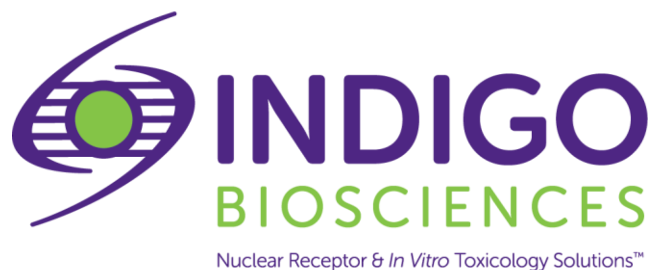

Human Fibroblast Growth Factor Receptor 4 Assay for Paracrine FGF Signaling

(FGFR4)

3x 32 Assays in 96-well Format
Product # IB43001-32

▪

Technical Manual
(version 7.2i)

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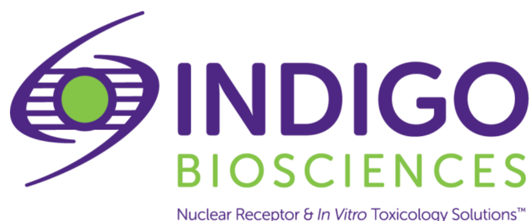


Human FGFR4 for Paracrine Signaling Reporter Assay System
3x 32 Assays in 96-well Format

I. Description

- Background ……………………………………………………………3
- The Assay System……………………………………………………3
- The Assay Chemistry…………………………………………………4
- Preparation of Test Compounds……………………………………5
- Assay Scheme…………………………………………………………5
- Assay Performance……………………………………………………5

II. Product Components & Storage Conditions ……………………7

III. Materials to be Supplied by the User……………………………7

IV. Assay Protocol

- A word about Inhibition-mode assay setup…………………………8
    - *DAY 1 Assay Protocol*……………………………………………8
    - *DAY 2 Assay Protocol*……………………………………………10

V. Related Products……………………………………………………11

VI. Limited Use Disclosures…………………………………………13

VII. Citations…………………………………………………………13

APPENDIX 1: Example Scheme for Serial Dilutions……………14

I. Description

▪ Background ▪

The family of Fibroblast Growth Factors (FGFs) comprise approximately 23 members that are related by core sequence and structure conservation, with the majority of FGFs being secreted signaling proteins. Secreted FGFs are predominantly autocrine and paracrine factors, with only three members evolved to function as endocrine factors[1].

FGFs bind and activate four FGF Receptors (FGFR1-4) which, themselves, are members of the family of high-affinity tyrosine kinase receptors[1]. Heparin and heparin sulfate proteoglycans (HSPGs) are essential cofactors for paracrine FGF (*e.g.,* FGF-1 and FGF-2) interactions with FGFRs. The association between paracrine FGFs and HSPGs ensures their limited diffusion and enhanced FGFR binding specificity.

In contrast to the paracrine ligand activators of FGFR, endocrine FGFs (*e.g.,* FGF-19, FGF-21, and FGF-23) have minimal affinity to heparin. Rather, they typically require association with members of the Klotho family of proteins as cofactors for efficient binding to their cognate receptor(s)[1, 2]. Although, FGF-23 activation of FGFR3 can occur in a Klotho independent manner, signaling through the PLCγ/calcineurin/NFAT pathway [3, 4].

The FGFs are broad-spectrum mitogens that, through their receptor interactions, regulate a variety of cellular functions including migration, proliferation, differentiation, metabolism and survival[1, 2]. In particular, FGF/FGFR signaling plays a critical role in regulating metabolism in the kidney, liver, brain, intestine and adipose tissues[1, 2]. Not surprisingly, dysfunctional FGFR signaling can lead to a range of physiological disorders. For example, mutation, amplification, and gene fusion may result in abnormal morphogenesis and the progression of several types of cancer[2]. Consequently, the FGF receptors continue to command much interest as targets for drug development and drug safety screening.

