

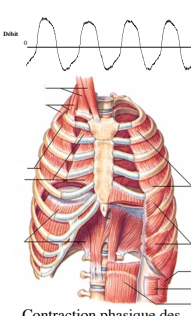
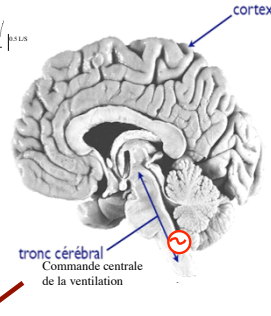
Aspects fondamentaux de la commande ventilatoire

Marie-Noëlle FIAMMA

*ER 10 UPMC
Groupe Hospitalier Pitié-Salpêtrière*

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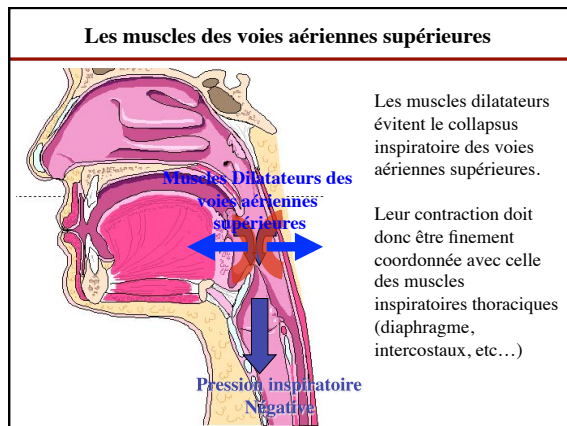
La ventilation et sa commande

Contraction phasique des muscles respiratoires

Les structures ACTIVES = Les muscles

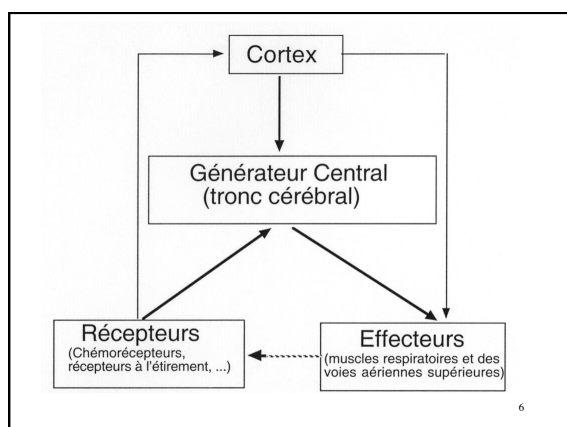
Muscles Inspiratoires	Muscles Expiratoires
Sterno-cleido-mastoldiens Scalènes Intercostaux Externes Parasternal Diaphragme	Intercostaux Internes Abdo. Oblique Externe Abdo. Oblique interne Abdo. Transverse Abdo. Grand Droit

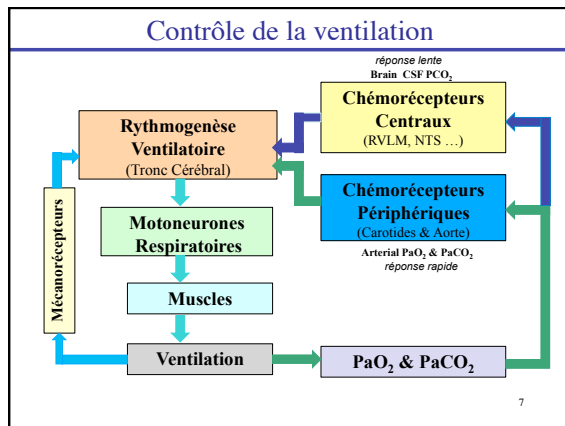


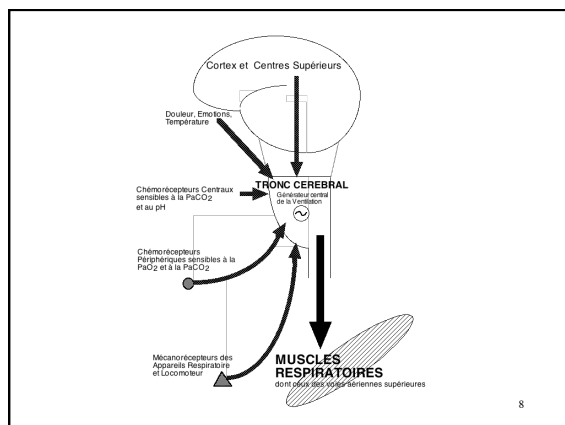
Les muscles respiratoires

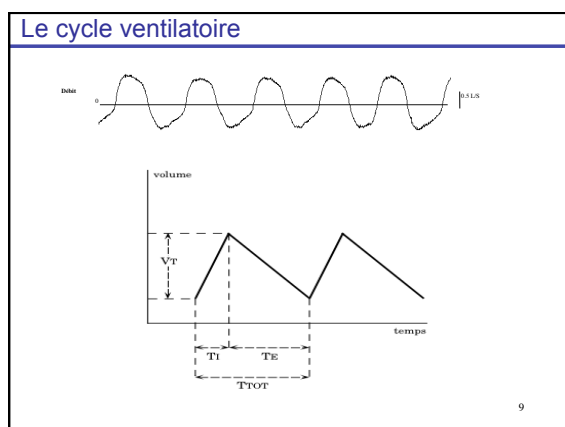
- Les muscles respiratoires du tronc (diaphragme, scalènes, intercostaux, abdominaux, etc...)
- Les muscles des voies aériennes supérieures

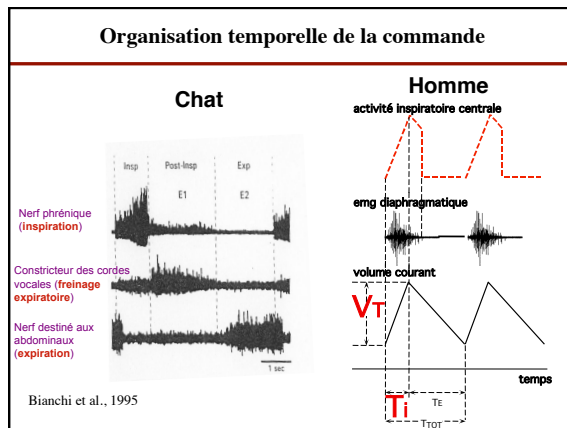
→ Intervention de la commande ventilatoire double commande chez l'homme

