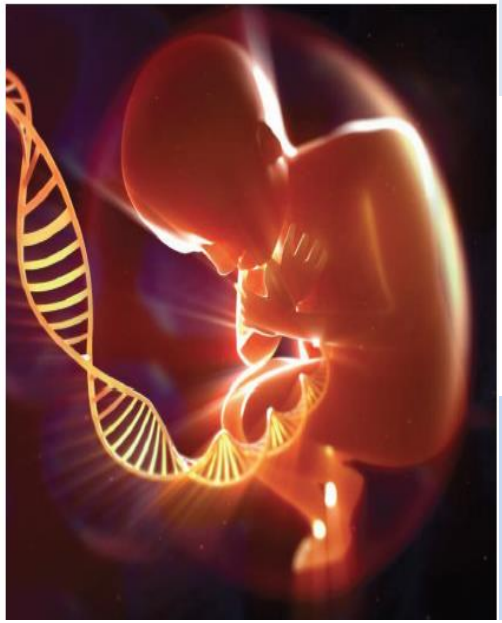
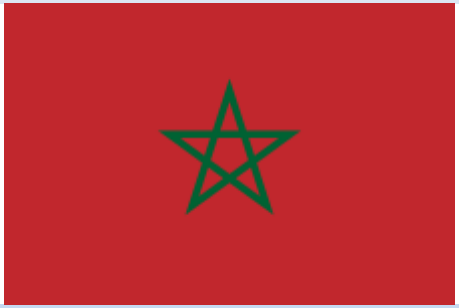
Non-invasive Prenatal Testing in Morocco





Dr Jalil EL ATTAR

مؤتمر الصحّة العربي – اليوناني الأول
1st Arab-Hellenic Health Conference
1ο Αραβο-Ελληνικό Συνέδριο για την Υγεία

Athens,
22-23 May
2024

- Laboratory which aims to develop a specialized biology since its creation in 2012 in Rabat.

- Member of a network of laboratories spread between Morocco and Portugal: Réseau Medical Bio-Santé

- The first private laboratory in Morocco to participate in the fight against the Covid 19, because it has a large technical virology platform.
- In 2023, the Laboriad Health Group has set itself the objective of launching Genomic tests.

Le Cosy® Test

Test de dépistage prénatal

Non invasif (DPNI) Fiable, rapide et précis

9 November 2023 – Yourgene Health and Laboriad Launch Non-invasive Prenatal Testing in Morocco

Yourgene Health installs first NIPT platform, the IONA test, in Morrocco, enabling Laboriad to offer safe, fast and accurate prenatal testing to expectant parents

Manchester, UK, and Rabat, MOROCCO, 09 November 2023: Yourgene Health (part of the Novacyt group of companies), a leading international molecular diagnostics group, has installed the first non-invasive prenatal testing (NIPT) workflow in Morocco based on the IONA® test at the Centre de Biologie Riad (Laboriad). By offering this service locally, Laboriad can broaden its offering and provide pregnant women fast, reliable results that reduce the need for invasive tests and the associated stress and anxiety for expectant parents.

read more

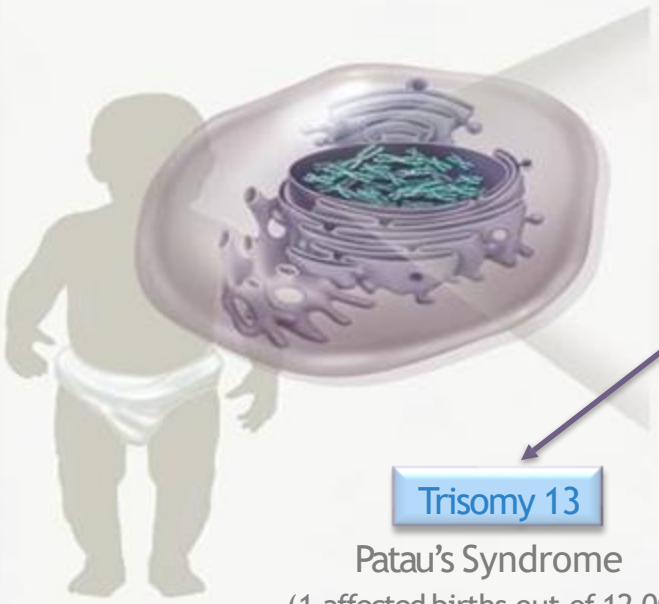
Le **Cosy®** test

First NIPT Platform in Morocco at Laboriad (Rabat)

LABORIAD

The Trisomy

A chromosome anomaly shows the presence of at least **1 extra chromosome.**



Trisomy 13

Patau's Syndrome

(1 affected births out of 12 000)

Trisomy 21

Down' Syndrome

(27 affected births out of 10 000)[1]

Trisomy 18

Edwards' Syndrome

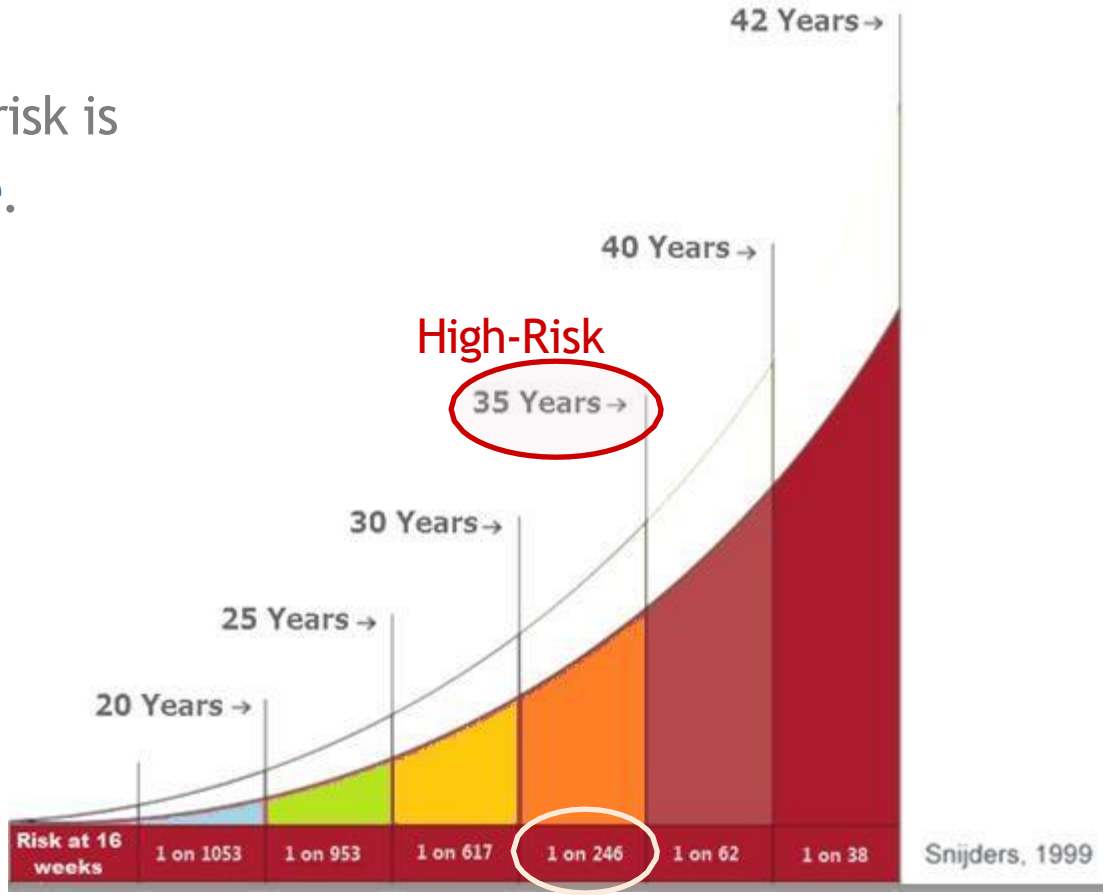
(1 affected births out of 8 000)

The **most common** chromosome condition seen in newborns.

Yourgene Health

The Trisomy
Background Risk

The **#1** background risk is the Maternal Age.



The Cosy® test NIPT for pregnant women

Yourgene Health

Les Aneuploïdies

Autres pratiques : NIPT en première intention

(AMCG)

Nombreux pays sans prise en charge

Combiné avec l'échographie

De nombreux pays sans recommendations

Albanie, Croatie, Finlande, Grèce, Lettonie, Norvège, Portugal, Slovaquie, etc.

ADN « foetal » circulant

➡ **Dennis LO 1997 couplé aux techniques NGS**

L'ensemble du génome fœtal est représenté

➡**Quantité suffisante : 5-10% de l'ADN libre circulant**

- Jusqu'à 20 - 25% au 3e trimestre

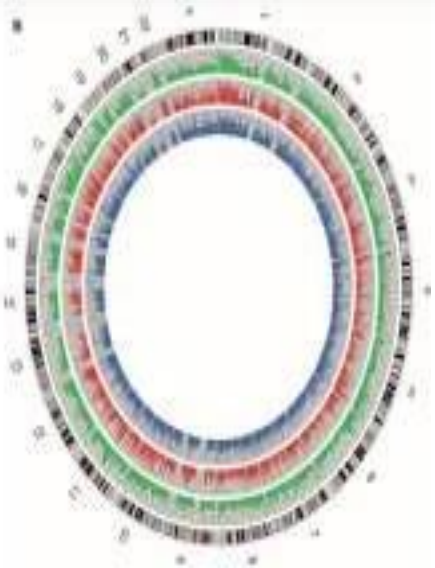
➡**1/2 vie courte ≈ 16 min**


RESEARCH ARTICLE

PRENATAL DIAGNOSIS

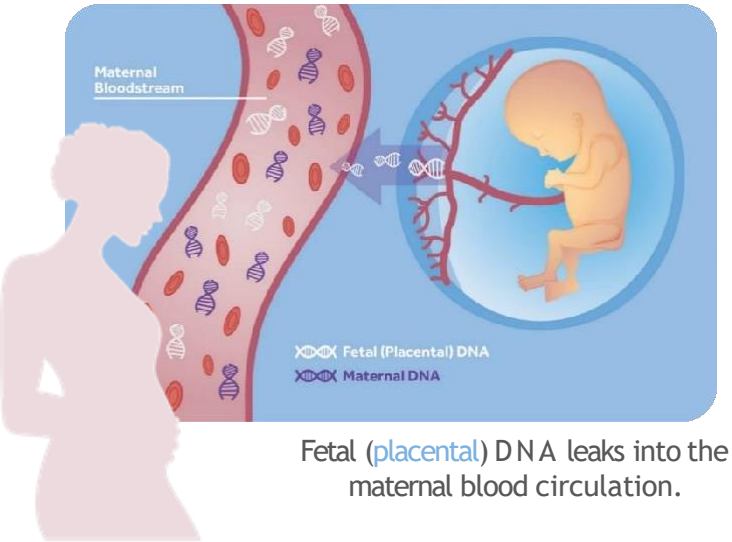
Maternal Plasma DNA Sequencing Reveals the Genome-Wide Genetic and Mutational Profile of the Fetus

Y. M. Dennis Lo, K. C. Allen Chan, Hao Sun, Eric Z. Chen, Peiyong Jiang, Fiona M. F. Lun, Yama W. Zheng, Tak Y. Leung, Tze K. Lau, Charles R. Cantor, Rossa W. K. Chiu



Circulating cell-Free DNA (ccfDNA)

Non-invasive prenatal testing (NIPT) is based on analysis of cell-free DNA (cfDNA) in maternal blood.