▪ The Assay System ▪

This assay utilizes proprietary human cells that have been engineered to provide constitutive expression of the **Human Fibroblast Growth Factor Receptor 4 (FGFR4)**.

INDIGO's Compound Screening Media is supplemented with heparin, thereby enabling the formation of FGF-2/Heparin complexes that bind with high-affinity to FGFR monomers. This binding interaction triggers conformational changes that drive the assembly of homo-dimeric receptors, and the activation of their respective cytosolic tyrosine kinase domains[1].

The tyrosine kinase activities of activated FGFR4 initiate intracellular signaling cascades that include RAS-MAPK, PI3-AKT, PLCγ and STAT pathways[1]. For example, activation of the PLCγ pathway leads to an increase of intracellular calcium[1]. One prominent outcome of the FGF/FGFR > PLCγ pathway is that calcineurin, a calcium-dependent phosphatase, dephosphorylates and activates the transcription factor NFAT[5]. It is FGFR4 signal transduction *via* the Ca^{+2}·calcineurin / NFAT cascade that is exploited by the reporter cells provided in this kit.

INDIGO's FGFR4 for Paracrine FGF Signaling Reporter Cells contain the luciferase reporter gene functionally linked to tandem NFAT consensus response element sequences upstream of a minimal promoter. Activated NFAT binds to these response elements to initiate the formation of a complete transcription complex that drives Luc gene expression. Quantifying relative changes in luciferase activity in the treated reporter cells relative to the untreated cells provides a sensitive, dose-dependent surrogate measure of drug-induced changes in FGFR4 activity. Accordingly, the principal application of this reporter assay is in the screening of test materials to quantify any functional interactions, either activating or inhibitory, that they may exert against FGFR4, or the coupled Ca^{+2}·calcineurin/NFAT signal transduction pathway. To reiterate, this assay is primarily focused on the paracrine signaling activities of FGFR4/FGFs.

INDIGO's Reporter Cells are transiently transfected and prepared as frozen stocks using a proprietary **CryoMite™** process. This cryo-preservation method allows for the immediate dispensing of healthy, division-competent reporter cells into assay plates. There is no need for intermediate treatment steps such as spin-and-rinse of cells, viability determinations or cell titer adjustments prior to assay setup.

(*continued*)

This assay kit provides the convenience of an all-inclusive cell-based reporter assay system for FGFR4 paracrine FGF signaling. In addition to Reporter Cells, included are an optimized culture medium for use in reviving the cryopreserved cells, a culture medium supplemented with heparin for use in preparing test sample treatments, the physiological paracrine activator FGF-2 (*aka* FGF-Basic), Luciferase Detection Reagents, and a cell culture-ready assay plate.

▪ The Assay Chemistry ▪

INDIGO's receptor assays capitalize on the low background, high-sensitivity, and broad linear dynamic range of bio-luminescence reporter gene technology.

Reporter Cells incorporate the cDNA encoding beetle luciferase, a 62 kD protein originating from the North American firefly (*Photinus pyralis*). Luciferase catalyzes the mono-oxidation of D-luciferin in a Mg^{+2}-dependent reaction that consumes O_2 and ATP as co-substrates to yield oxyluciferin, AMP, PP_i, CO_2, and photon emission. Luminescence intensity of the reaction is quantified using a luminometer and is reported in terms of Relative Light Units (RLU's).

This assay kit features a luciferase detection reagent specially formulated to provide stable light emission between 5 and 90+ minutes after initiating the luciferase reaction. Incorporating a 5-minute reaction-rest period ensures that light emission profiles attain maximal stability, thereby allowing assay plates to be processed in batch. By doing so, the signal output from all sample wells, from one plate to the next, may be directly compared within an experimental set.

▪ Preparation of Test Compounds ▪

Small molecule compounds are typically solvated in DMSO at high concentrations; ideally 1,000x-concentrated stocks relative to the highest desired treatment concentration in the assay. Using high-concentration stocks minimizes DMSO carry-over into the assay plates. Note that the final concentration of DMSO carried over into assay wells should not exceed 0.4%.

