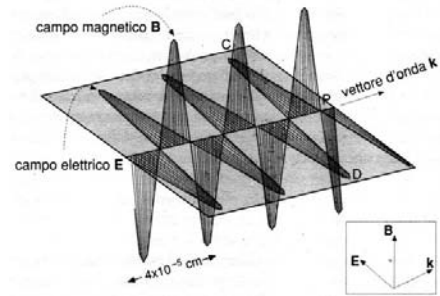
Cosa è la luce?

Cosa è un colore fisico?

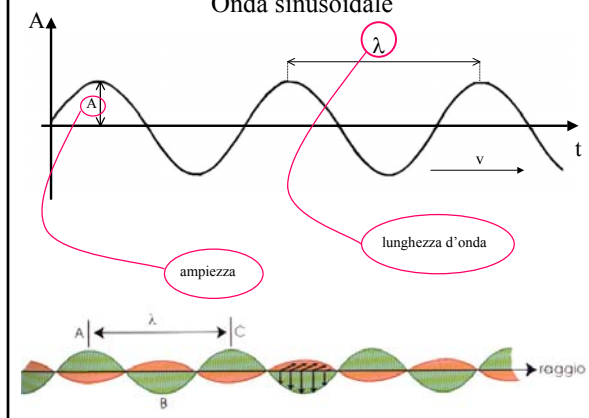
Cosa è un osservatore (umano)?

Come un osservatore valuta un colore?

## Onda elettromagnetica

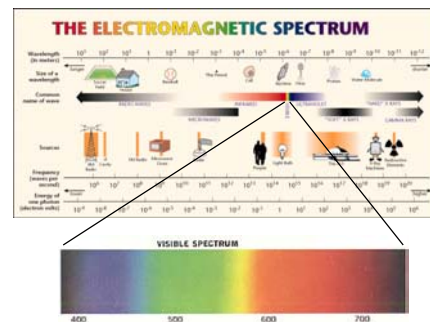


## Onda sinusoidale

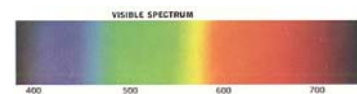
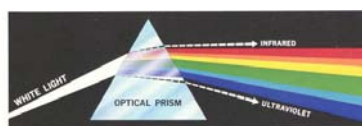