Fetal (placental) DNA leaks into the maternal blood circulation.

abundantly released from **placental trophoblasts**.

From **5-7** **Weeks of gestation** till only 2h after birth.
=> Perfect for pregnancy-specific testing.

Shed as **small fragments** not whole chromosome.
(~<200 base pairs (bp))

Size Fetal and maternal DNA can be distinguished by their size difference. *(size peak 143 base pairs vs. 166 bp).*

The amount of cf fetal DNA is called **Fetal Fraction.**

~**10-15%** of total cfDNA is of placental origin.

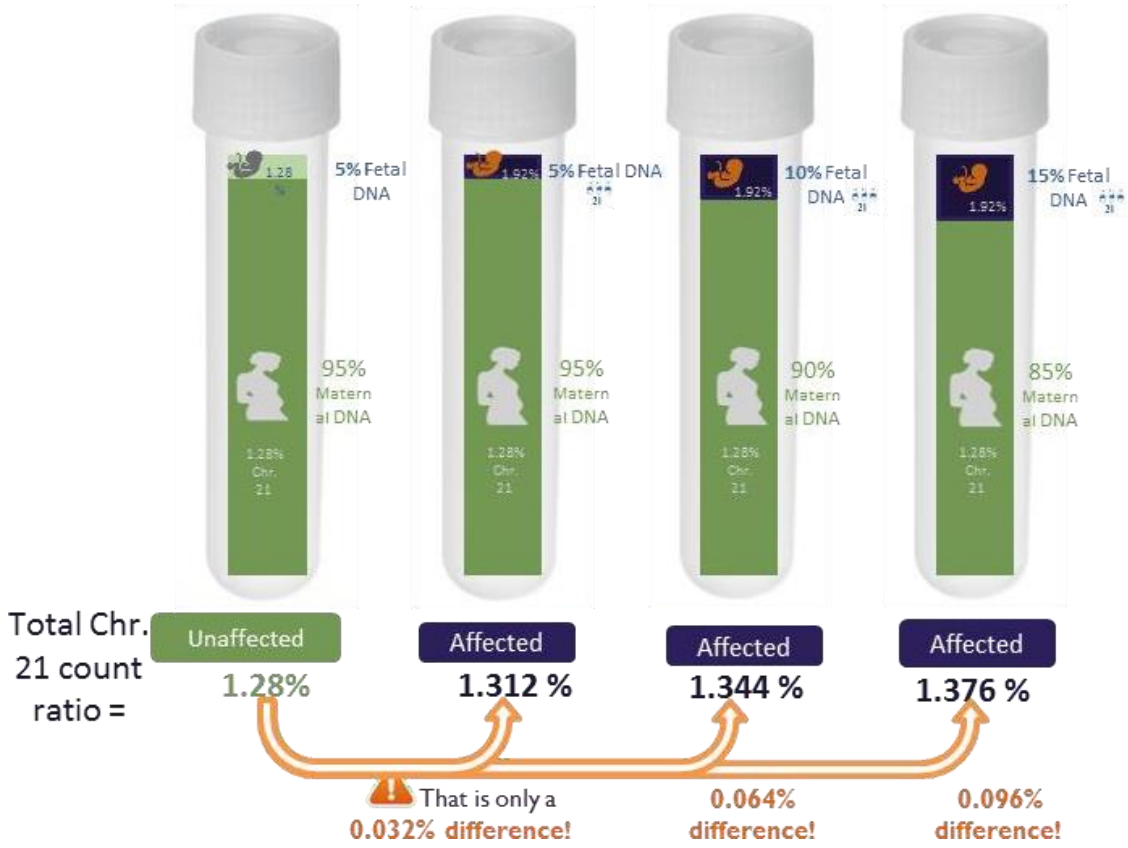
Yourgene Health

Circulating cell-Free DNA (ccfDNA)

Challenges:

- **Low concentration** of cell-free fetal DNA in maternal blood.
- Each mL of blood will have **millions of fragments** present from all 23 chromosome pairs.
- DNA from the plasma is **highly fragmented.**

Ratio of chromosome 21 for euploid and triploid pregnancies in function of Fetal fraction.



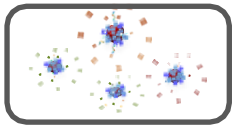
Yourgene Health

Circulating cell-Free DNA (ccfDNA)

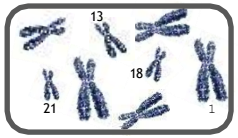
To distinguish such small differences in the amount chromosomal DNA found, an incredibly accurate and fast counting and sorting method is required.

THE SOLUTION :

Next Generation Sequencing Technology (NGS)
(also called massively-parallel sequencing)



Allows millions of sequencing reactions to be carried out simultaneously per run.



Sequencing of hundreds to thousands of genes at one time.

Allows multiplexing for different patient samples.

ThermoFisher SCIENTIFIC

Cost-effective | Comprehensive | Fast

Yourgene Health

the IONA® test

Principle :

Quantitative Methodology

The IONA test measures the
Relative Proportion of chromosomes 13,18,21
in order to show an excess of chromosomal material
which indicates the fetus is affected by a trisomy.

Technique :

Next Generation Sequencing (or NGS)

A single
Blood Sample

from 10 Gestational
Weeks

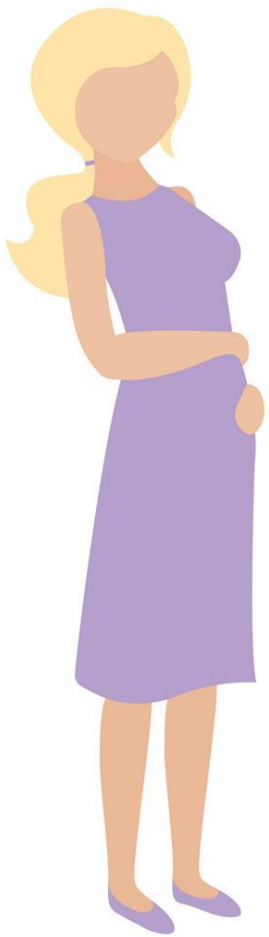
Sex Determination
(optional)

>99% Detection Rate

<1% False-positive

Yourgene Health

Suitability



Who can have the IONA® test

- ✓ From 10 weeks gestation
- ✓ Singleton or twin pregnancies
- ✓ IVF, donor egg or surrogate pregnancies

Unsuitable if the mother has:

- ✗ Received an organ transplant
- ✗ Cancer
- ✗ Carries a chromosomal imbalance
- ✗ Had a transfusion of heterologous cells in the last year
- ✗ Complete or partial monosomy X (Turner syndrome)

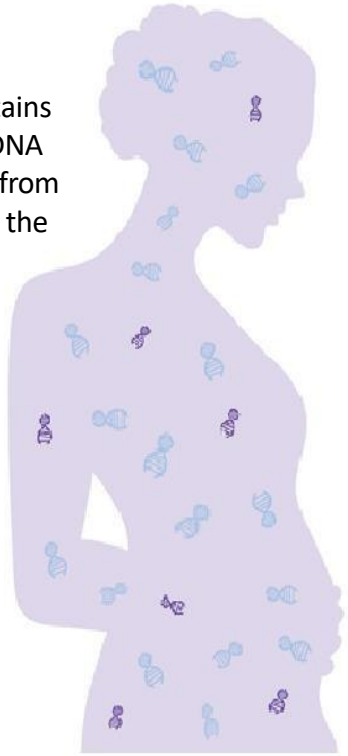
Yourgene Health

The Fetal Fraction (FF)

Estimation of the FF

One of the key factor which determine the NIPT performances is the Fetal Fraction (FF) : the proportion of circulating DNA fragments released by the foetus (placenta) among the maternal blood. It is important to measure the FF in order to reduce the risk of false-negative

Maternal plasma contains circulating cell-free DNA fragments originating from both the mother and the placenta.



Maternal blood sample

~90% Maternal DNA

~10% Fetal placental cfDNA

From Placenta

Apoptosis of trophoblast cells

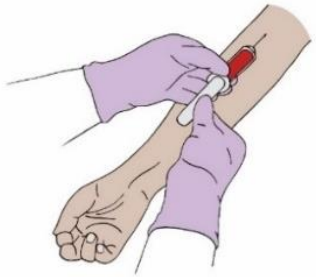
$$\frac{\text{Fetal placental cfDNA}}{\text{Total cfDNA (Maternal + Fetal)}} \times 100 = \text{Fetal fraction \%}$$

Maternal Plasma

Apoptosis of hematopoietic cells and/or adipose tissue

Workflow du Cosy® test

Collection du sang maternel



Le test nécessite **10 ml** de sang maternel dans un tube Streck ou EDTA.

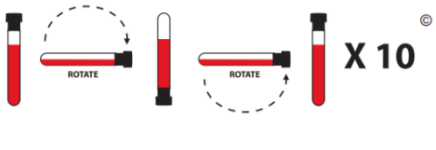
Tubes Streck cell-free DNA BCT CE :

Les tubes Streck ont des propriétés de stabilisation uniques.

L'ADN reste stable

à température ambiante (6-37°C)

pendant 14 jours.



Tubes de collection K2EDTA or EDTA KE :

Fixe le calcium du sang et empêche le sang de coaguler.

L'ADN reste stable entre

4◦C - température ambiante

jusqu'à 8 heures.*

* Une amélioration permettra de prolonger la durée de conservation à 3 jours.

Le sang doit être centrifugé dans les 8 heures suivant la prise de sang pour séparer le plasma.

Le Séquençage NGS

Principe du NGS

Génération de plusieurs millions de séquences ou « reads »