Stocks of test materials that are **Protein** or **Poly-peptide** ligands, or **Antibodies**, should be solvated in aqueous buffered solutions with carrier protein (*e.g.,* PBS + 0.1% BSA) at concentrations *no less* than 10x-concentrated relative to the highest desired treatment concentration. The FGF-2 stock included with this kit is prepared in PBS + 0.1% BSA at a 100x-concentration relative to the highest recommended treatment (refer to APPENDIX 1).

Immediately prior to setting up an assay, the above master stocks are serially diluted using one of two alternative strategies:

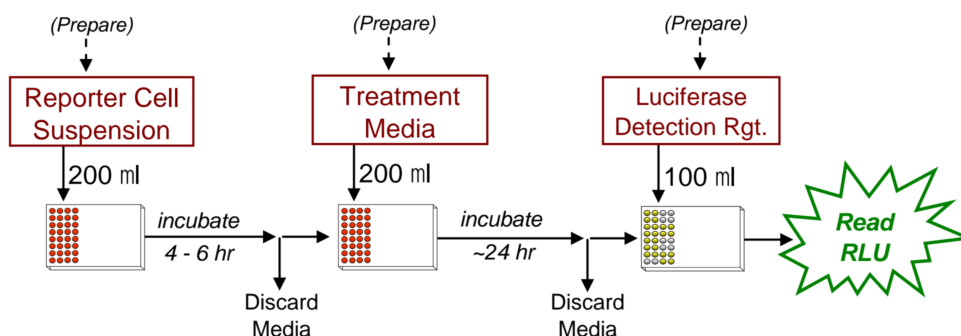
> *1.)* For both **small-molecule** and **proteinaceous** test samples, **Compound Screening Medium (CSM+H)** may be used as the diluent to achieve the desired assay concentration series, as described in *Step 7* (pg. 9).
>
> Alternatively, if **small-molecule** test compound solubility is expected to be problematic, *2.)* DMSO may be used to make serial dilutions to produce 1,000x-concentrated stocks for each independent test concentration. Treatment media are then prepared using CSM to make 1,000-fold dilutions of the prepared DMSO dilution series. NOTE: Do *not* use DMSO as the diluent for proteinaceous test compounds.

Regardless of the dilution method used, the concentration of total DMSO (or any organic solvent) carried over into assay wells should not exceed 0.4%. Emerging cytotoxicity can be expected above 0.4% DMSO exposure over the 24-hour assay period.

> *NOTE:* CSM+H contains heparin. In addition, it is formulated to help stabilize hydrophobic small-molecule test compounds in the aqueous environment of the treatment media. Nonetheless, high concentrations of small organic molecules diluted in CSM may lack long-term stability and/or solubility, especially if further stored at low temperatures. Hence, it is recommended that compound dilutions are prepared in CSM immediately prior to assay setup and are then treated as 'single-use' reagents.

▪ Assay Scheme ▪

Figure 1. Assay workflow. *In brief*, 200 µl of Reporter Cells is dispensed into wells of the assay plate and for 4-6 hours. Following the pre-incubation period, culture media are discarded and 200 µl/well of the prepared treatment media are added. Following 22-24 hr incubation, discard the treatment media and add Luciferase Detection Reagent. The intensity of light emission (in units of 'Relative Light Units'; RLU) from each assay well is quantified using a plate-reading luminometer.