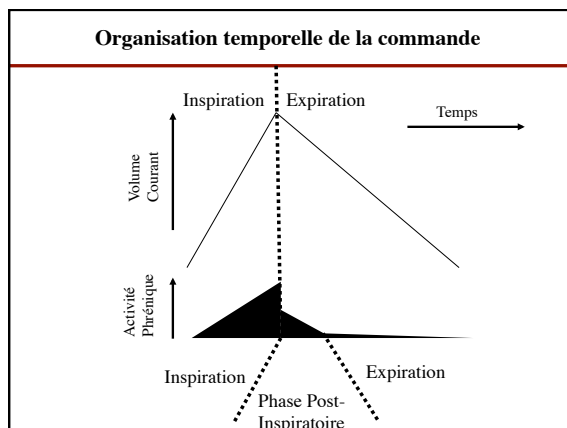


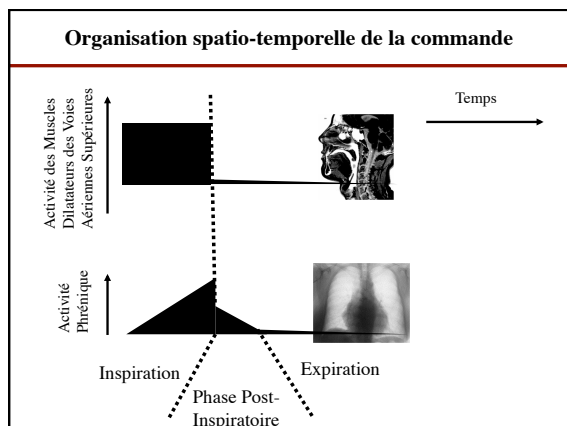


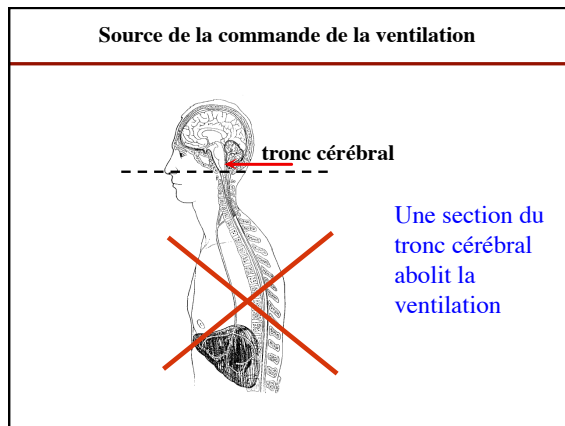


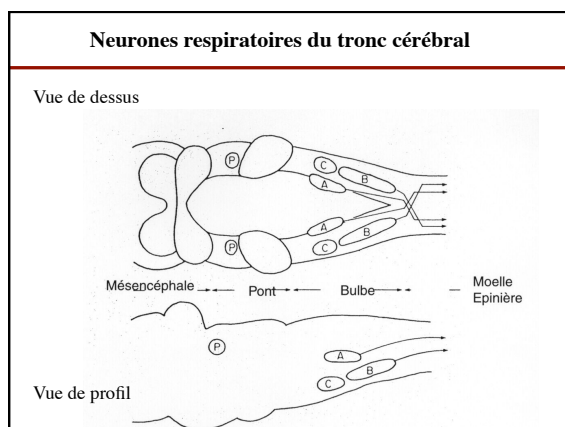


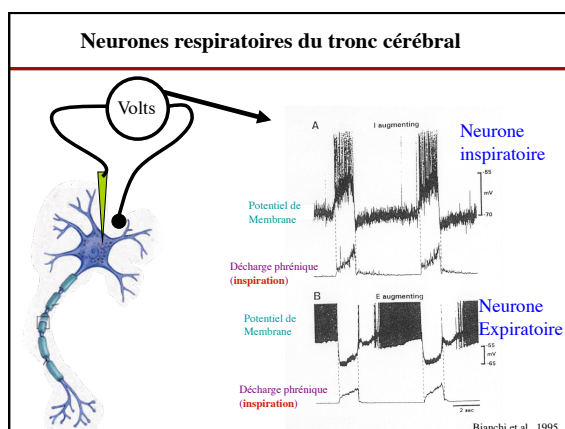


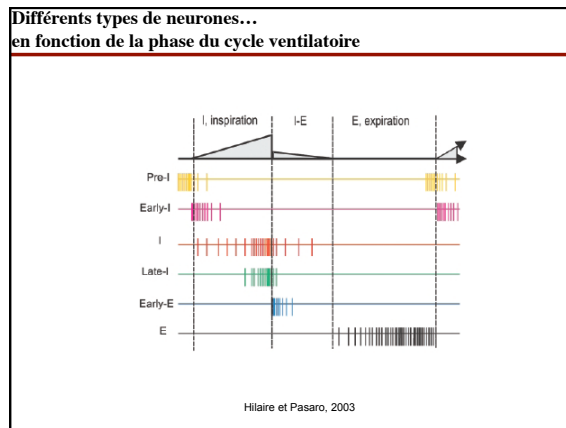


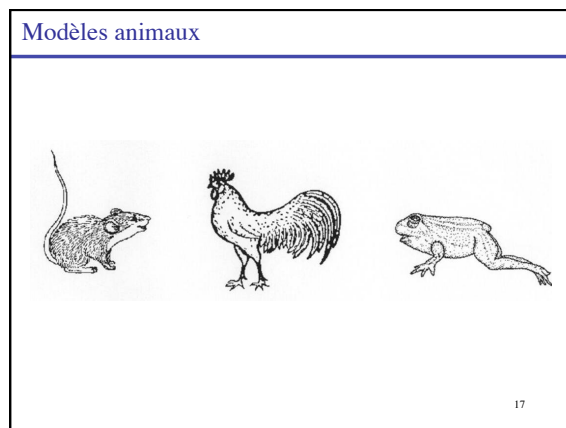


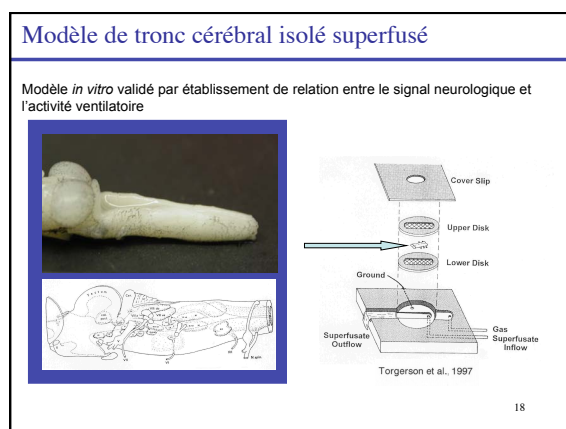


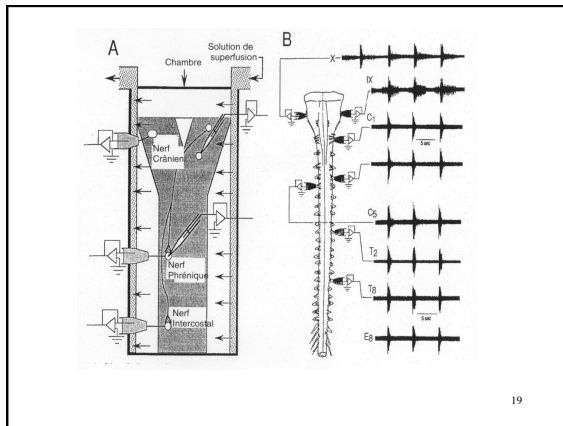


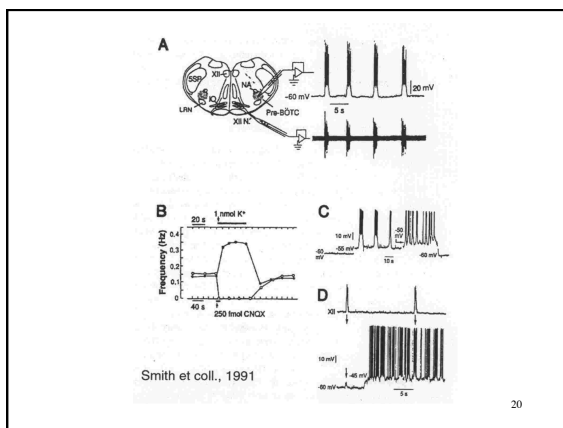


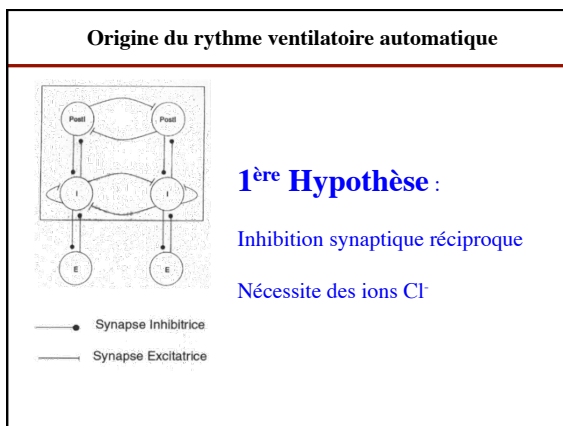


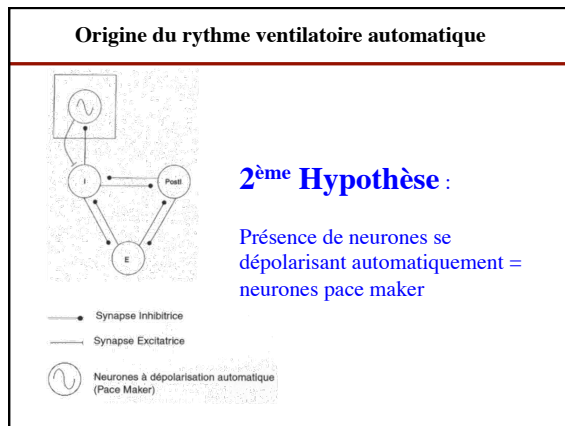


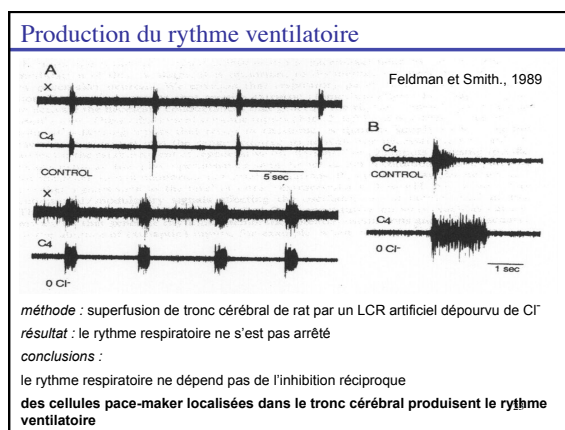


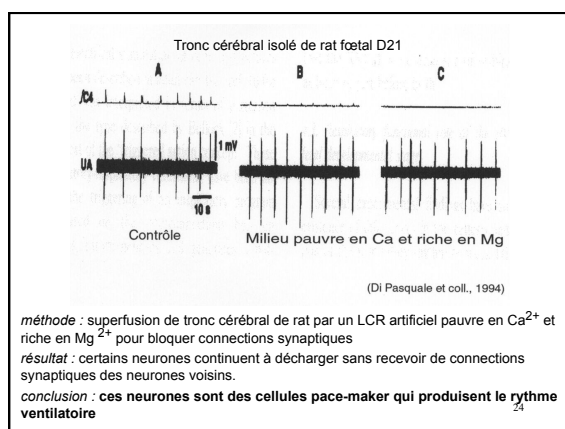










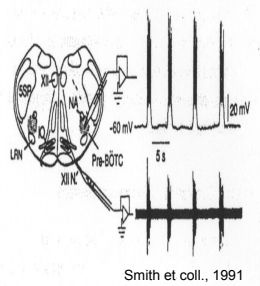


Neurones pace-maker

Un milieu pauvre en Ca^{2+} et riche en Mg^{2+} empêche les synapses de fonctionner