Ion 540™ Chip Kit

GCTGACTGATCCGCTGACTGATCCG

Reads : 200 pb

60 – 80 Mb reads

10-15 Gb produits

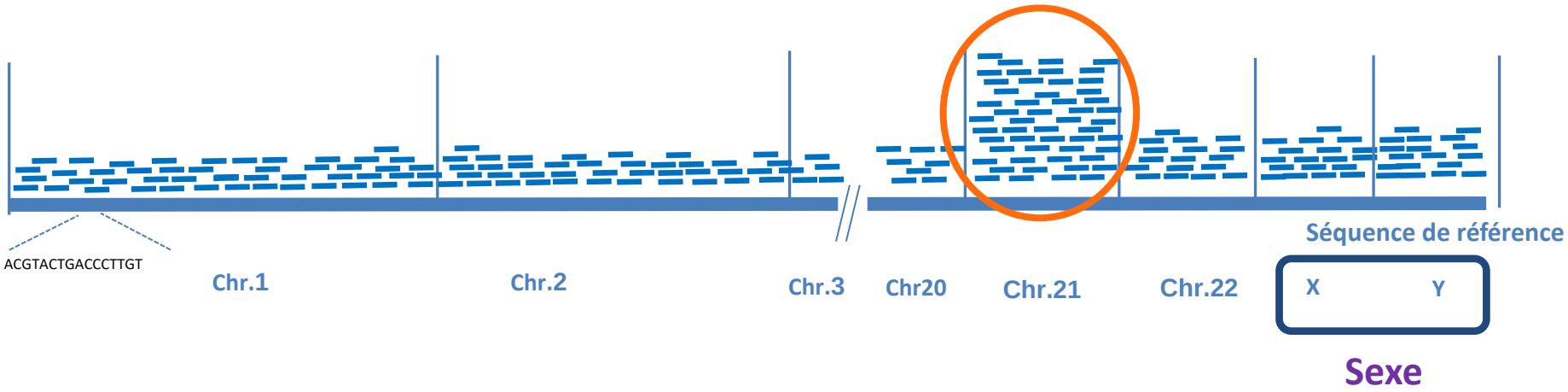
Ion Chef

Séquenceur Ion S5

ThermoFisher SCIENTIFIC

Le Séquençage NGS

Le séquençage NGS appliqué au DPNI



Recherche d'aneuploïdies

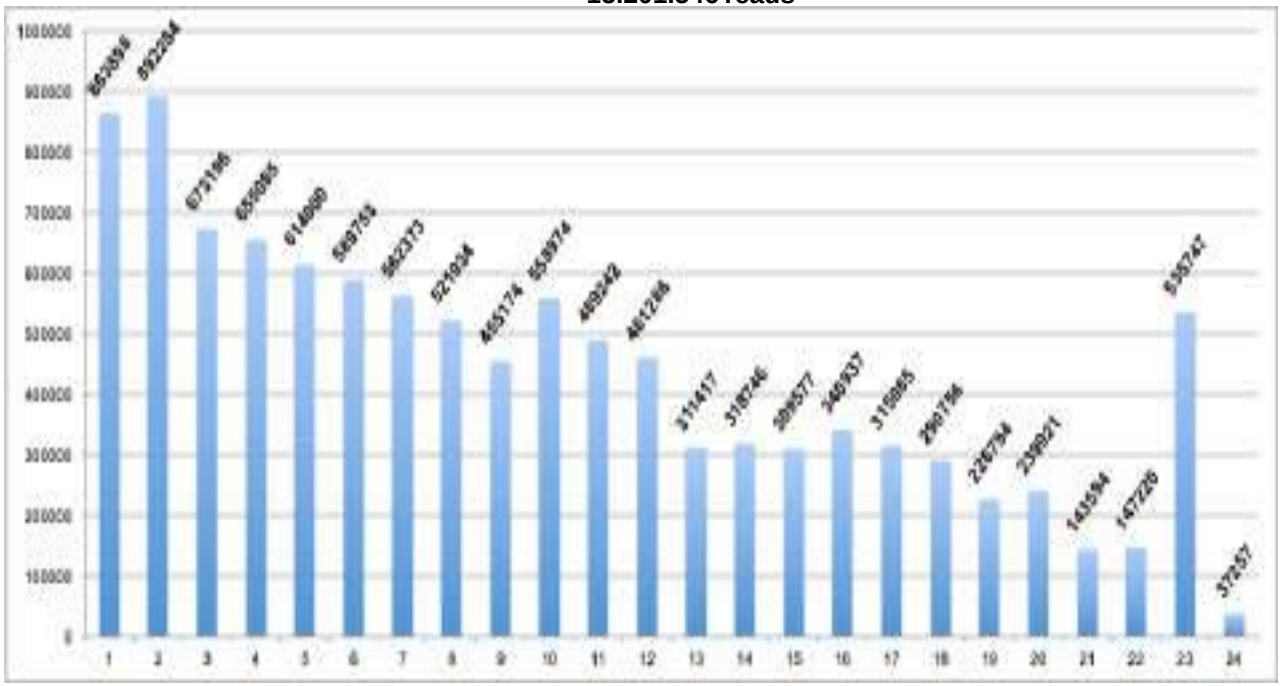
On mesure la proportion relative de chaque chromosome individuellement afin de caractériser un **excès** ou un **manque** de matériel chromosomique qui indique que le génome du fœtus comporte une trisomie ou une monosomie

z-score : Test statistique.

probabilité d'une surreprésentation des séquences dérivées d'un chromosome en tenant compte de la variabilité de représentation dans une population euploïde

Bio-informatique : Alignement

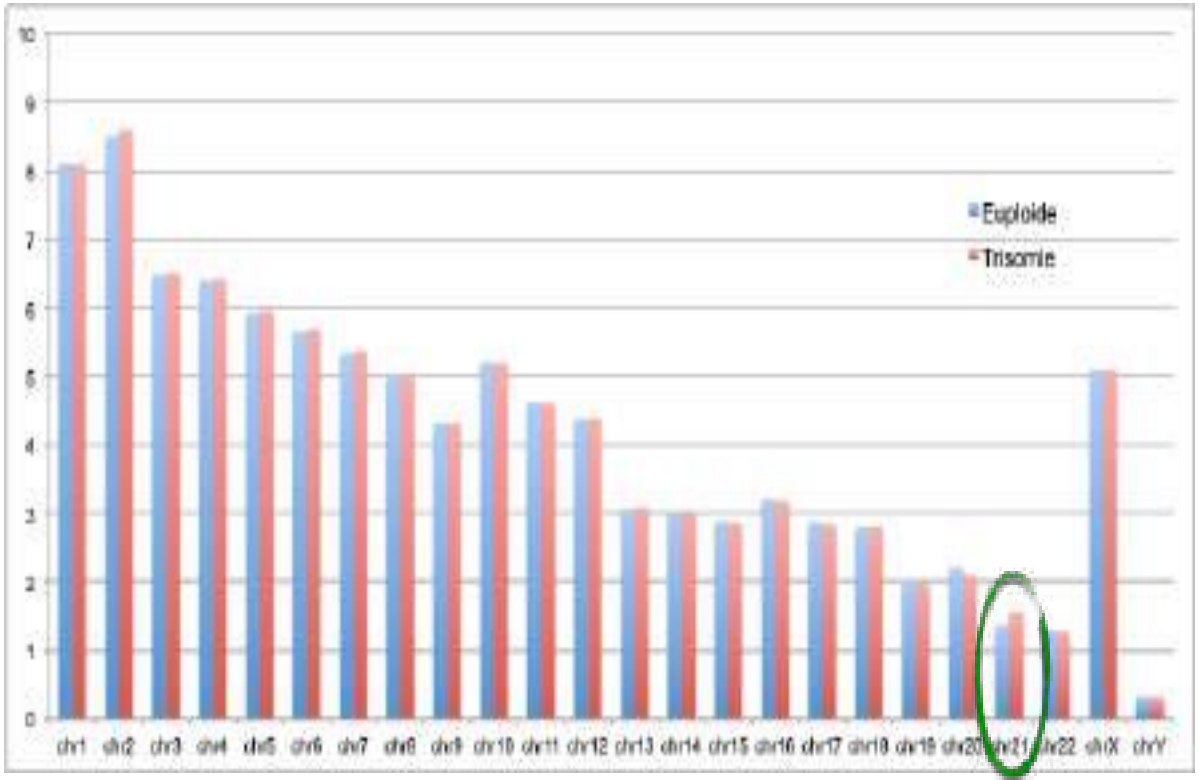
15.201.546 reads



Bio-informatique : Dénombrement

➡Hypothèse à tester : Sur représentation du chromosome 21 ?

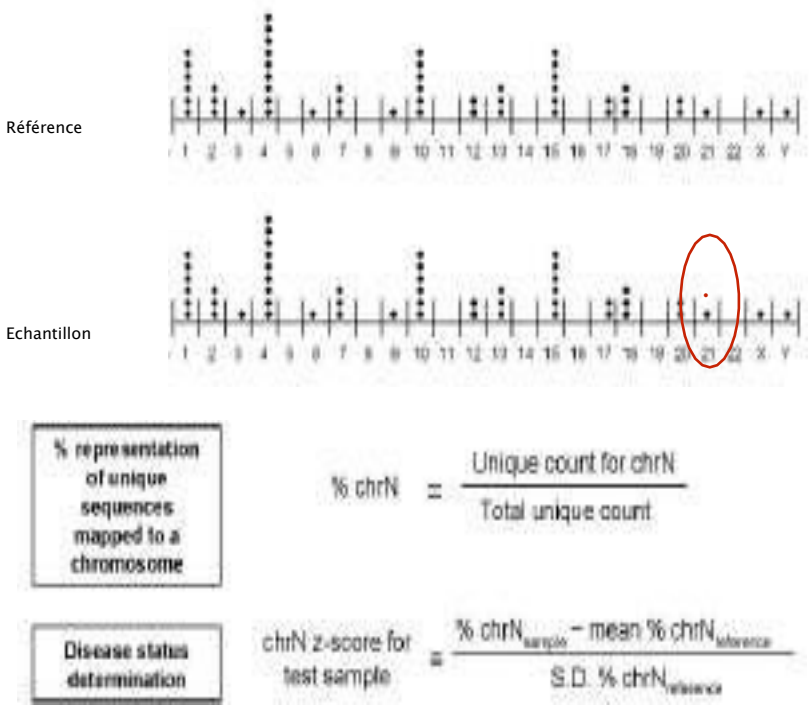
- Comparaison avec un groupe de référence euploïde
- ± Comparaison avec les autres chromosomes



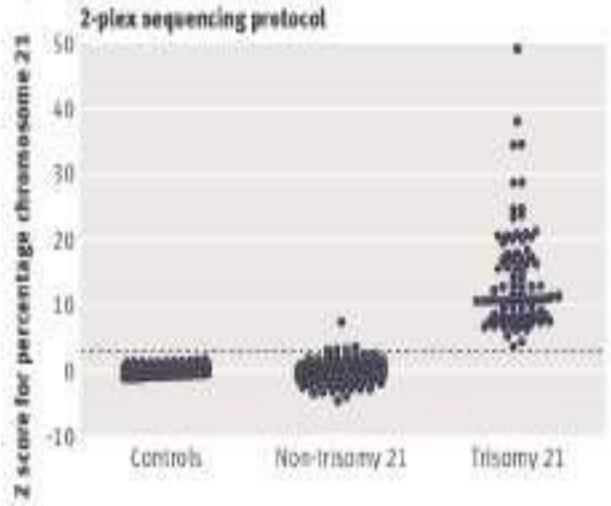
Bio-informatique : z-score

➡ DPNI : **C'EST UN TEST STATISTIQUE**

- Z-score = probabilité d'une surreprésentation des séquences dérivées d'un chromosome en tenant compte de la variabilité de représentation dans une population euploïde