▪ Assay Performance ▪

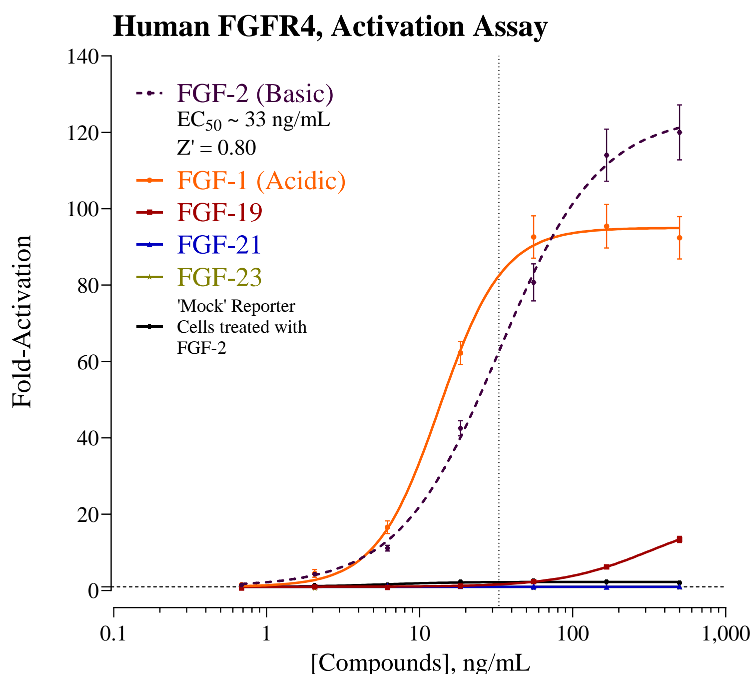


Figure 2. Activation of FGFR4. Activation assays were performed using the paracrine reference activators FGF-2 (*aka* FGF-Basic; provided) and FGF-1 (*aka* FGF-Acidic). The limited activity by the *endocrine* activator FGF-19, and absence of activity with FGF-21, and FGF-23 demonstrates assay specificity. All polypeptide ligands were procured from Peprotech.

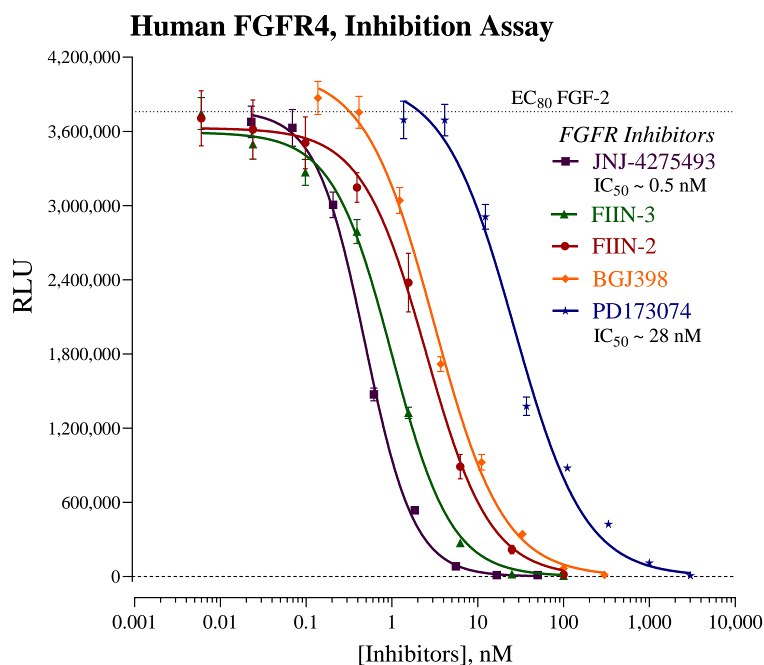


Figure 3. Inhibition of FGFR4. FGFR4 cells were treated with an EC80 concentration of the reference activator FGF-2 and varying concentrations of the FGFR inhibitors JNJ-4275493, FIIN-3, FIIN-2, BGJ398 and PD173074 (all compounds obtained from Cayman Chemical). INDIGO's Live Cell Multiplex (LCM) Assay confirmed that no treatment concentrations were cytotoxic (data not shown). For both Activation and Inhibition assays, luminescence was quantified and values of average (n=3) relative light units (RLU), corresponding standard deviation (SD), Fold-Activation, and Z'[5] values were calculated. GraphPad Prism software was used to plot data using the least-squares method of non-linear regression for Fold-Activation or RLU *vs.* Log_{10} [Cmpd], and to determine EC_{50} / IC_{50} values.