Un neurone qui continue de décharger dans un tel milieu est un neurone pace-maker puisqu'il est capable de fonctionner sans recevoir d'information d'autres neurones

Localisation des neurones pace-maker



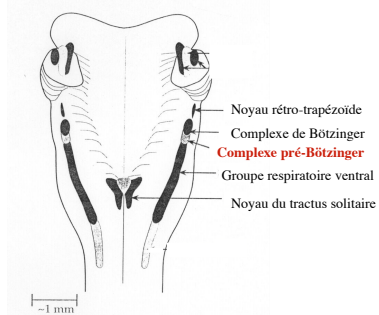
complexe pré-Bötzinger

(générateur rythmique)

- > position caudale/noyau rétro-facial
- > position ventrale/noyau ambigu
- > en regard de l'émergence des racines du XII

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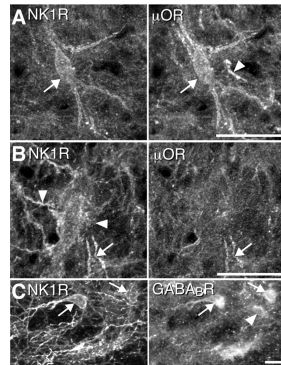
Localisation du complexe pré-Bötzinger



Récepteurs exprimés par les neurones du complexe Pré-Bötzinger

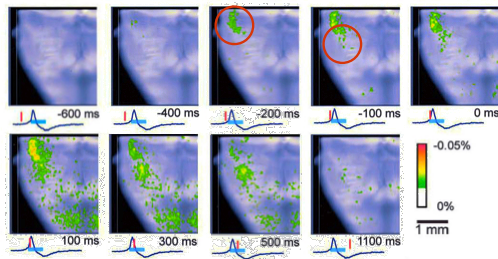
neurones identifiables par co-expression à leur surface de **récepteurs aux opioïdes (μ OR)** et de **récepteurs à la substance P (NK1 R)**
il existe aussi des récepteurs au $GABA_B$