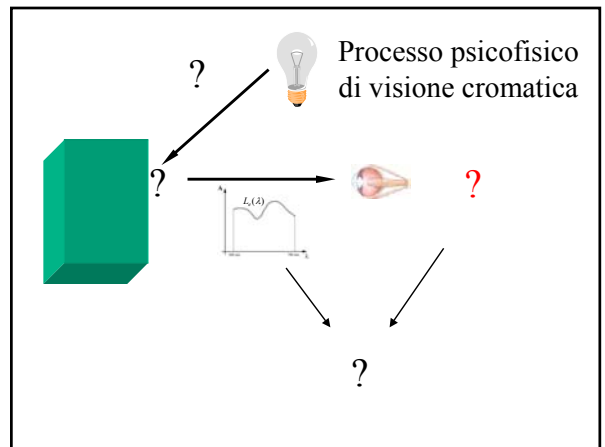
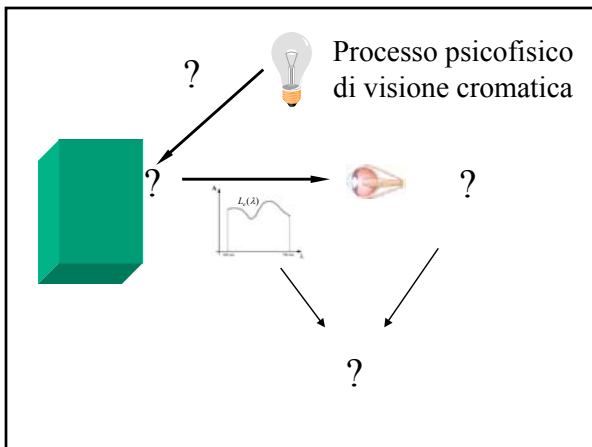
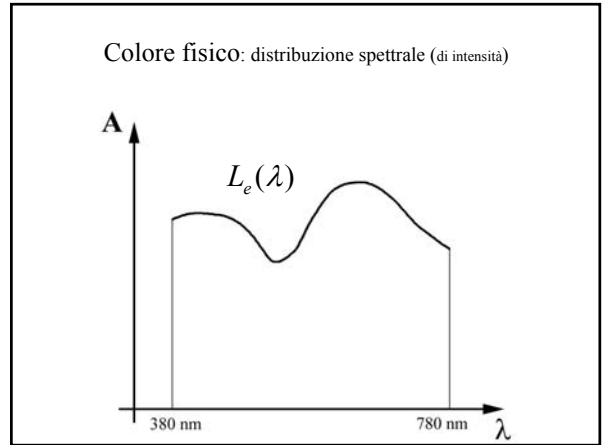
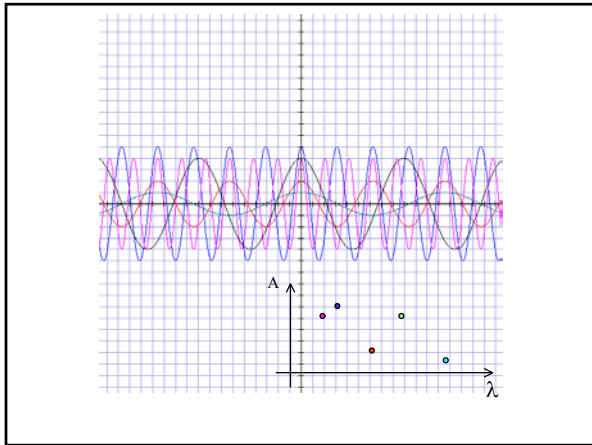
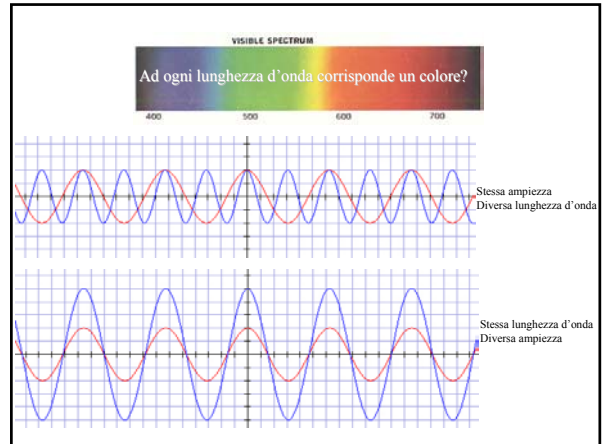
## La luce

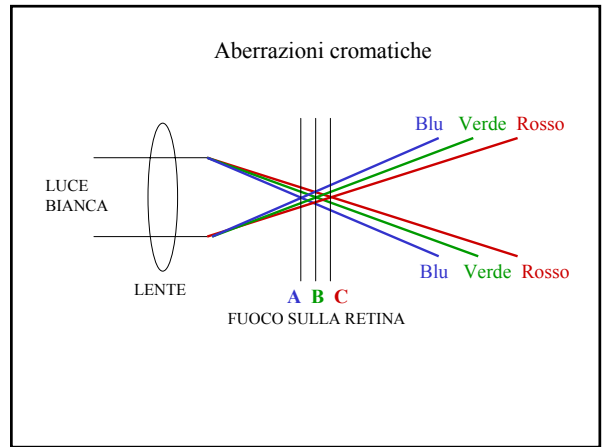
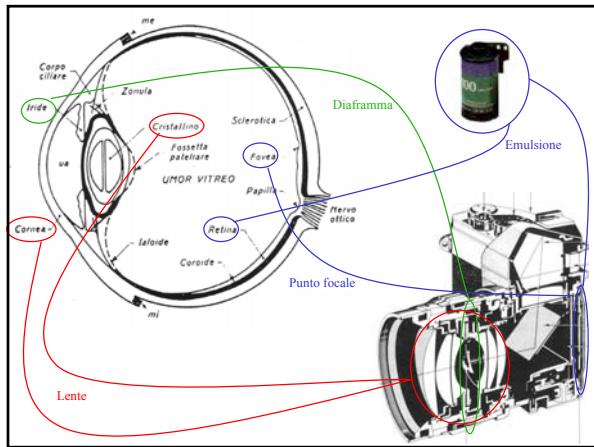
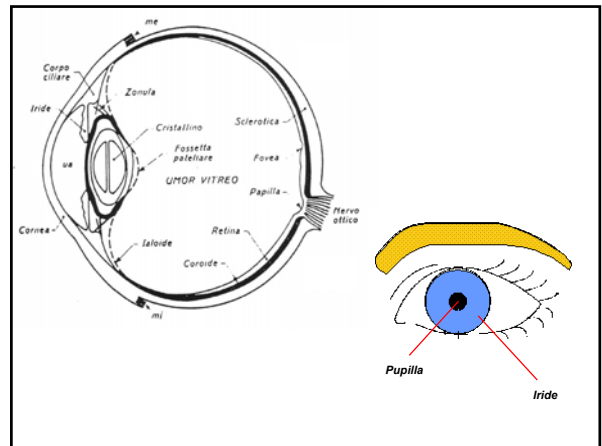
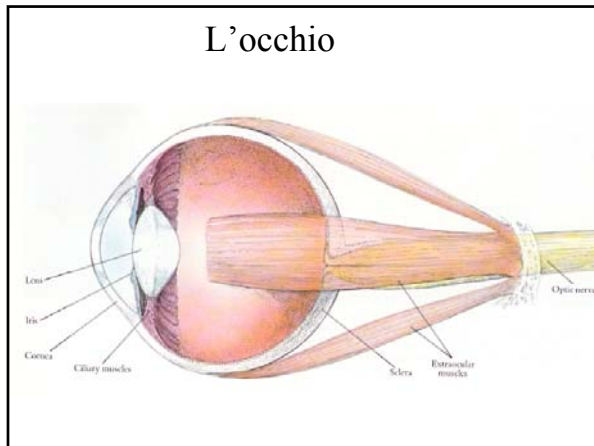
Distribuzione di energia elettromagnetica nella parte dello spettro con lunghezza d'onda compresa tra 380 nm e 780 nm