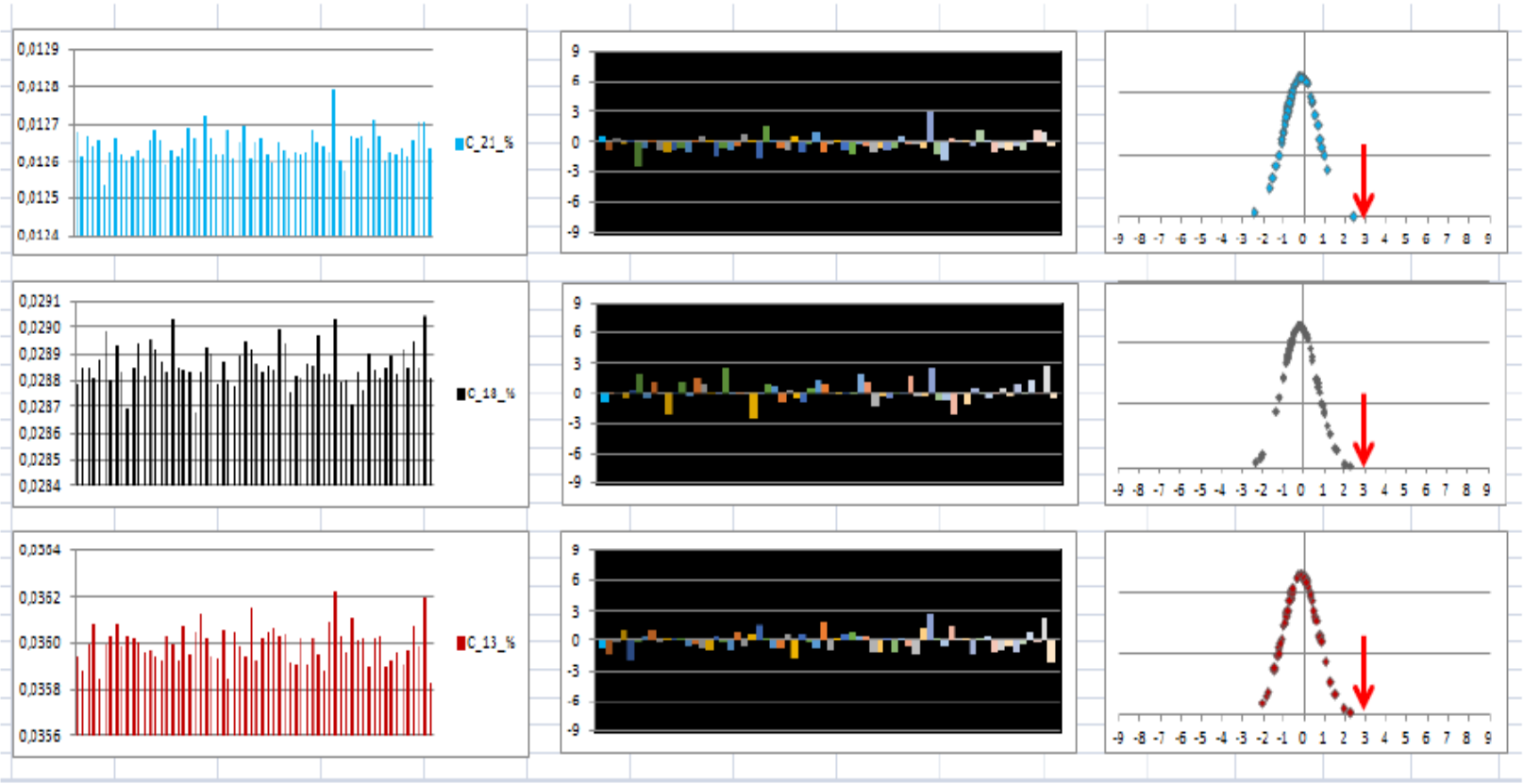
R. W. Chi ,et al., Proc Natl Acad Sci U S A 105, 20458-63 (2008).



Chiu, R. W., , et al. BMJ 342, c7401 (2011).

Dosage chromosomique fœtal par MPS

Calcul de la fraction chromosomique | **Calcul du Z-score** | **Interprétation**



Le Cosy® test

Les options du test

Safe.
Fast.
Accurate.

✓ **Les trisomies les plus courantes**

- **Trisomie 21 (syndrome de Down)**
- Trisomie 18 (syndrome d'Edwards)
- Trisomie 13 (syndrome de Patau)

✓ **Détermination du sexe du fœtus (en option)**

✓ **Aneuploïdies autosomiques rares (AAR)**

- Autres trisomies ou monosomies

✓ **Aneuploïdies des chromosomes sexuels (en option)**

- 45,X (syndrome de Turner)
- 47,XXX (Trisomie X)
- 47,XXY (syndrome de Klinefelter)
- 47,XYY (syndrome de Jacob)

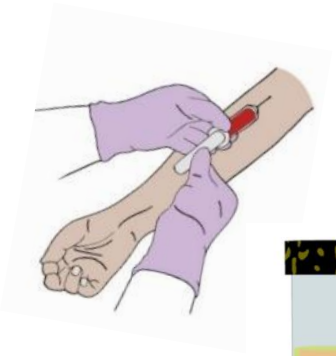
✓ **Microdélétions associées aux conditions (2024):**

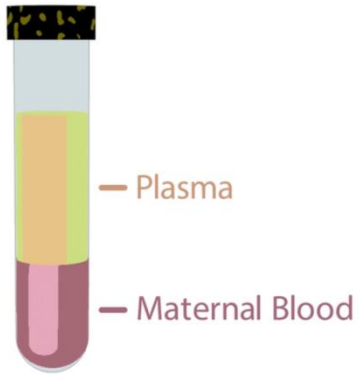
- Syndrome de DiGeorge
- Syndrome de la délétion 1p36
- Syndrome de Prader-Willi
- Syndrome d'Angelman
- Syndrome du Cri-du-Chat
- Syndrome de Wolf-Hirschhorn

✓ **Grands remaniements: insertions/ délétions/ CNVs (2024):**

- Délétions, duplications, etc. dans l'ensemble du génome

Workflow
IONA® CE-IVD
Le Cosy® test





Traitement de l'échantillon


Automate

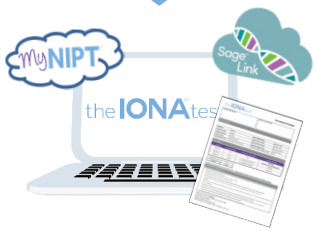
Extraction d'ADN


Automate

Construction de librairies

Préparation des matrices

Séquençage

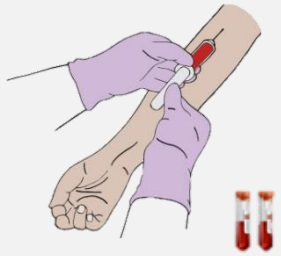


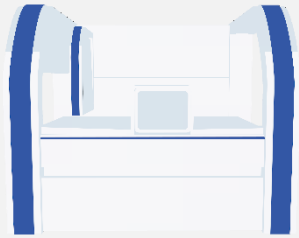
Analyse

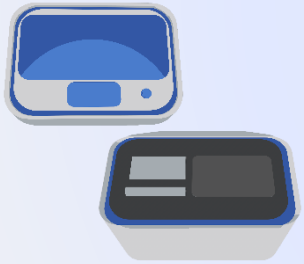
ev D

Workflow du Cosy® test

Des résultats en 3 -5 jours







Plasma maternel	Extraction de l'ADN	Préparation des librairies	Séquençage	Analyse
Un échantillon de sang de **10 ml** est prélevé sur le patient. *2.5mL de plasma utilisé dans le workflow.*	**L'extraction de l'ADN** est entièrement automatisée avec le **QIAsymphony®**.	**Préparation automatisée des librairies** à l'aide du kit IONA® sur le **NGS Sciclone®.** **Quantification** de l'ADN avec le **Labchip GX Touch.**	**Amplification** clonale des librairies par le **ION Chef™.** **Séquençage** par le **ION S5 ™ XL.**	**Analyse** automatique **des résultats** par le **IONA® Software** Validation par les contrôles et **génération des rapports**

3 – 5 jours

Workflow du Cosy® test

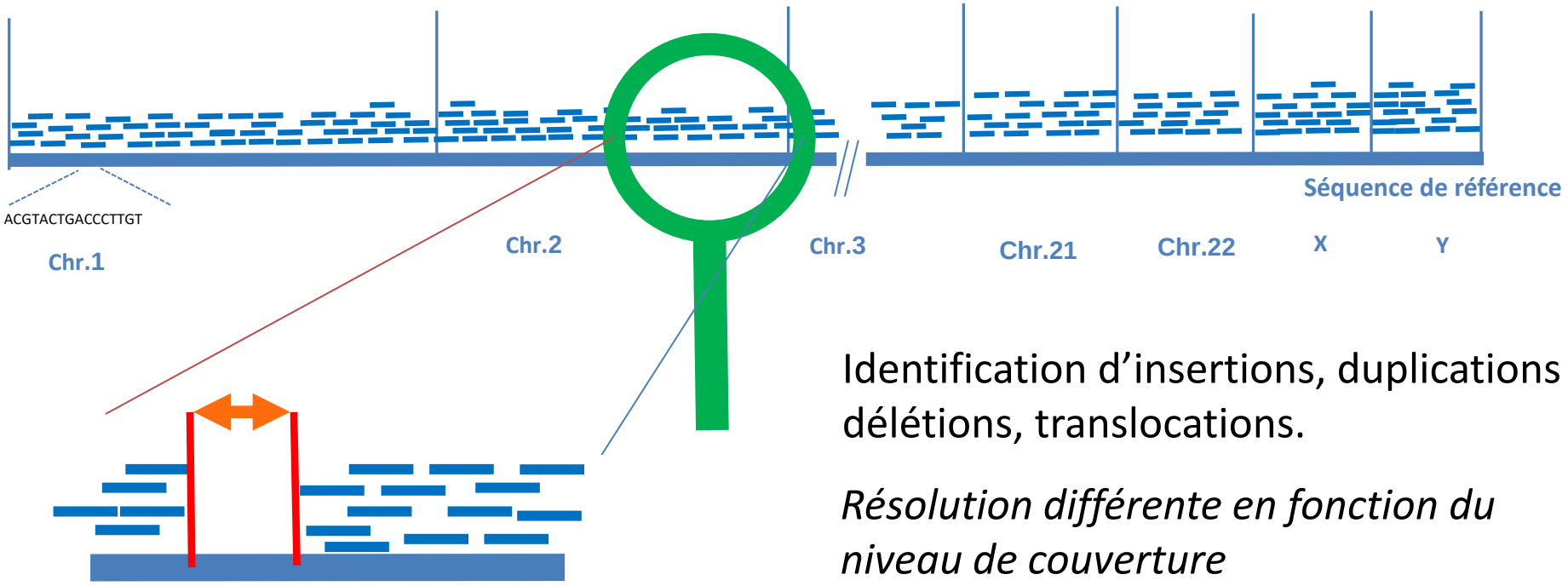
Le séquençage des librairies

Le workflow IONA CE-IVD a été validé avec la technology Ion Torrent (Thermofisher).
Les données de séquençage sont contenues dans un fichier BAM

La durée de cette étape varie en fonction des automates utilisés

Le Séquençage NGS

Le séquençage NGS appliqué au DPNI



Identification d'insertions, duplications délétions, translocations.