II. Product Components & Storage Conditions

This FGFR4 for Paracrine FGF signaling Assay kit contains materials to perform three distinct groups of assays in a 96-well plate format. Reagents are configured so that each group will comprise 32 assays. If desired, however, reagents may be combined to perform either 64 or 96 assays.

Cryopreserved mammalian cells are temperature sensitive! **To ensure maximal viability the tubes of Reporter Cells must be maintained at -80°C until immediately prior to the rapid-thaw procedure described in *Step 2* of this protocol.**

Assay kits are shipped on dry ice. Upon receipt of the kit transfer it to -80°C storage. If you wish to first inspect and inventory the individual kit components, please be sure to first transfer and submerge the tube of reporter cells in dry ice.

The aliquots of Reporter Cells are provided as a single-use reagent. Once thawed, reporter cells can NOT be refrozen, nor can they be maintained in extended culture with any hope of retaining downstream assay performance. Therefore, extra volumes of these reagents should be discarded after assay setup.

The date of product expiration is printed on the Product Qualification Insert (PQI) enclosed with each kit.

Kit Components	*Amount*	*Storage Temp.*
▪ FGFR4 Reporter Cells	3 x 0.6 mL	**-80°C**
▪ Cell Recovery Medium (CRM)	2 x 10.5 mL	-20°C
▪ Compound Screening Medium (CSM+H) (supplemented with Heparin)	1 x 45 mL	-20°C
▪ FGF-2, 50µg/ml (in PBS+0.1%BSA) (physiological activator of FGFR4)	1 x 40 µL	-20°C
▪ Detection Substrate (Note: contains DTT)	3 x 2.0 mL	**-80°C**
▪ Detection Buffer	3 x 2.0 mL	-20°C
▪ Plate Frame	1	ambient
▪ Snap-in 8-well strips (white, sterile, collagen-coated wells)	12	**-20°C**

NOTE: This Assay kit contains 8-well strips that have been collagen-coated and dried; these strip wells should be stored frozen (-20°C or colder) until use.

III. Materials to be Supplied by the User

The following materials must be provided by the user, and should be made ready prior to initiating the assay procedure:

DAY 1

▪ container of dry ice (see *Step 2*)
▪ cell culture-rated laminar flow hood
▪ 37°C, humidified 5% CO_2 incubator for mammalian cell culture
▪ 37°C water bath
▪ 70% alcohol wipes
▪ 8-channel electronic, repeat-dispensing pipettes & sterile tips
▪ disposable media basins, sterile
▪ sterile multi-channel media basins (such as the Heathrow Scientific "Dual-Function Solution Basin"), *or* sterilized 96 deep-well blocks (*e.g.,* Axygen Scientific, #P-2ML-SQ-C-S), *or* appropriate similar vessel for generating dilution series of reference and test compound(s)
▪ *Optional:* inhibitor reference compound (*e.g.,* Figure 3)
▪ *Optional:* clear 96-well assay plate, cell culture treated, for viewing cells on *Day 2*

DAY 2 plate-reading luminometer

IV. Assay Protocol

The assay protocol begins on the next page. Please review the entire Assay Protocol before starting. Completing the assay requires an overnight incubation. *Steps 1-11* are performed on ***Day 1***, requiring less than 2 hours of bench work and a 4 hour incubation step to complete. *Steps 12-17* are performed on ***Day 2*** and require less than 1 hour to complete.

▪ A word about Inhibition-mode assay setups ▪

Receptor inhibition assays expose the Reporter Cells to a fixed, sub-maximal concentration (typically between EC_{50} – EC_{85}) of a known activator AND varying concentrations of the test compound(s) to be evaluated for chemical inhibition. This FGFR4 Assay kit includes a 50 µg/mL stock solution of FGF-2, the physiological paracrine activator of FGFR4, that may be used to set up inhibition-mode assays. ~ 90 ng/mL FGF-2 approximates EC_{80} in this assay and, therefore, is a suitable *final assay concentration* of activator to be used when screening test compounds for inhibitory activity.