## Dispersione luminosa

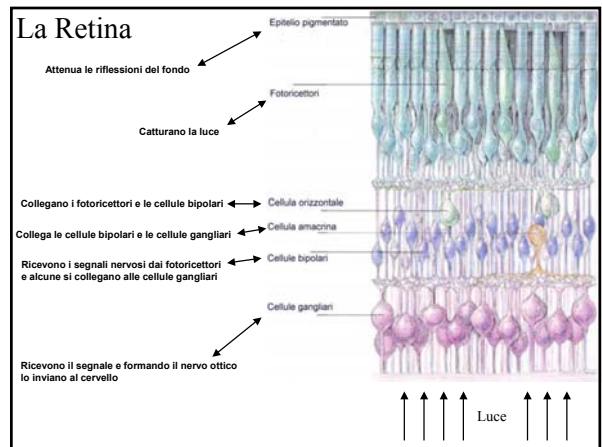




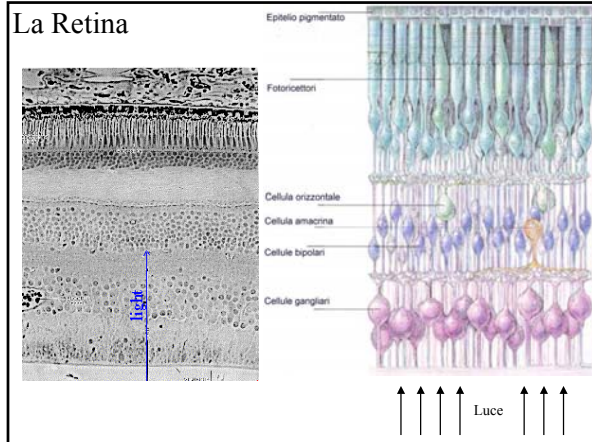


Da questo esempio si vede la difficoltà di messa a fuoco contemporanea del rosso e del blu: da molti le righe di questi due colori vengono viste, per i motivi descritti, come se fossero collocate a distanze diverse dagli occhi.

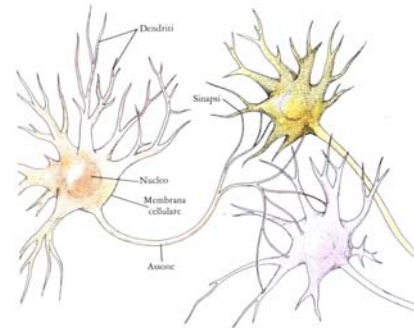
Questo fenomeno non si verifica se si usano due colori che si trovino fra loro più vicini sullo spettro visibile, come si può facilmente verificare da questo secondo esempio, che non dovrebbe presentare l'effetto tridimensionale di cui sopra.