Gray et al, 1999



Groupe respiratoire para-facial

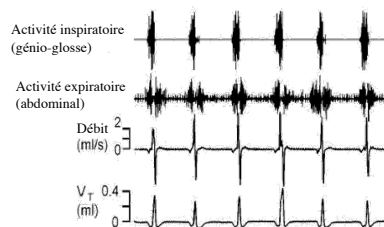
Un deuxième groupe de neurones pace-maker décharge avant le complexe pré-Bötzinger



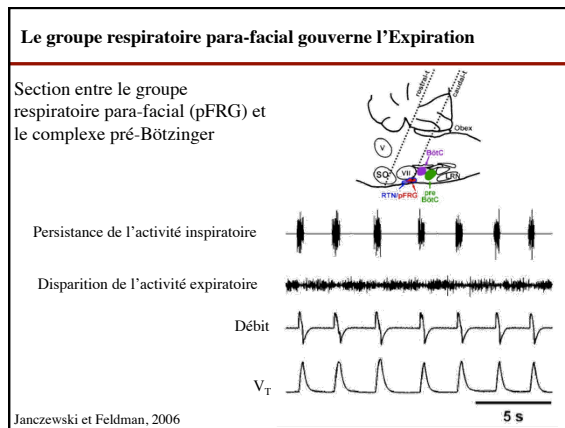
Onimaru et Homma, 2003

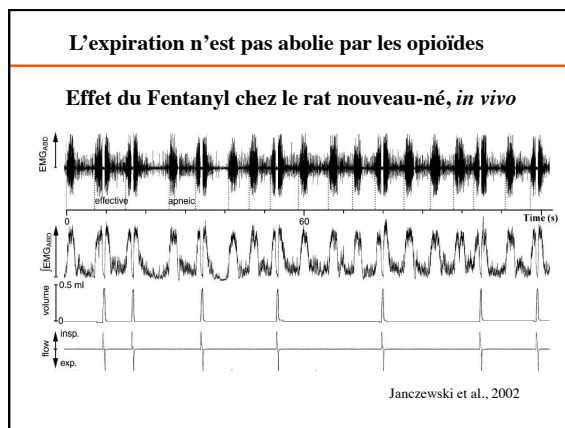
Le groupe respiratoire para-facial gouverne l'Expiration

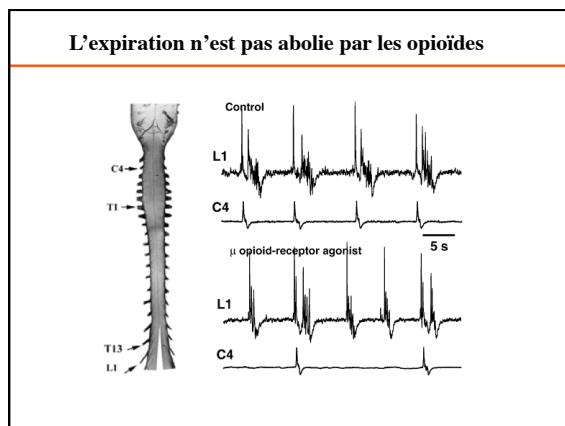
Animal « entier » décérébré



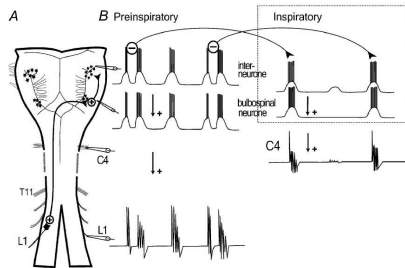
Janczewski et Feldman, 2006





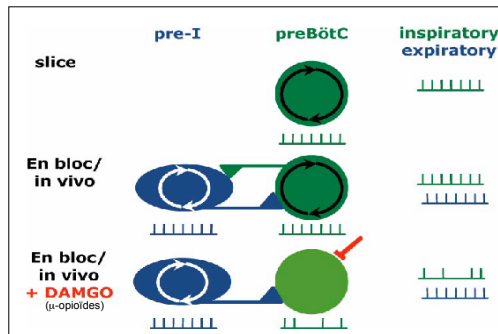


Interactions neuronales inspiratoires et pré-inspiratoires



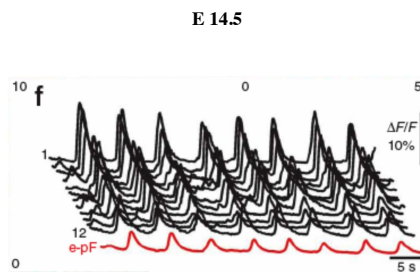
Janczewski et al., 2002

Interactions des réseaux inspiratoires et pré-inspiratoires

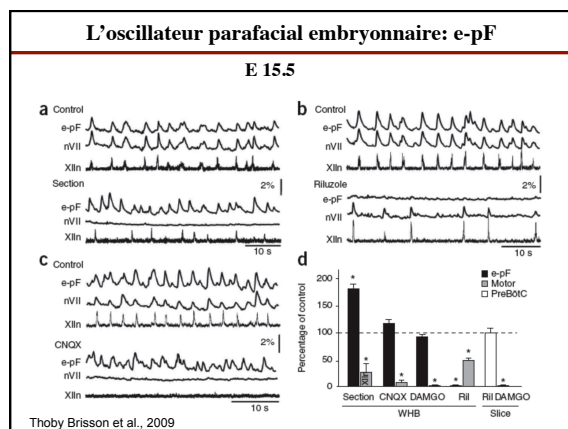


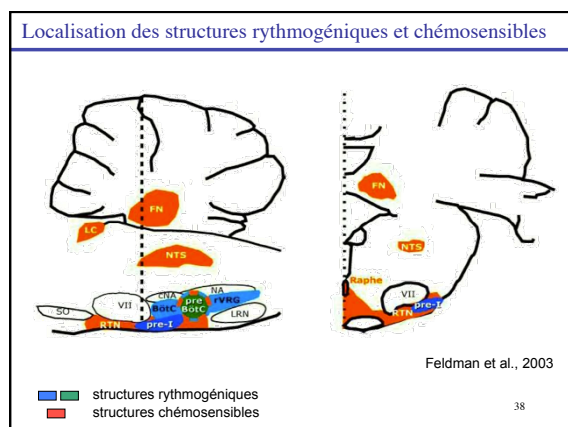
Feldman et al., 2003 35

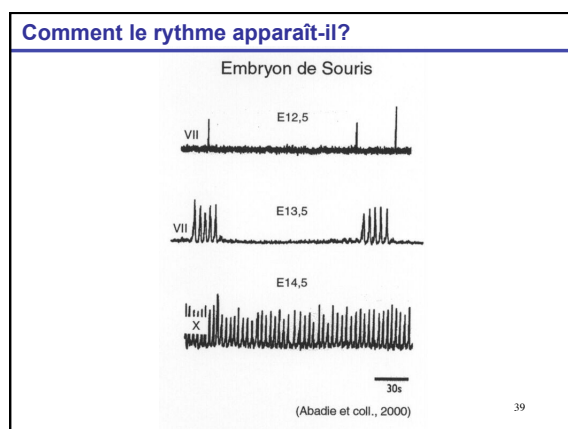
L'oscillateur parafacial embryonnaire: e-pF