Résolution différente en fonction du niveau de couverture

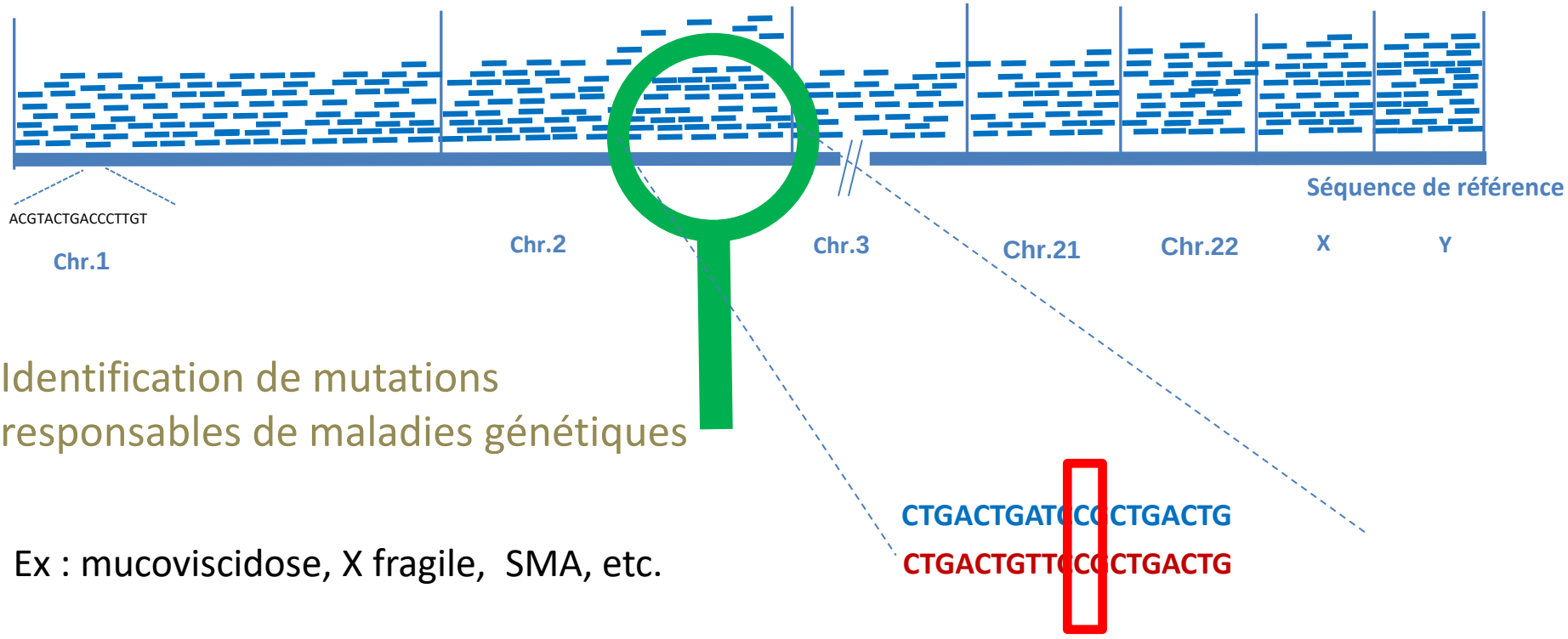
Les grands réarrangements
(> 7 Mbs)

Les microdélétions
(~ 3 Mbs et +)

Avenir Le Séquençage NGS

Le séquençage NGS appliqué au DPNI

Le futur PROCHE



Identification de mutations responsables de maladies génétiques

Ex : mucoviscidose, X fragile, SMA, etc.

Workflow du Cosy® test

Les résultats

Workflow du Cosy® test

Le rapport de résultats

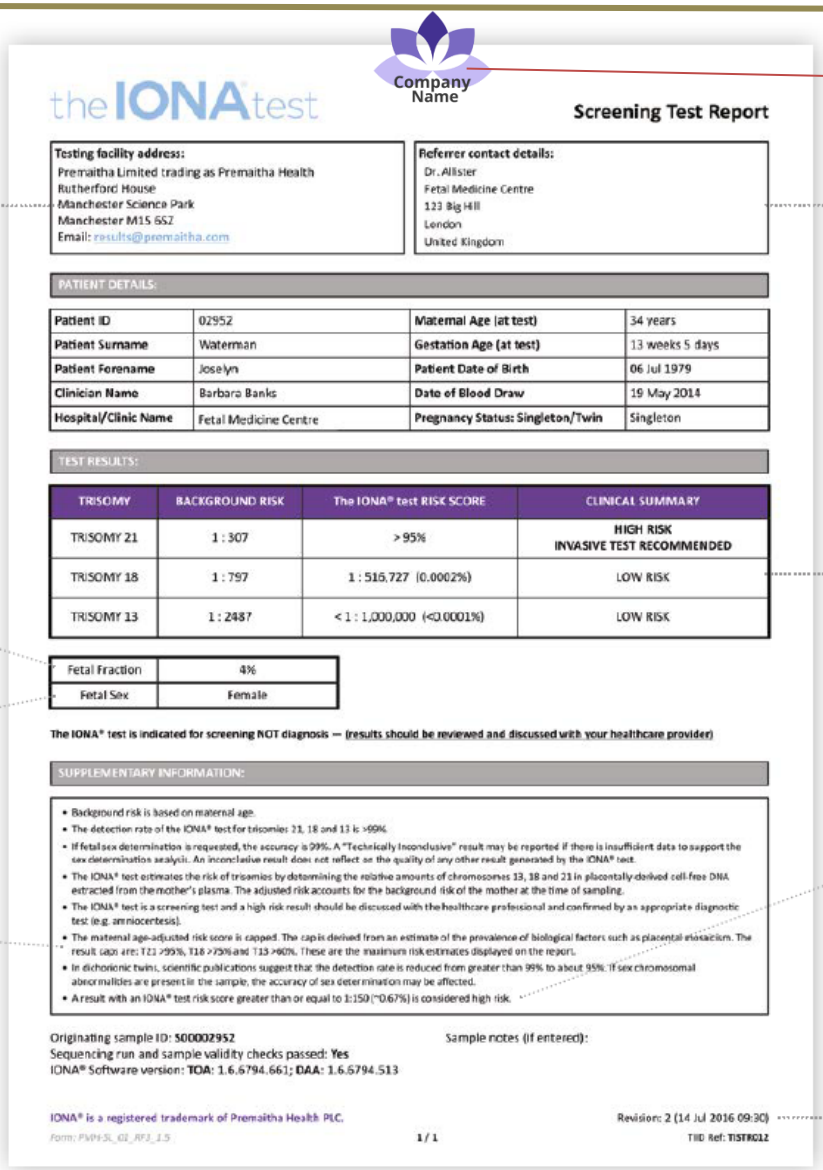
Détail du laboratoire d'analyses

Résultats valables même avec une fraction fœtale faible

Indiqué uniquement lorsque le sexe du fœtus est demandé (% précision)

Estimation du risque maximum indiqué

Le test IONA® Nx, comme les autres tests NIPT, est un test de dépistage et non de diagnostic. Les résultats doivent être considérés avec les autres résultats de dépistage disponibles. Tous les résultats de risque élevé doivent être confirmés par un test de diagnostic tel qu'une amniocentèse.



Company Name

the IONA test

Screening Test Report

Testing facility address:
Premaitha Limited trading as Premaitha Health
Rutherford House
Manchester Science Park
Manchester M15 6SZ
Email: results@premaitha.com

Referrer contact details:
Dr. Allister
Fetal Medicine Centre
123 Big Hill
London
United Kingdom

PATIENT DETAILS:

Patient ID	02952	**Maternal Age (at test)**	34 years
Patient Surname	Waterman	**Gestation Age (at test)**	13 weeks 5 days
Patient Forename	Joselyn	**Patient Date of Birth**	06 Jul 1979
Clinician Name	Barbara Banks	**Date of Blood Draw**	19 May 2014
Hospital/Clinic Name	Fetal Medicine Centre	**Pregnancy Status: Singleton/Twin**	Singleton

TEST RESULTS:

TRISOMY	BACKGROUND RISK	The IONA® test RISK SCORE	CLINICAL SUMMARY
TRISOMY 21	1 : 307	> 95%	HIGH RISK INVASIVE TEST RECOMMENDED
TRISOMY 18	1 : 797	1 : 516,727 (0.0002%)	LOW RISK
TRISOMY 13	1 : 2487	< 1 : 1,000,000 (<0.0001%)	LOW RISK

Fetal Fraction	4%
Fetal Sex	Female

The IONA® test is indicated for screening NOT diagnosis — (results should be reviewed and discussed with your healthcare provider)

SUPPLEMENTARY INFORMATION:

- Background risk is based on maternal age.
- The detection rate of the IONA® test for trisomies 21, 18 and 13 is >99%
- If fetal sex determination is requested, the accuracy is 99%. A "Technically Inconclusive" result may be reported if there is insufficient data to support the sex determination analysis. An inconclusive result does not reflect on the quality of any other result generated by the IONA® test.
- The IONA® test estimates the risk of trisomies by determining the relative amounts of chromosomes 13, 18 and 21 in placentally derived cell-free DNA extracted from the mother's plasma. The adjusted risk accounts for the background risk of the mother at the time of sampling.
- The IONA® test is a screening test and a high risk result should be discussed with the healthcare professional and confirmed by an appropriate diagnostic test (e.g. amniocentesis).
- The maternal age-adjusted risk score is capped. The cap is derived from an estimate of the prevalence of biological factors such as placental mosaicism. The result caps are: T21 >95%, T18 >75% and T13 >60%. These are the maximum risk estimates displayed on the report.
- In dichorionic twins, scientific publications suggest that the detection rate is reduced from greater than 99% to about 95%. If sex chromosomal abnormalities are present in the sample, the accuracy of sex determination may be affected.
- A result with an IONA® test risk score greater than or equal to 1:150 (~0.67%) is considered high risk.

Originating sample ID: **S00002952**
Sequencing run and sample validity checks passed: **Yes**
IONA® Software version: **TOA: 1.6.6794.661; DAA: 1.6.6794.513**

Sample notes (if entered):

IONA® is a registered trademark of Premaitha Health PLC.

Revision: 2 (14 Jul 2016 09:30)

Form: PVPH-SL_02_RF3_1.5

1 / 1

TID Ref: TISTR012

Nom et adresse du prescripteur

Résumé des résultats
. **Risque de base** : Risque d'une grossesse affectée en fonction de l'âge maternel. Test combine T1.
Score de risque : calcul du risque d'une grossesse problématique. Combine le risque lié à l'âge maternel et l'analyse de l'ADNlc.
Résumé clinique : tous les résultats supérieurs au seuil appliqué représentent un risque élevé et une confirmation par une procédure invasive est recommandée.

Valeurs limites appliquées. Elles peuvent être ajustées pour correspondre à la règlementation locale

Numéro de révision du rapport, si des informations patients sont ajoutées après le rapport initial qu'un nouveau rapport est généré

Performance du NIPT dans la population obstétricale générale

SRMGO, Casablanca, 15-17 Février 2024

>98% of cases received a result after first sampling
>99,7% of cases received a result after second sampling

Test Performance

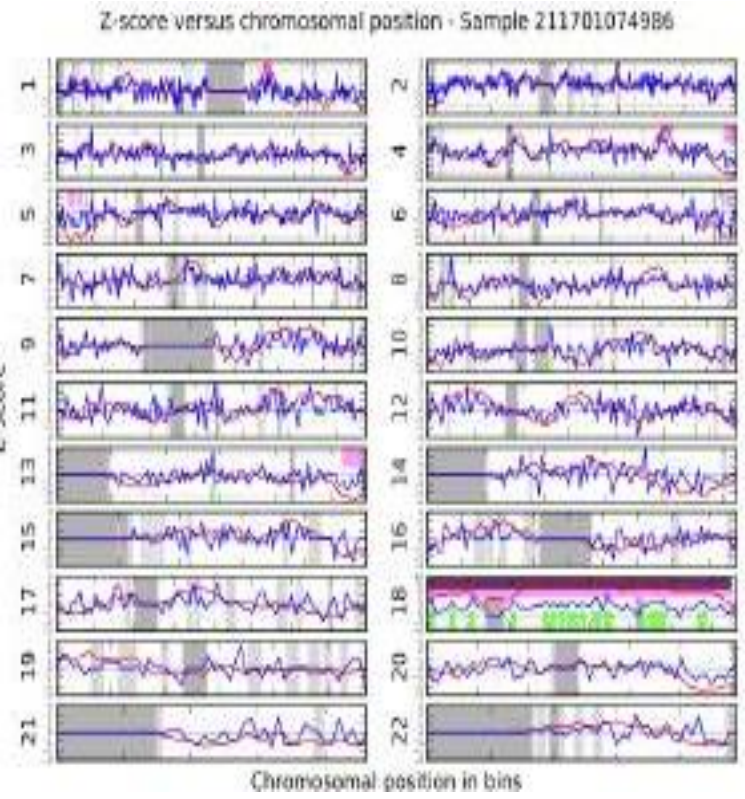
Unprecedented sensitivity for detection of fetal trisomy 21, 18 and 13