## La Retina

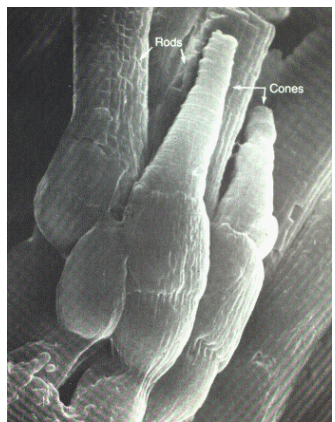


## Struttura delle cellule



## I fotoricettori

Bastoncelli  
e Coni



## I fotoricettori

### Bastoncelli

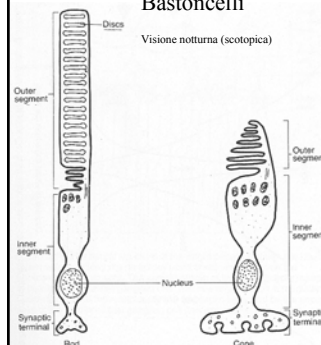
Visione notturna (scotopica)

### Coni

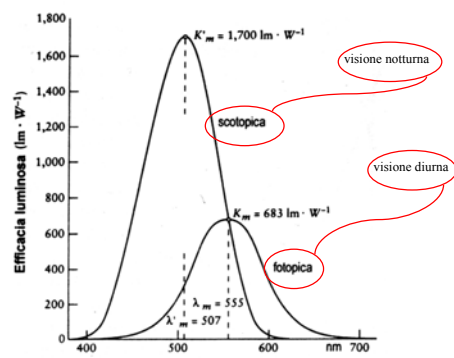
Visione diurna (fotopica)

Visione cromatica

Sono di 3 tipi:  
Coni L (sensibili alle alte  $\lambda$ )  
Coni M (sensibili alle medie  $\lambda$ )  
Coni S (sensibili alle basse  $\lambda$ )



## Curve di efficacia luminosa



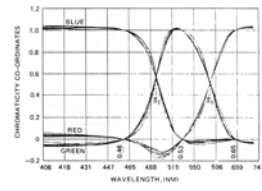
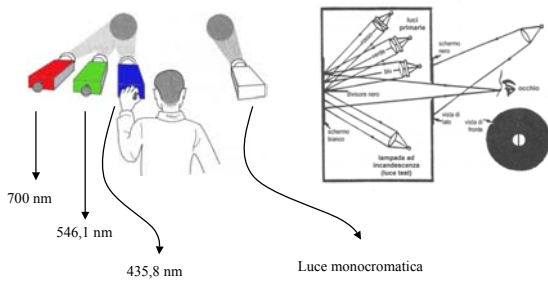
## La teoria del Tristimolo



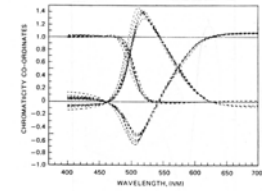
**Hermann von Helmholtz**  
1867, Heidelberg  
**Ottica Fisiologica**

per primo individua coni  
e bastoncelli e formula la  
teoria del tristimolo

### Esperimento di Wright (1928) e Guild (1931)



Risultati di Wrigt (1928)

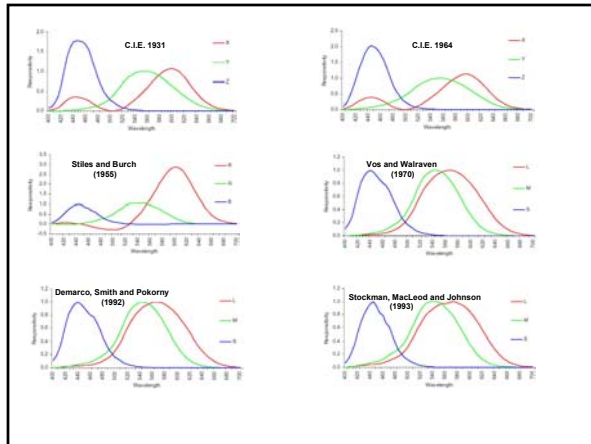
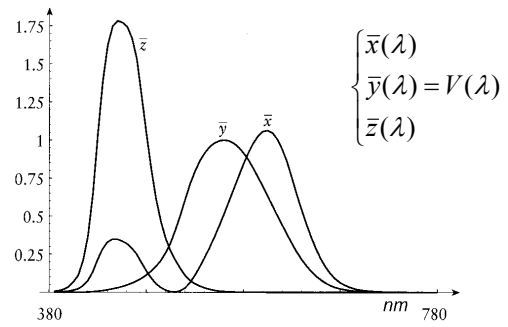