Add FGF-2 to a bulk volume of **CSM+H**, as described above. This activator-supplemented medium is then used to prepare serial dilutions of test material stocks to achieve the desired respective final assay concentrations. This is an efficient and precise method of setting up FGFR4 inhibition assays, and it is the method described in *Step 7b* of this protocol.

DAY 1 Assay Protocol: All steps should be performed using aseptic technique.

1.) Remove the **2 tubes** of **Cell Recovery Medium (CRM)** from freezer storage, thaw and equilibrate to 37°C using a water bath.

2.) **Rapid Thaw of the Reporter Cells:** *First*, retrieve the two tubes of **CRM** from the 37°C water bath and sanitize their outside surfaces with a 70% ethanol swab.

Second, retrieve **Reporter Cells** from -80°C storage and place them directly into dry ice to transport them to the laminar flow hood: 1 tube for 32 assay wells, 2 tubes for 64 assay wells, or 3 tubes for 96 assay wells. When ready to begin, transfer the tube(s) of reporter cells into a rack and, *without delay*, perform a rapid thaw of the frozen cells by transferring **6.4 ml** of pre-warmed CRM into each tube of frozen cells. Recap the tube of Reporter Cells and immediately place it in a 37°C water bath for 5 - 10 minutes. The resulting volume of cell suspension will be **7.0 ml** per tube.

Third, during the 5 - 10 minutes incubation period, work in the cell culture hood to *carefully* mount four sterile 8-well strips into the blank assay plate frame. Strip-wells are fragile. Note that they have keyed ends (square and round), hence, they will fit into the plate frame in only one orientation.

3.) Retrieve the tube(s) of Reporter Cell Suspension from the water bath and sanitize the outside surface with a 70% alcohol swab.

4.) If more than one tube of Reporter cells was thawed, combine them and gently invert several times to disperse cell aggregates and gain a homogenous cell suspension. Dispense **200 µl / well** of cell suspension into the assay plate.

> *NOTE 4.1:* If INDIGO's Live Cell Multiplex Assay is to be incorporated, a minimum of 3 'blank' wells (meaning cell-free but containing 'CSM') must be included in the assay plate to allow quantification of fluorescence background (refer to the LCMA Technical Manual).
>
> *NOTE 4.2:* Increased well-to-well variation will occur if care is not taken to prevent cells from settling in the reservoir during the dispensing period. Likewise, take care to ensure precision in dispensing exact volumes across the assay plate.
>
> *NOTE 4.3:* Users sometimes wish to examine the reporter cells using a microscope. If so, the extra volume of cell suspension provided with each kit may be dispensed into a clear, collagen-coated 96-well assay plate. Continue to process the assay plate in identical manner to the white assay plate.

5.) Pre-incubate reporter cells: Place the assay plate into a cell culture incubator (37°C, ≥ 70% humidity, 5% CO_2) for 4 - 6 hours.

6.) Near the end of the pre-culture period: Remove Compound Screening Medium **(CSM)** from freezer storage and thaw in a 37°C water bath.

7.) Prepare the Test Compound(s) and Reference Compound treatment media: Use **CSM+H** to prepare an appropriate dilution series of the reference and test compound stocks. In *Step 9*, the prepared treatment media will be dispensed at 200 µl / well into the assay plate. Manage dilution volumes carefully; this assay kit provides **45 ml** of CSM+H.

NOTE: Total DMSO carried over into assay reactions should not exceed 0.4%.

***a. Activation*-mode assays**. This FGFR4 Assay kit includes a concentrated stock of FGF-2, 50 µg/ml prepared in PBS+0.1%BSA. The following 7-point treatment series, with concentrations generated using serial 3-fold dilutions, provides a complete dose-response: 500, 167, 55.6, 18.5, 6.17, 2.06, and 0.686 ng/mL. Always include 'no treatment' control wells. **APPENDIX 1** provides guidance for generating such a dilution series.

~ or ~

***b. Inhibition*-mode assays**. When setting up inhibition assays, first supplement a bulk volume of CSM+H with the challenge activator FGF-2 to achieve an EC_{50} – EC_{80} concentration (refer to "*A word about inhibition-mode assay setup*", pg. 8). The FGF-2-supplemented CSM+H is then used to generate dilutions of test compound stocks to achieve the desired series of treatment concentrations.