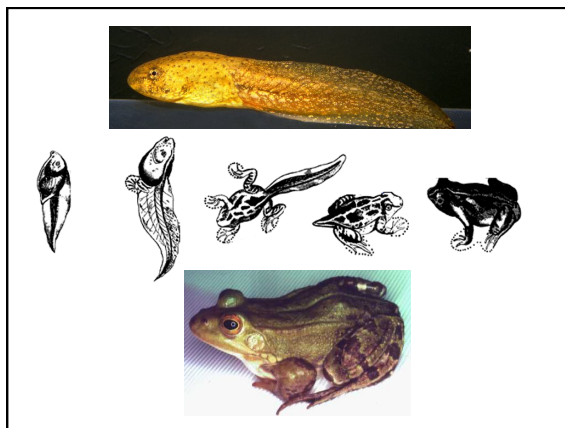
Thoby Brisson et al., 2009



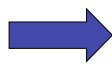
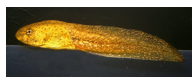




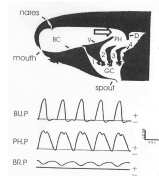
Conservation phylogénétique du patron ventilatoire



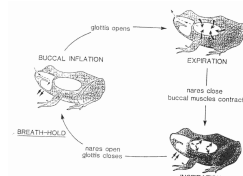
Deux types de ventilation

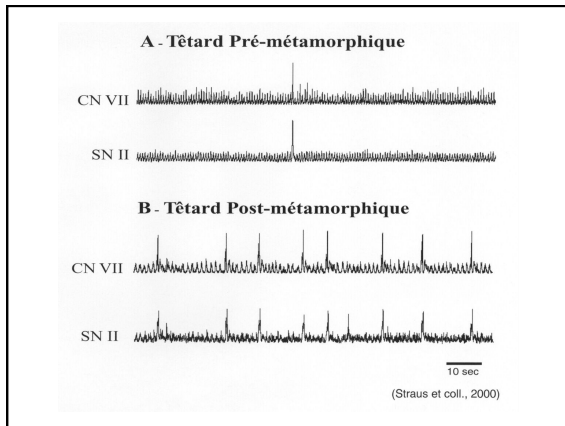


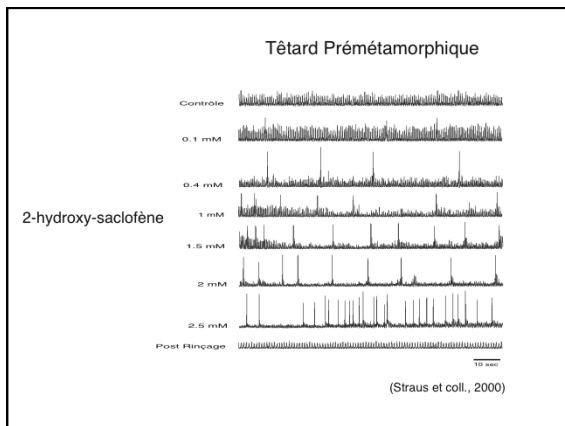
Ventilation Branchiale

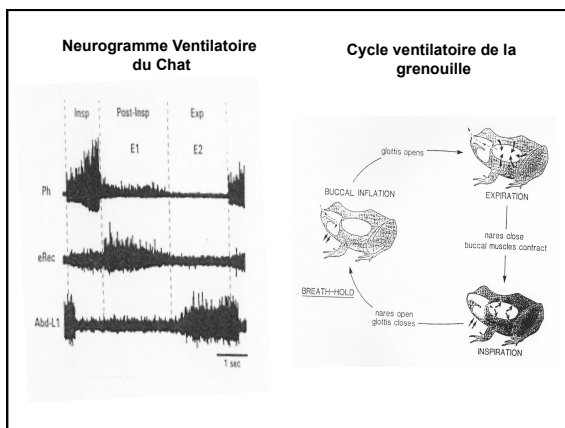


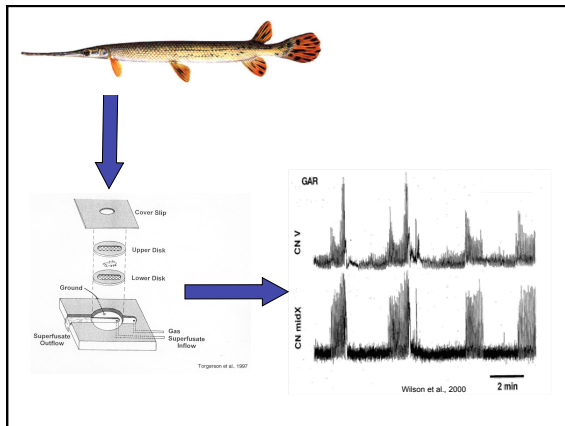
Ventilation Pulmonaire

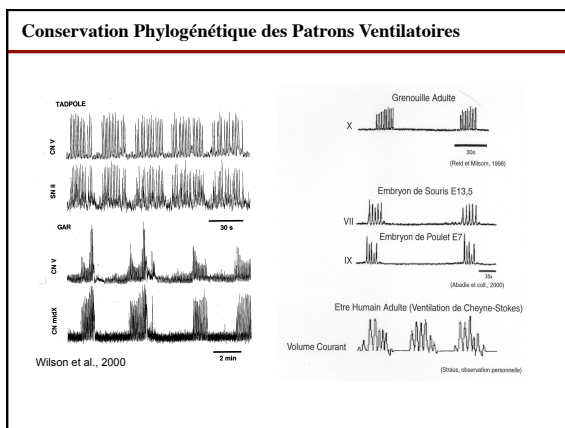


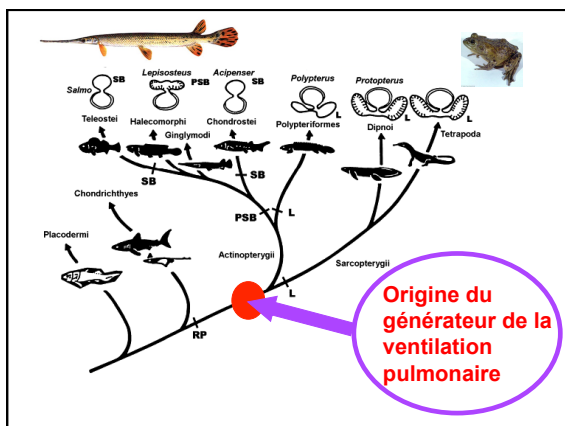






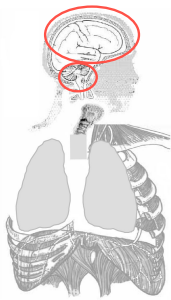






Influences supra-pontiques et corticales

Commandes de la ventilation humaine



➤ une commande automatique
(tronc cérébral)