Risultati di Guild (1931)

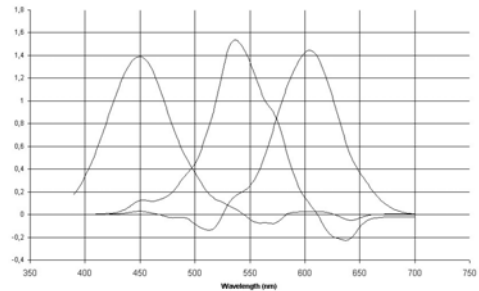
### Standardizzazione C.I.E. (Commision Internationale de l'Eclairage)

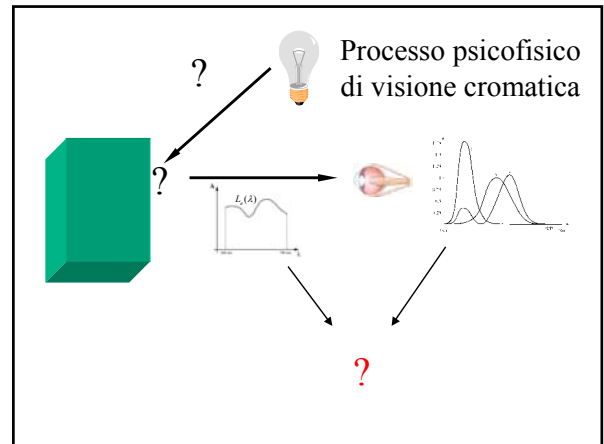
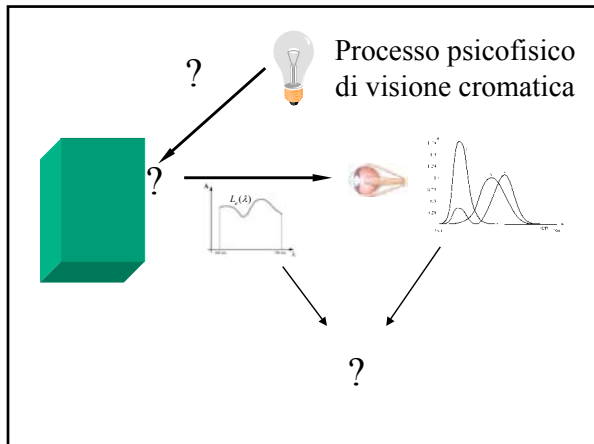
- 1 - Le funzioni non devono avere valori negativi
- 2 - Una delle funzioni deve essere equivalente alla funzione di visibilità
- 3 - Una delle funzioni deve avere valore nullo per la maggior parte del range del visibile
- 4 - Le aree sotto le curve delle funzioni deve essere uguali fra loro

### Osservatore Standard C.I.E. 1931



### Thornton (2002)





$$\begin{cases} X = \int L_e(\lambda) \bar{x}(\lambda) d\lambda \\ Y = \int L_e(\lambda) \bar{y}(\lambda) d\lambda \\ Z = \int L_e(\lambda) \bar{z}(\lambda) d\lambda \end{cases} \quad \text{Valori di Tristimolo}$$

Processo psicofisico di visione cromatica

$$\begin{aligned} X &= \int L_e(\lambda) \bar{x}(\lambda) d\lambda \\ Y &= \int L_e(\lambda) \bar{y}(\lambda) d\lambda \\ Z &= \int L_e(\lambda) \bar{z}(\lambda) d\lambda \end{aligned}$$

**Metamerismo**

Non esiste corrispondenza biunivoca tra distribuzione spettrale e valori di tristimolo

$$\begin{aligned} X &= \int L_e(\lambda) \bar{x}(\lambda) d\lambda \\ Y &= \int L_e(\lambda) \bar{y}(\lambda) d\lambda \\ Z &= \int L_e(\lambda) \bar{z}(\lambda) d\lambda \end{aligned}$$

**Spazio Colore**

I colori sono rappresentati da una terna di numeri XYZ (**Valori di tristimolo**)

I colori possono essere ambientati in uno spazio tridimensionale

Ogni colore è rappresentato da un vettore nello spazio tridimensionale