8.) ***At the end of the cell pre-culture period:*** **Discard the culture media**. Because the assay plate is composed of a frame with snap-in strip-wells, the practice of physically ejecting media is NOT advised. Complete removal of the media is efficiently performed by tilting the plate on edge and aspirating media using an 8-pin manifold (*e.g.,* Wheaton Science Microtest Syringe Manifold, # 851381) affixed to a vacuum-trap apparatus. Do *not* touch the well bottom or run the tip of the aspiration device around the bottom circumference of the assay well. Such practices will result in destruction of the cells and greatly increased well-to-well variability.

9.) Dispense **200 µl** of each treatment media into appropriate wells of the assay plate.

10.) Transfer the assay plate into a cell culture incubator for 22 - 24 hours.

NOTE: Ensure a high-humidity (≥ 70%) environment within the cell culture incubator. This is critical to prevent the onset of deleterious "edge-effects" in the assay plate.

11.) For greater convenience on *Day 2,* retrieve the appropriate number of vials of **Detection Substrate** *and* **Detection Buffer** from freezer storage and place them in a dark refrigerator (4°C) to thaw overnight.

DAY 2 Assay Protocol: Subsequent manipulations do *not* require special regard for aseptic technique and may be performed on a bench top or in a **fume hood.**

12.) Approximately 30 minutes before intending to quantify receptor activity, remove **Detection Substrate** and **Detection Buffer** from the refrigerator and place them in a low-light area so that they may equilibrate to room temperature.

> *NOTE:* Do NOT actively warm Detection Substrate above room temperature. If these solutions were not allowed to thaw overnight at 4°C, a room temperature water bath may be used to expedite thawing.

13.) Set the plate-reader to "luminescence" mode. Set the instrument to perform a single 5 second "plate shake" prior to reading the first assay well. Read time may be set to 0.5 second (500 mSec) per well, *or less*.

14.) Immediately before proceeding to *Step 15*. To read 32 assay wells, transfer the entire volume of 1 vial of Detection Buffer into 1 vial of Detection Substrate, thereby generating a 4 ml volume of **Luciferase Detection Reagent (LDR)**. Mix gently to avoid foaming.

> *NOTE:* 'Detection Substrate' contains a high concentration of DTT, which produces a strong odor that some users may find objectionable. It is advised to work in a **fume hood** when preparing LDR, and subsequently when dispensing it into the assay plate and throughout the 'plate rest' period (*Step 16*).

15.) Following 22 - 24 hours incubation in treatment media, remove media contents from each well of the assay plate (as before in *Step 8*).

16.) Add 100 µl of **LDR** to each well of the assay plate. Allow the assay plate to rest at room temperature for at least 5 minutes following the addition of LDR. Do not shake the assay plate during this period.

17.) Quantify luminescence.

18.) Data analyses.

V. Related Products

Fibroblast Growth Factor 4 Assay for Paracrine FGF Signaling	
IB43001-32	FGFR4 Assay for Paracrine FGF signaling 3x 32 assays in 8-well strips (96-well plate format)
IB43001	FGFR4 Assay for Paracrine FGF signaling 1x 96-well format assay
IB43002	FGFR4 Assay for Paracrine FGF signaling 1x 384-well format assays

Fibroblast Growth Factor 4/α-Klotho Assay for Endocrine FGF Signaling	
IB43101	FGFR4/α-Klotho Assay for Endocrine FGF signaling 1x 96-well format assay
IB43102	FGFR4/α-Klotho Assay for Endocrine FGF signaling 1x 384-well format assays

Fibroblast Growth Factor 4/β-Klotho Assay for Endocrine FGF Signaling	
IB43201	FGFR4/β-Klotho Assay for Endocrine FGF signaling 1x 96-well format assay
IB43202	FGFR4/β-Klotho Assay for Endocrine FGF signaling 1x 384-well format assays