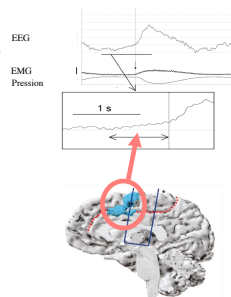
➤ une commande corticale
(suprapontine et volontaire)

Le cortex cérébral face à une contrainte respiratoire mécanique

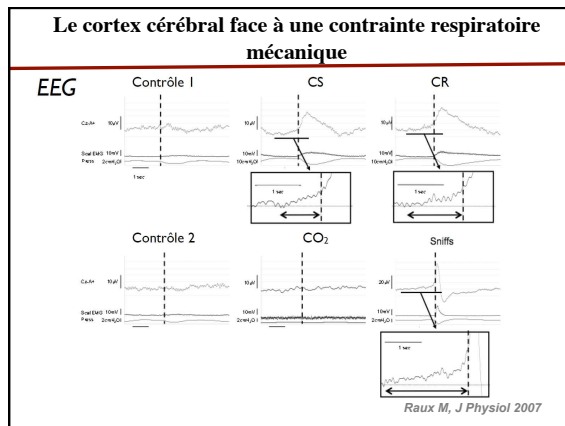
- une charge inspiratoire évoque un potentiel EEG précédant l'inspiration

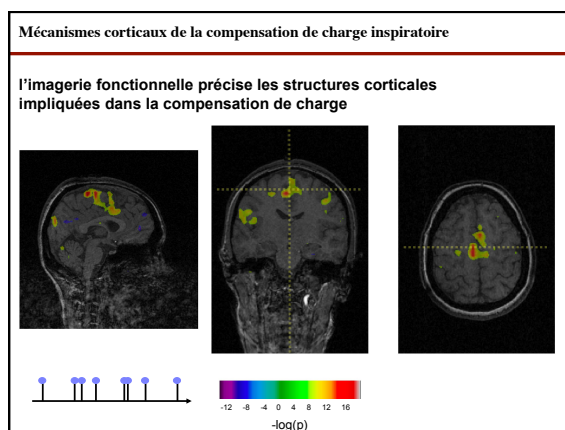
potentiel pré moteur

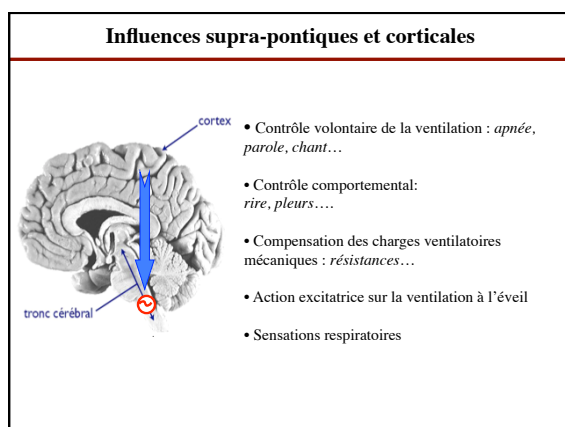
témoin très probable de l'activation de l'aire motrice supplémentaire



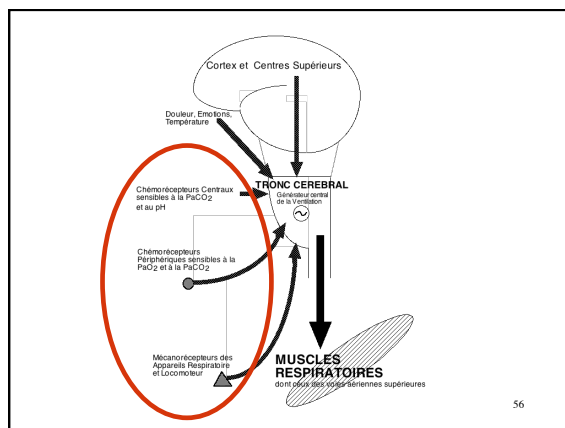
Raux M, J Physiol 2007
Raux M, Anesthesiology 2007

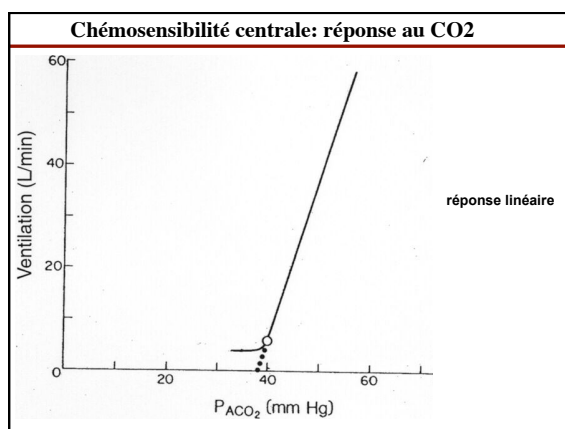




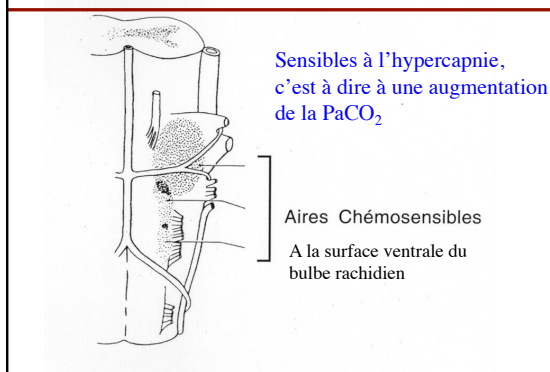


Régulation neurovégétative de la ventilation





Chémorécepteurs Centraux : situés dans le tronc cérébral



Régions chémosensibles du tronc cérébral du rat

Identification par micro-injections acides

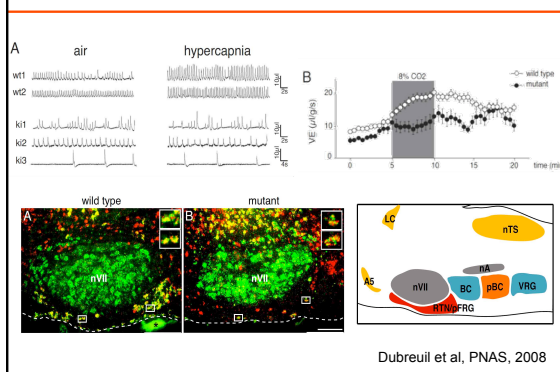
- Noyau du tractus solitaire
- Noyau rétro-trapézoïde
- Raphé bulbaire