Singleton pregnancies	Observed sensitivity	Observed specificity	PPV	NPV
Trisomy 21	99,47%	99,99%	93,97%	100%
Trisomy 18	91,89%	99,99%	73,91%	100%
Trisomy 13	100%	99,98%	55,56%	100%

IPG

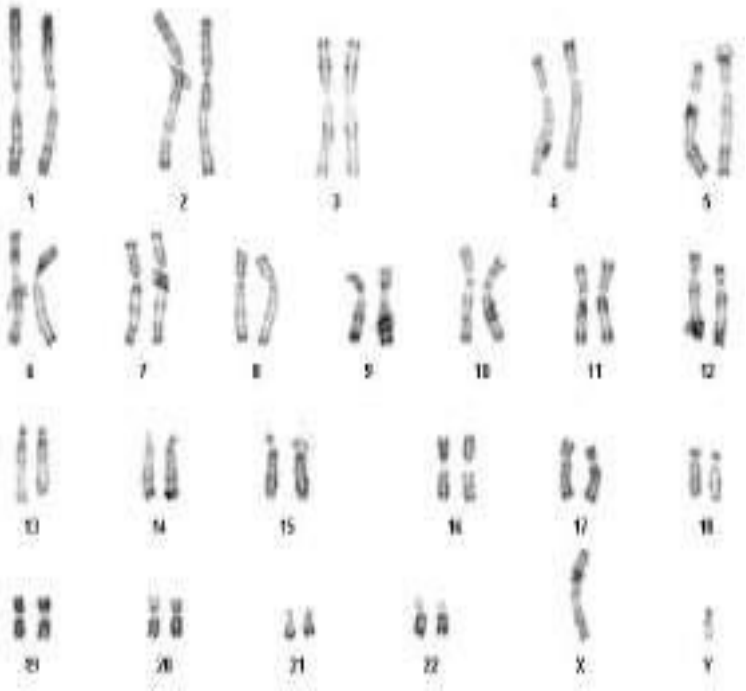
Contrôle sur tissus foetaux et placentaires

DPNI - Sang maternel



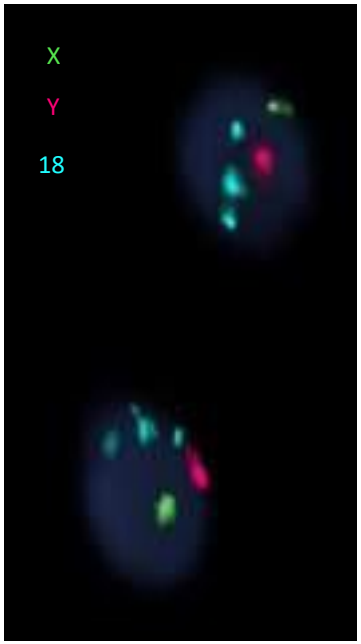
Tri 18

Ponction de liquide amniotique



Caryotype foetal normal

Placenta à la naissance



Tri 18

L'ADN « foetal » est un ADN placentaire

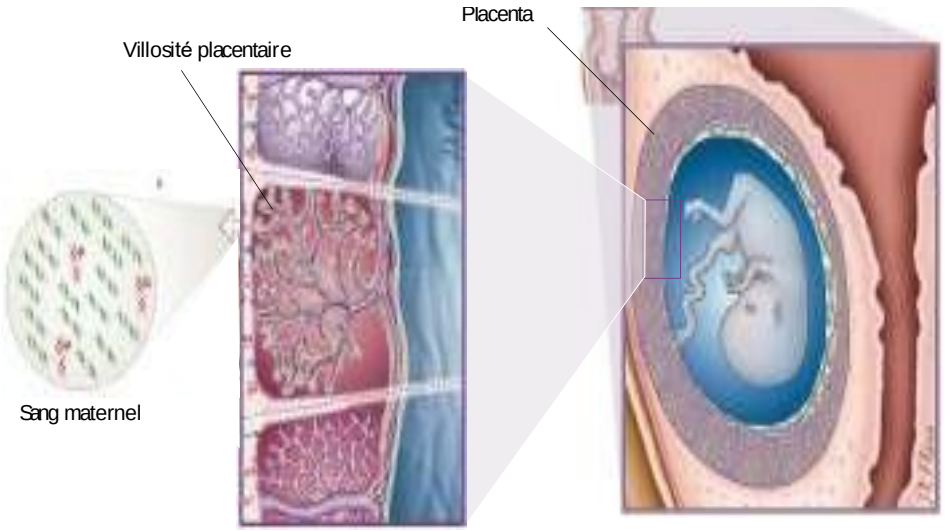
Human Reproduction Vol.19, No.3 pp. 723–724, 2004
Advance Access publication 29 January, 2004
DOI: 10.1093/humrep/deh117

➡Origine trophoblastique de l'ADN « fœtal » circulant

Circulating cell-free fetal DNA in maternal serum appears to originate from cyto- and syncytio-trophoblastic cells. Case report

E.Flori[1], B.Doray[1], E.Gautier[2], M.Kohler[3], P.Ernault[2], J.Flori[3] and J.M.Costa[2,4]

- Grossesse sans embryon
- profil de méthylation placenta spécifique
- anomalies chromosomiques confinées au placenta



DPNI: Interprétation des résultats
Un contexte biologique particulier

➡**ADN « fœtal »**

- discordances foeto-placentaire

➡**ADNs maternels**

- constitutionnel
- somatique

IONA®

The Report

The **probability** that a sample, at a given concentration, is affected or non-affected is evaluated.

A **report** is generated for each patient.

The information is automatically conbined with the **maternal age** or with the **1st trimestre combined test result (FTCT)** to give an adjusted and personalised probability (**Risk Score**).

Customisable for your own laboratory.

TRISOMY	BACKGROUND RISK	The IONA® test RISK SCORE	CLINICAL SUMMARY
TRISOMY 21	1:171	>95%	HIGH RISK INVASIVE TEST RECOMMENDED
TRISOMY 18	1:542	<1:1,000,000 (<0.0001%)	LOW RISK
TRISOMY 13	1:1655	<1:1,000,000 (<0.0001%)	LOW RISK

Fetal Fraction (%)	10%
Fetal Sex	Male

For clarity, this **Risk Score** is expressed as « **High Risk**- or **Low risk** ».

The fetal fraction and sex can be indicated on the report (optional).

The **Risk cut-off** can be customised according to the specific health regulation in the country (ex: 1/150).

False-Positive and False-Negative

The NIPT technologies test cfDNA in maternal blood released by the **Placenta**.

Thus, NIPTs are **indirect** screening tests with the inherent limitations.

Numerous biological factors on the placenta, fetus, or mother can affect the test results:

- Confined Placental mosaicism (CPM). (*When CVS is performed, CPM is found in 1–2% of first trimester placenta samples*[45].
- Maternal mosaicism (e.g., 45X/46XX) [2]
- In uterine demise of a twin [2] and volunteer reduction ('vanishing twin'),
- Maternal causes (ex: cancer non detected, maternal aneuploidy (e.g., 47,XXX),ect…) [2],
- Suboptimal storage or transport of samples,
- NIPT done too early in gestation (<10 weeks),
- High maternal BMI,
- Maternal copy number variations (e.g., subchromosomal duplications or deletions, including 22q11.2 microdeletion carriers or Isochromosome 21q) [2],
- Low-molecular-weight heparin,
- Prior organ transplant [2]
- Autoimmune disease (ie:evere thrombocytopenia and neutropenia) [22]
- Other…

Placental mosaicism

When the risk is estimated to be equal or above the risk cut-off (country specific), a fetal karyotype is required which required an invasive diagnostic test (amniocentesis or choriocentesis).

Yourgene Health

Discordances Foeto-placentaires

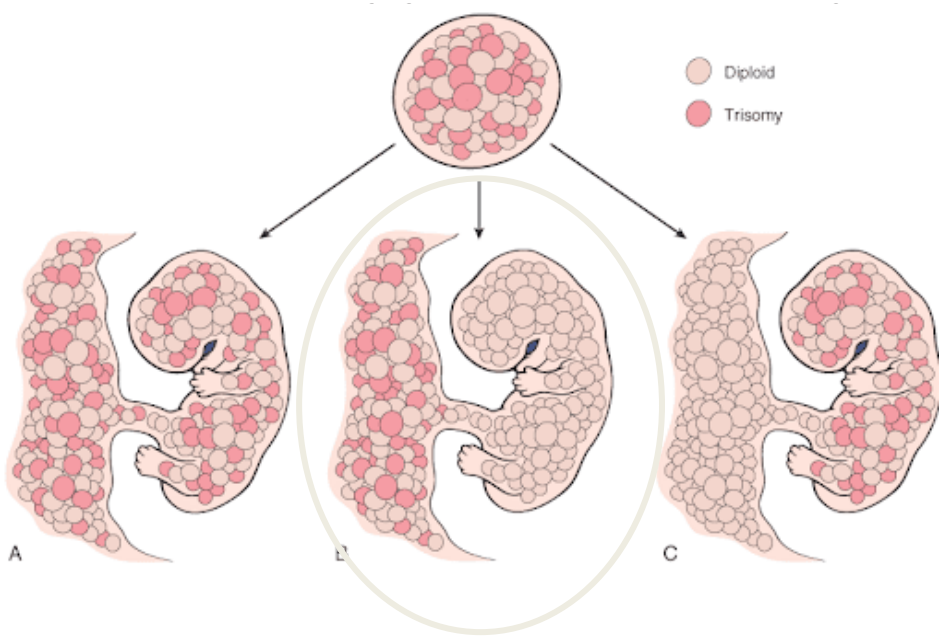
Le NIPT reste un test de dépistage et non un test diagnostique...

Faux positifs (FP) : discordances entre le résultat du TPNI et le caryotype fœtal

Les résultats discordants s'expliquent par la méthode elle-même qui analyse la totalité de l'ADN libre circulant dans le sang maternel (ADN foetal + ADN maternel).
L'ADN fœtal libre circulant dans le sang maternel provient essentiellement de l'apoptose des cellules trophoblastiques.
Le NIPT n'est donc pas seulement le reflet du caryotype fœtal, mais peut, potentiellement, être le reflet d'anomalies confinées au placenta, d'anomalies génétiques maternelles méconnues et, plus rarement d'anomalies tumorales.