Fibroblast Growth Factor Receptor 1 / 2 Assay for Paracrine FGF Signaling	
IB21001-32	FGFR1/2 Assay for Paracrine FGF Signaling 3x 32 assays in 8-well strips (96-well plate format)
IB21001	FGFR1/2 Assay for Paracrine FGF Signaling 1x 96-well format assay
IB21002	FGFR1/2 Assay for Paracrine FGF Signaling 1x 384-well format assays

Fibroblast Growth Factor 1c/β-Klotho Assay for Endocrine FGF Signaling	
IB22001-32	FGFR1c/β-Klotho Assay for Endocrine FGF signaling 3x 32 assays in 8-well strips (96-well plate format)
IB22001	FGFR1c/β-Klotho Assay for Endocrine FGF signaling 1x 96-well format assay
IB22002	FGFR1c/β-Klotho Assay for Endocrine FGF signaling 1x 384-well format assays

(continued)

Fibroblast Growth Factor 1c/α-Klotho Assay for Endocrine FGF Signaling	
IB40001	FGFR1c/α-Klotho Assay for Endocrine FGF signaling 1x 96-well format assay
IB40002	FGFR1c/α-Klotho Assay for Endocrine FGF signaling 1x 384-well format assays
Bulk volumes of FGFR Assay Reagents may be custom manufactured to accommodate any scale of HTS. ***NOTE:* Single receptor FGFR1 or FGFR2 Assays are available upon request**. Please Inquire.	

NFAT Assays (recommended for receptor-specificity screening)	
IB18001-32	NFAT Reporter Assay System 3x 32 assays in 8-well strips (96-well plate format)
IB18001	NFAT Reporter Assay System 1x 96-well format assay

LIVE Cell Multiplex (LCM) Assay	
LCM-01	Reagent volumes sufficient to perform **96** Live Cell Assays in 1x96-well, or 2x48-well, or 3x32-well assay plate formats
LCM-05	Reagent in **5x bulk volume** to perform **480** Live Cell Assays contained in 5 x 96-well assay plates
LCM-10	Reagent in **10x bulk volume** to perform **960** Live Cell Assays contained in 10 x 96-well assay plates

INDIGlo Luciferase Detection Reagent	
LDR-10, -25, -50, -500	INDIGlo Luciferase Detection Reagents, available in 10 mL, 25 mL, 50 mL, 500 mL, and larger custom volumes

Please refer to INDIGO Biosciences website for updated product offerings.

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Product prices, availability, specifications, claims and technical protocols are subject to change without prior notice. The printed Technical Manual provided in the kit box will always be the most current version available.

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VII. Citations

[1] Ornitz, *et al*. (2015) The Fibroblast Growth Factor signaling pathway. WIREs Dev Biol. **4**:215-266.

[2] Xie, Y, *et al.* (2020) FGF/FGFR signaling in health and disease. Signal Transduction and Targeted Therapy (Springer Nature) **5**:181, 1-38.

[3] Bo, BB, *et. al.* (2021) FGF-23 signaling and Physiology. Journal of Molecular Endocrinology. **66**(2): R23-R32.

[4] Richter, B, *et. al.* (2018) FGF-23 Action on Target Tissues – With and Without Klotho. Frontiers in Endocrinology. doi: 10.3389/fendo.2018.00189.

[5] Park JY, *et. al.* (2020) The Role of Calcium-Calcineurin-NFAT Signaling Pathway in Health and Autoimmune Disease. Frontiers in Immunology.:doi:10.3389/fimmu.2020.00195.

[6] Zhang JH, *et al.* (1999) A Simple Statistical Parameter for Use in Evaluation and Validation of High Throughput Screening Assays. J Biomol Screen.:**4**(2), 67-73.

$$Z' = 1 - [3*(SD^{Reference} + SD^{Untreated}) / (RLU^{Reference} – RLU^{Untreated})]$$

APPENDIX 1

Example scheme for the serial dilution of FGF-2 and the setup of an FGFR4 dose-response assay.