Identification de neurones chémosensibles

- Bulbe rostro-ventro-latéral
- Locus coeruleus

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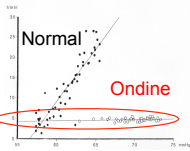
Rôle du Noyau Retro-Trapezoïde : souris mutantes



Syndrome d'ondine

- **Prévalence:** 1 naissance sur 200.000 : maladie rare
- **Génotype:** mutation du gène PHOX2B : expansion d'alanines (5-9 résidus)
- **Phénotypes:**

Réponse au CO₂ chez l'homme



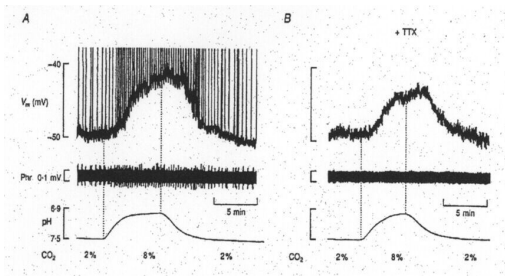
réduction/absence totale de réponse ventilatoire à l'hypercapnie



hypoventilation sévère et mortelle pendant le sommeil

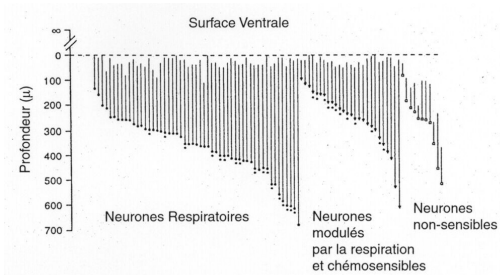
Assistance respiratoire totale par masque ou trachéotomie

Identification des neurones chémosensibles

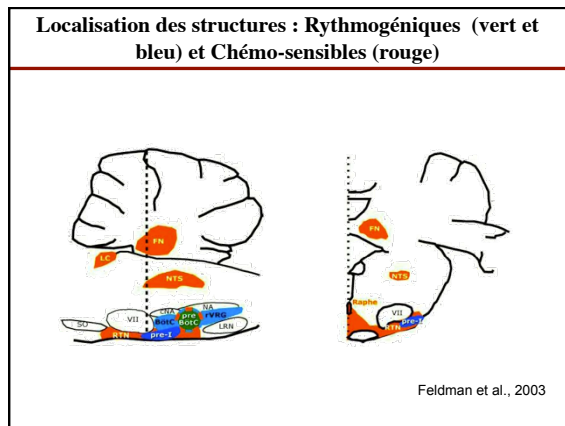


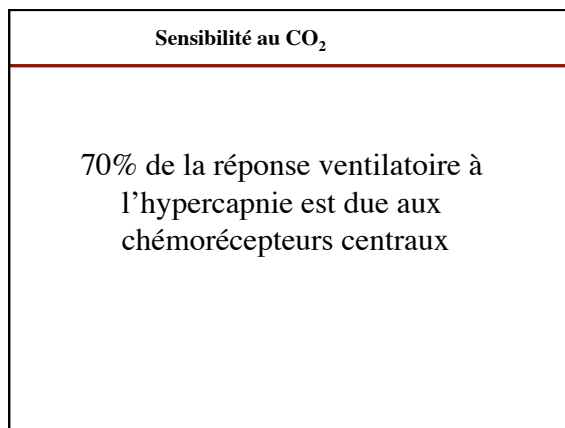
(Kawai et coll. 1996)

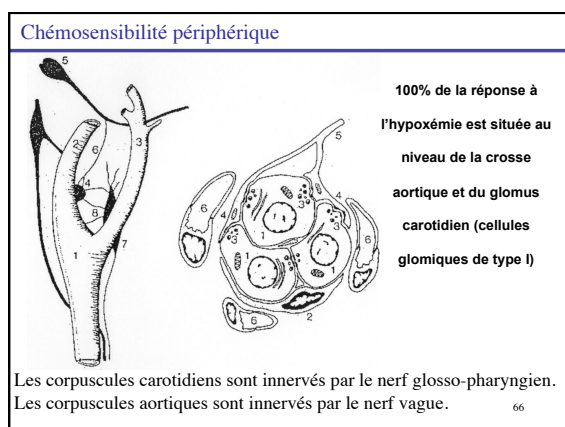
Identification des neurones chémosensibles