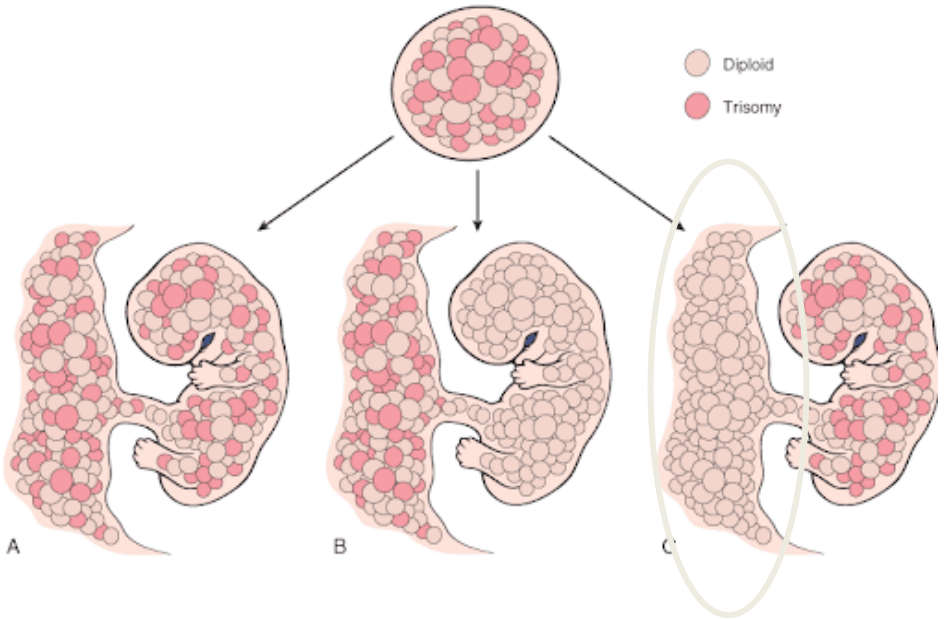
- **La mosaïque confinée au placenta** est la cause principale des FP décrits dans la littérature.

Ces mosaïques concernent 1 à 2 % des placentas au premier trimestre et sont à l'origine de la majorité des FP. C'est pourquoi, avant d'envisager une interruption de grossesse, tout TPNI positif doit être confirmé par la réalisation d'un génotype fœtal nécessitant une procédure invasive (amniocentèse).

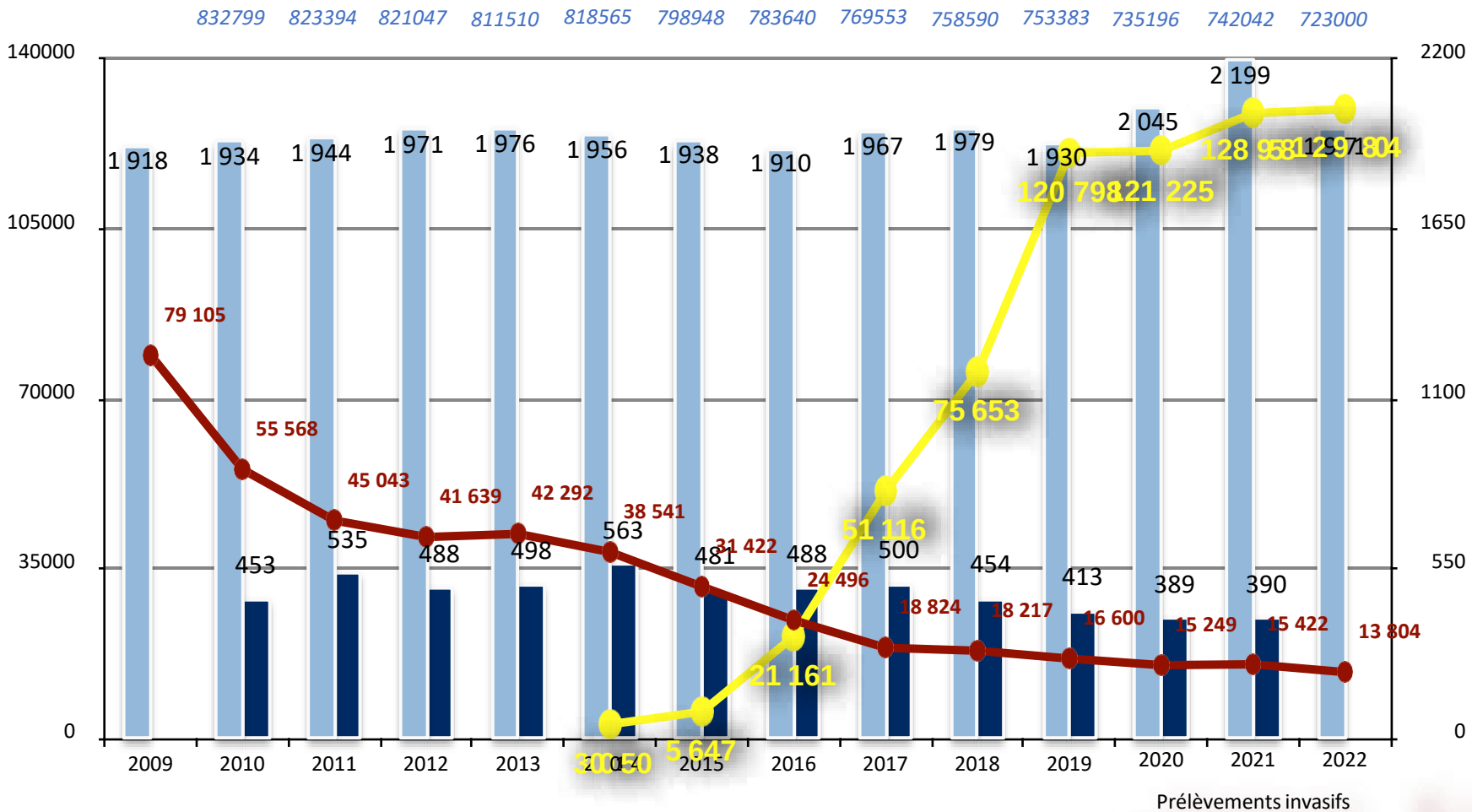


DPNI Faux négatifs

- Des résultats faussement négatifs pour la trisomie 21, 18 et 13 ont été rapportés dans 4, 2 et 0 cas respectivement (sur un total de 155.000 tests).
- Pour un cas de T21, la trisomie était présente dans 7% des cellules placentaires, 100% des cellules fœtales et 75% des cellules du cordon ombilical.



Les résultats cliniques du DPNI



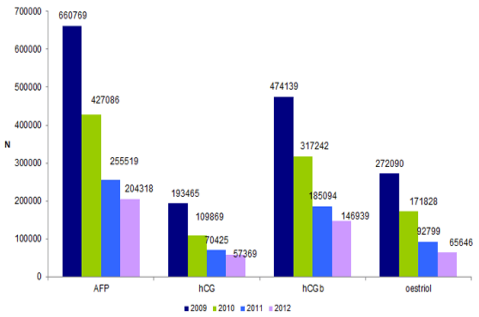
➡**2017 - 2022 : 627.554 analyses en France**

- 7.831 analyses positives pour T21 ou T18 ou T13 (1,2%)

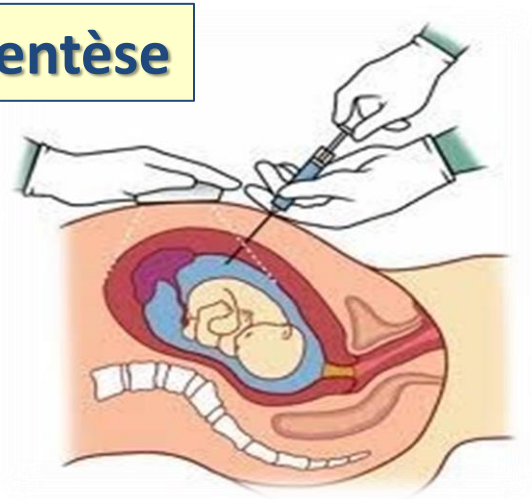
Invasive diagnostic procedure

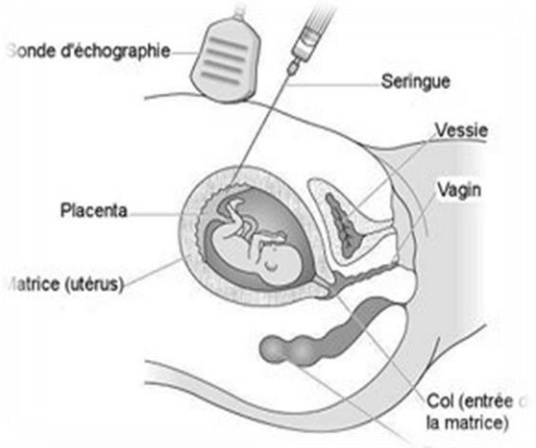
Dépistage intégré Séquentiel

Figure DPN8. Evolution du nombre de marqueurs sériques du 2ème trimestre réalisés par les laboratoires

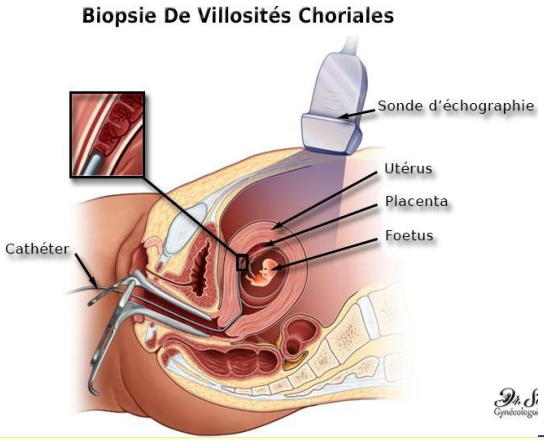


Amniocentèse

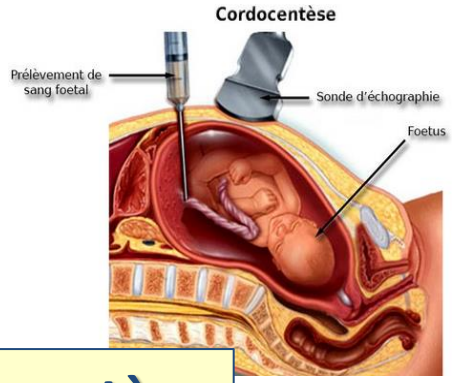




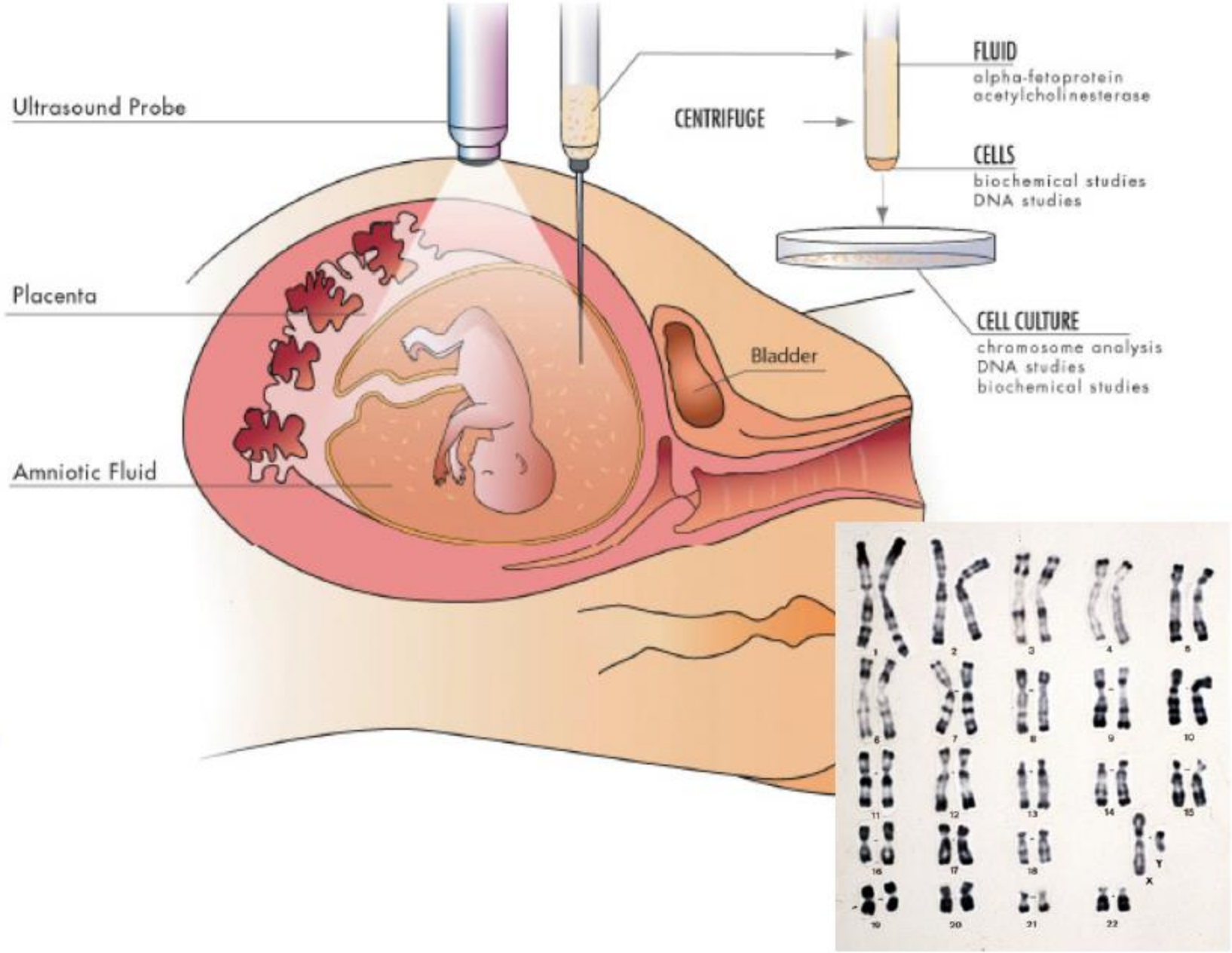
Biopsie de trophoblaste



Prélèvement des villosités choriales

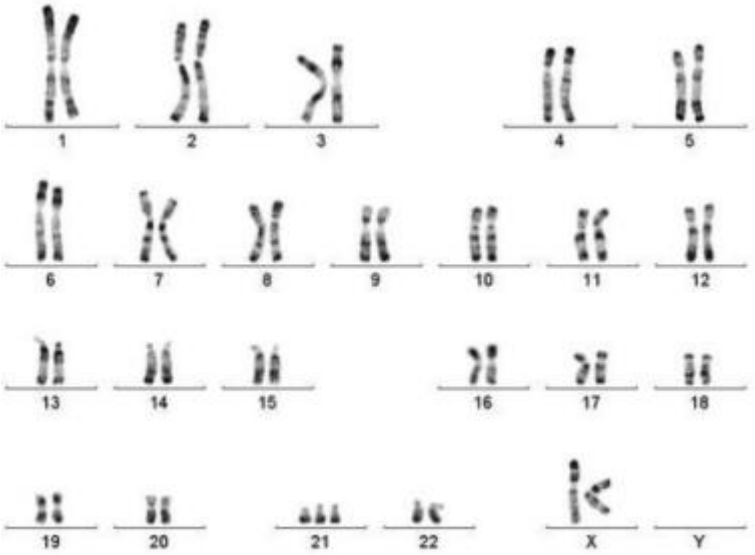


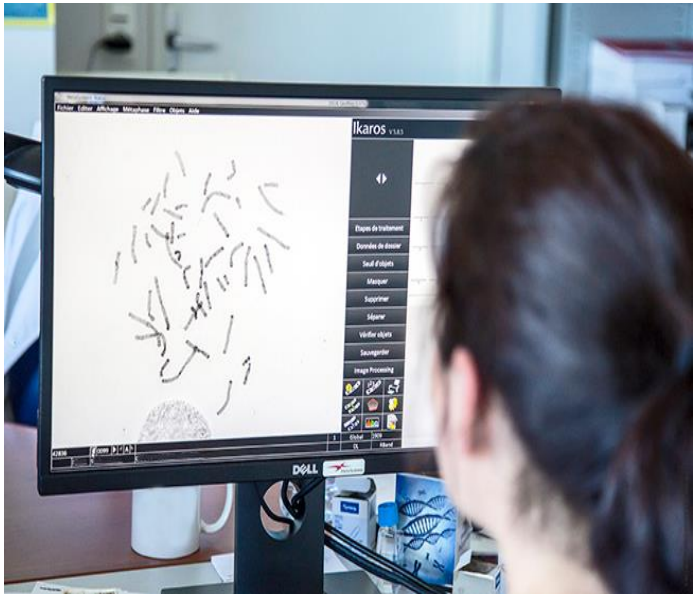
Cordocentèse

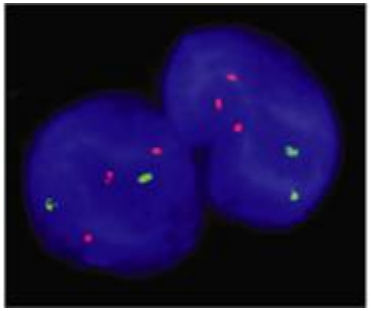

Ultrasound Probe
Placenta
Amniotic Fluid
Bladder
CENTRIFUGE
FLUID
alpha-fetoprotein
acetylcholinesterase
CELLS
biochemical studies
DNA studies
CELL CULTURE
chromosome analysis
DNA studies
biochemical studies

Conventional Karyotype

Cytogenetics laboratory

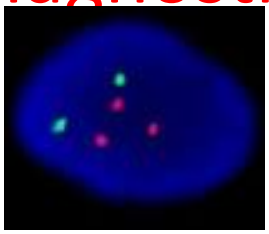


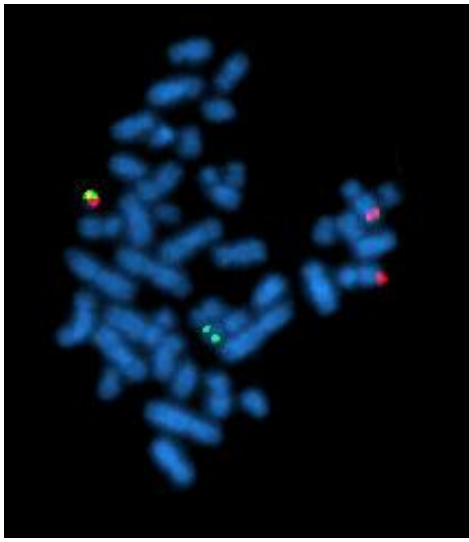




DPN: Apport de la FISH et QF PCR

- Diagnostic des Aneuploïdie (13, 18, 21, X et Y)





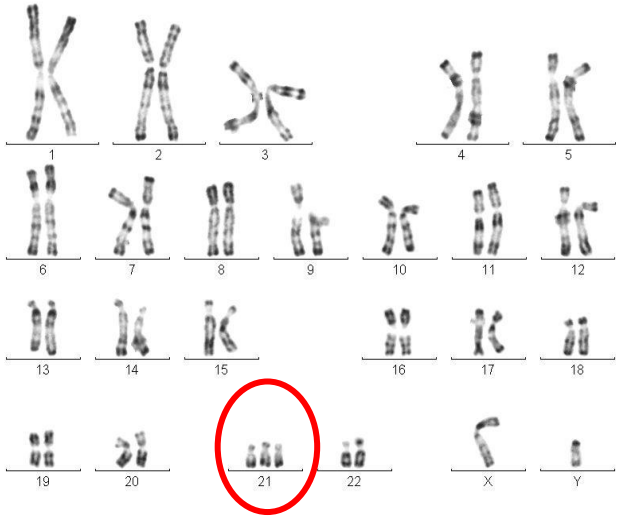
- Sondes : Locus spécifiques

  Syndromes microdélétionnels

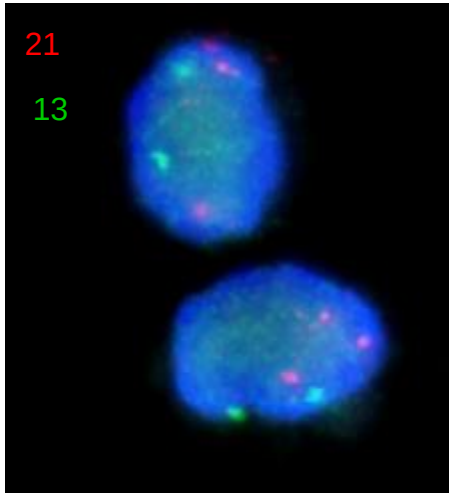
  Di-George, Prader-Willi, Angelman

- Caractérisation des anomalie de structure

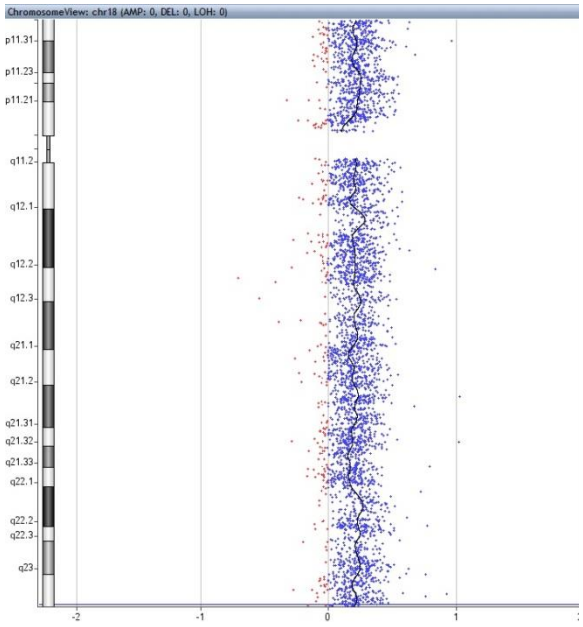
	Caryotype	FISH	ACPA
Aneuploïdies	☑	☑	☑



47,XY,+21



T21



T18

⇒ Suspicion de trisomie, Σ Turner, Σ Klinefelter

Caryotype Results

- Confirmation du Diagnostic de la Trisomie 21

47, XX, +21

47, XY, +21

- Trisomie 21 libre et Homogène (95% des cas)
- Trisomie 21 libre en mosaique (2 à 3% des cas)
- Trisomie 21 par translocation

  Conseil génétique +++

  Evaluation du risque de récurrence

Dépistage Avancé

Non Invasif

NIPD: Non invasive prenatal diagnosis

NIPT: Non invasive prenatal testing

NIAPS: Non invasive advanced prenatal screening

Conclusion

- Non-invasive screening for chromosomal abnormalities in maternel blood: NIPT

  Major turning point in prenatal screening for aneuploidies VPP +++

- Essential benefit: reduce the number of invasive diagnostic procedures at risk of abortion
- Rapid advancement of new technologies NGS: **Prenatal screening for monogenic diseases**.
- Project of a consortium between prenatal prenatal screening centers in Arab countries ?

Thank you for your attention

Contact Information:

jalil.elattar@laboriad.ma