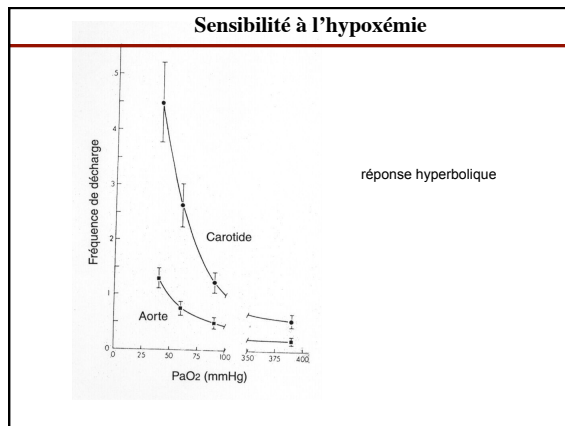


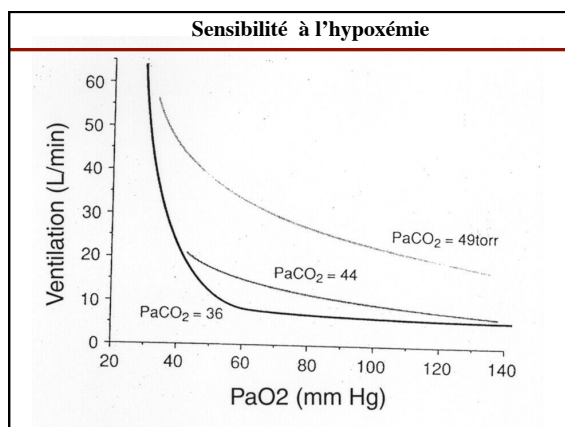
Kawai et al, 1996

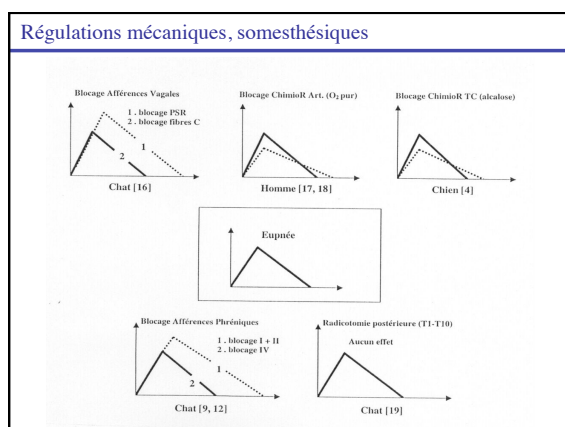


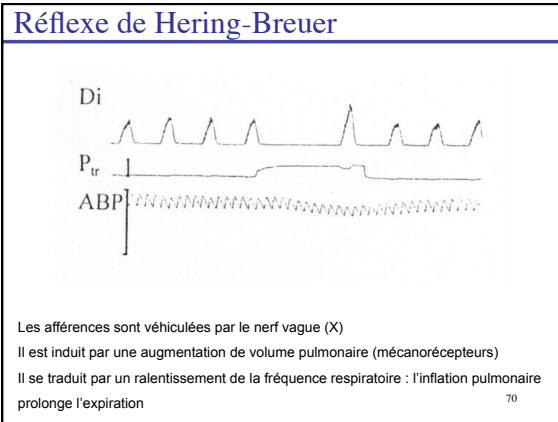




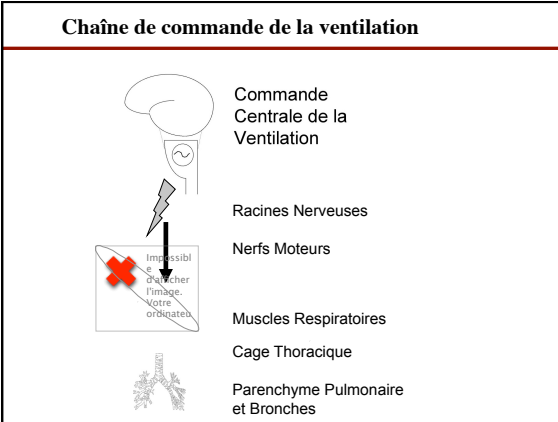








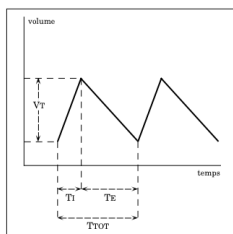
Exploration de la Commande Ventilatoire Chez l'Homme



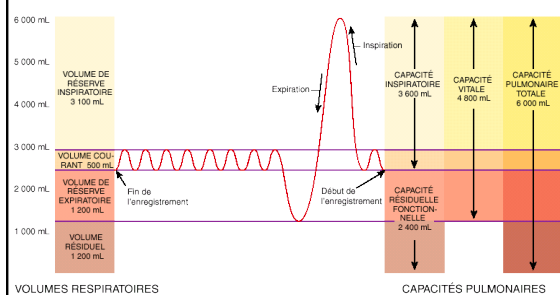
Le spiogramme

$$V_E = V_T \times F = V_T \times \frac{1}{T_{TOT}}$$

$$V_E = \frac{V_T}{T_I} \times \frac{T_I}{T_{TOT}}$$

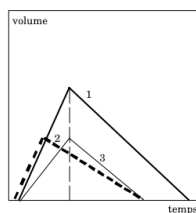


Le cycle ventilatoire



Tortora et Grabowski aux éditions ERPI

Spiogramme

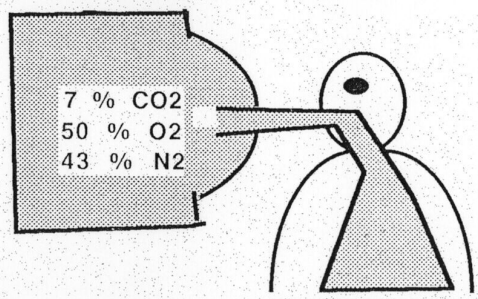


1 : spiogramme normal

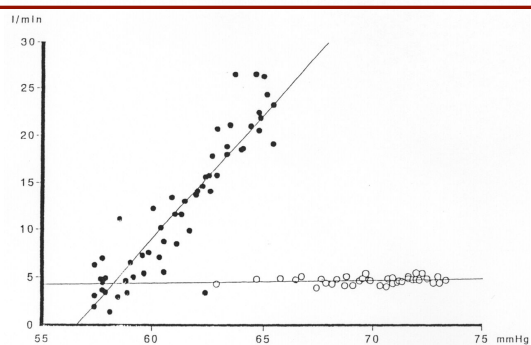
2 : IRCO

3 : commande centrale diminuée

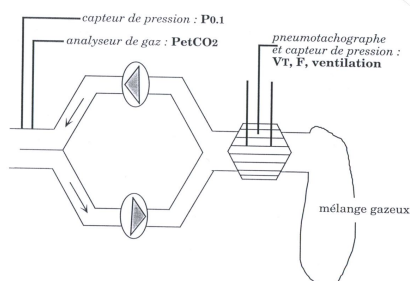
Test au CO₂

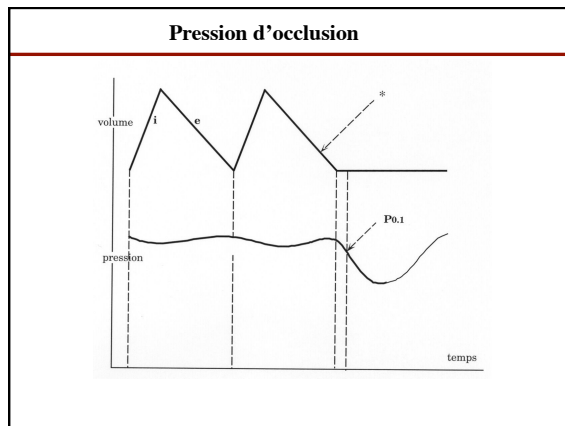


Test au CO₂



Test au CO₂



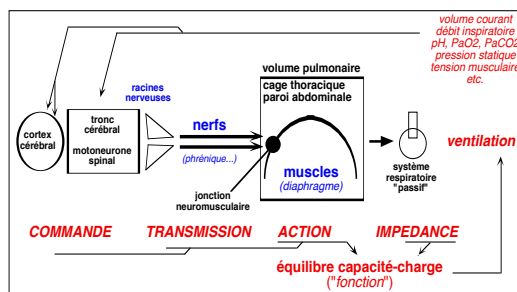


Facteurs influençant la pression d'occlusion - $P_{0.1}$

- Changement de volume télé-expiratoire
- Activation des muscles expiratoires
- Changements de longueur et de vitesse musculaire
- Distorsion de la paroi thoracique
- Forme de l'onde de pression
- Constante de temps du système respiratoire
- Déphasage pression-débit

Tobin et coll. 1994

Synthèse « chaîne » respiratoire



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